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Complexity, Unpredictability and Maritime Safety

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Complexity, Unpredictability and Maritime Safety

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Johanna Salokannel

Complexity, Unpredictability and Maritime Safety

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Merenkulku mielletään suhteellisen turvalliseksi kuljetusmuodoksi vaikka merenkulku ammattina onkin vaarallisempi kuin monet maissa sijaitsevat ammatit. Lisääntyvä automaatio, voimakas taloudellinen paine, miehistön määrän lasku, kasvavat alusten koot ja uudet, korkean riskin väylät kuten Arktiset väylät lisäävät kaikki osaltaan merenkulun kompleksisuutta. Yksi onnettomuus herättää suurta kansainvälistä huomiota (esim. Costa Concordia) ja ihmisten tekemät virheet lasketaan olevan merellisten onnettomuuksien syynä noin 80% tapauksista. Uusi turvallisuusajattelu kuitenkin näkee inhimillisen virheen liian mustavalkoisena ja pelkistävänä syynä onnettomuuksille. Systeemien ja niiden toimintaympäristön kompleksisuus tekee tulevaisuuden mahdollisten vaarojen ennustamisesta vaikeaa ellei mahdotonta. Kompleksisuus tuo riskien ja turvallisuuden hallintaan epävarmuuksia ja tästä syystä myös toimet, joilla riskejä pyritään hallitsemaan ovat usein puutteellisia. Tämän takia yllättäviä tapahtumia voi esiintyä, jotka vaativat ihmisiä sopeuttamaan ja mukauttamaan toimintaansa tilannekohtaisesti. Tämä kyky sopeutua ja mukautua yllättäen ilmenevän tilanteen vaatimuksiin on erittäin tärkeää turvallisuuden varmistamisen kannalta.

Tämän työn tavoitteena on ymmärtää syvemmin kompleksisuuden vaikutusta turvallisuuden hallintaan erityisesti merenkulussa ja etsii vastauksia kysymykseen miten hallita ja johtaa turvallisuutta, jos emme tarkalleen tiedä tai kykene ennustamaan kaikkia riskejä. Tämä työ perustuu niin teoreettisen kuin ammattikirjallisuuden analyysiin, jossa pyritään sitomaan ja heijastamaan teoreettista viitekehystä artikkelien kautta merenkulkuun käytännön näkökulmasta.

Tutkimuksen tuloksena syntyi ymmärrys siitä, että ihmiset jotka konkreettisesti tekevät työn ovat avain asemassa turvallisuuden varmistamisessa. Turvallisuus voidaan nähdä systeemin ominaisuutena, joka on emergenssi. Se ei ole jotain, joka kerran luodaan ja jätetään sen jälkeen huomiotta vaan jotain joka dynaamisesti luodaan uudelleen ja uudelleen. Merenkulku on kehittänyt turvallisuuttaan tutkimalla jo tapahtuneita onnettomuuksia, mutta kompleksisuudesta johtuen määrätyn tilanteen olosuhteet voivat olla hyvin erilaiset ajankohdasta riippuen. Tästä syystä turvallisuus on myös tilannesidonnainen. Näin ollen jo tapahtuneiden onnettomuuksien tutkiminen merenkulun turvallisuuden parantamisessa tarvitsee rinnalle myös menestyksen ymmärrystä. Jos halutaan ymmärtää mistä menestys ja näin ollen myös turvallisuus syntyy, tulee meidän tutkia myös menestystä, ei ainoastaan epäonnistumisia.

Merenkulun turvallisuus on myös nähty hyvin pitkälle koostuvan sääntöjen, määräysten ja parhaiden toimintatapojen kurinalaisesta noudattamisesta. Kompleksisuus kuitenkin vaatii sääntöihin ja määräyksiin joustoa, jotta voidaan sopeuttaa toimintaa tilanteen vaatimalla tavalla. Yksi tapa hallita turvallisuutta joustavien määräysten alueella on sitouttaa ihmiset yritysten ydinarvoihin. Merenkulussa toimintaa ohjaavana ydinarvona voidaan pitää ”Hyvää Merimiestaitoa”, jonka osana on myös merenkulkijan toiminnan turvallisuus. Tämä tutkimus osoittaa, että turvallisuus on paljon muuta kuin kirjalliset säännöt ja määräykset. Turvallisuus on ihmisten mielessä, heidän asenteissaan ja päätöksissä, jotka johtavat toimintaa tiettynä ajankohtana tietyssä paikassa ja joka useimmiten on menestyksekästä. Tämä myös korostaa johtajuutta turvallisuuden kehityksessä.

Avainsanat: Merenkulun turvallisuus, kompleksisuus, epävarmuus, inhimillinen elementti
Ohjaaja: Seppo Leminen and Jukka Ojasalo, Laurea

Laurea University of Applied Sciences **Abstract**
Degree Programme in Safety and Security Management
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Complexity, Unpredictability and Maritime Safety

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Shipping is considered a relatively safe form of transport, but seafaring is still seen as a high-risk profession. Increasing automation, high economical pressure, decreasing crew size, increasing ship size, and new high-risk routes like the Arctic all introduce complexities into seafaring. One single accident, although very rare, gains a lot of international attention (e.g. Costa Concordia). Human error is stated as the cause of maritime accidents in approximately 80% of the cases. However, new safety thinking sees "human error" as too narrow and simplistic of a reason for accidents. Complexity of systems makes it difficult, if not impossible, to predict all possible paths to failure. Due to this uncertainty, the safety guards to prevent failures are most likely also insufficient. The unpredictability of exact future events requires humans to adapt and adjust performance according to the situational needs of unexpected events. This capability of performance variability is a crucial factor to ensure safety.

The objective of this thesis is to understand the element of complexity and its impact on safety especially in shipping, and find answers to how safety can be managed and led if we do not know or cannot predict all risks. This thesis is a study and analysis of theoretical and professional literature. The aim is to connect and reflect the theoretical framework into practice using maritime articles.

The main findings are that humans, the ones at the sharp end doing the actual work, are vital for safety development. Safety can be seen as an emergent property of a system, which is dynamic and possibly changing from one moment to the next. Safety is not something that is once achieved and then left in a static mode, but something that is dynamically created again and again. Shipping has developed its safety by studying past accidents. Due to complexity, the specific situational conditions for an event in a particular space and time can be completely different for the similar event in another moment of space and time. Hence, safety is also situationally bound. Therefore, hindsight and study of past accidents might not be sufficient to develop safety. In order to understand and ensure success, shipping should also study and focus on success, not only failure.

The safety of shipping is widely seen as the result of compliance to rules, regulations and best practices. Complexity, however, requires more flexibility in rulemaking to ensure correct adjustments of performance. One way to manage safety in the area of flexible rule making is commitment to core values, which in shipping can be seen as the concept of "Good Seamanship". Safety is an integral part of seamanship, even though it might lie very deep in the tacit knowledge of professional seafarers. Therefore, this thesis also demonstrates that safety is much more than safety management systems, written rules and written international codes. Safety lies in the minds of humans, their attitudes and decisions leading to action in a particular moment that is usually successful. This also highlights the importance of leadership in safety development.

Keywords: complexity, unpredictability, safety, shipping, the human element
Supervisor: Seppo Leminen and Jukka Ojasalo, Laurea

Tiivistelmä / Executive Summary

Tämän työn tavoitteena on ymmärtää syvemmin kompleksisuuden ja epävarmuuden vaikutus merenkulun turvallisuuteen. Tutkimuksen keskiössä on merenkulkijat eli inhimillinen tekijä. Viimeisimmät turvallisuustutkimukset korostavat ihmiselementin tärkeyttä ja toiminnan mukautumiskykyä vastata erilaisten tilanteiden vaatimuksiin. Tämä mukautumiskyky on edellytys onnistuneelle toiminalle. Näitä turvallisuuskäsityksiä ja hypoteeseja on peilattu merenkulkuun tässä työssä. Yksinkertaistettuna tämä työ etsii vastausta kysymykseen, miten voimme hallita ja johtaa turvallisuutta jos emme tiedä tarkalleen kaikkia riskejä?

Turvallisuuden ja kompleksisuuden käsitteet ovat aika abstrakteja, joten tämän tutkimuksen metodit ja data ovat keskittyneet teoreettisen ja ammattikirjallisuuden tutkimiseen ja analysointiin. Tämän lisäksi väistämättä tutkimukseen on tullut henkilökohtainen ote, koska työskentelen merenkulun turvallisuuteen liittyvien projektien parissa samoin kuin olen myös koulutukseltani merenkulun ammattilainen. Näiden projektien pohdinnat heijastuvat teoreettisiin synteeseihin ja luovat oman vivahteensa itse työhön. Työn ymmärtämisen logiikka on ollut abduktiivinen argumentointi, joka sisältää niin vahvuuksia kuin heikkouksia. Tämä työ on tekijänsä näköinen, mutta samalla jättää oven auki uusille todisteille, jotka saattavat tuoda tässä työssä argumentoiduille asioille uuden käänteen. Tässä työssä ei esitetä absoluuttista totuutta vaan tavoitteena on valaista ihmiselementin tärkeyttä kompleksisessa ympäristössä sekä luoda pohjaa keskustelulle ja jatkotutkimuksille siitä, miten merenkulun turvallisuuden kehitystä kannattaa viedä eteenpäin. Turvallisuuden kehityksessä tulisi keskittyä muihin asioihin kuin vain läheltä piti tilanteiden tai onnettomuuksien tutkimiseen. Nämä varmasti kertovat omaa tarinaansa siitä miten turvallisuutta tulisi kehittää, mutta tämän työn tulosten perusteella se ei riitä. Turvallisuus on myös johtajuutta. Se on ihmisten johtamista ja voimaannuttamista turvalliseen toimintaan ja jatkuvaan kehitykseen. Se on niiden merimiesten johtamista, jotka elävät ja työskentelevät laivalla. He ovat se taho, joka luo turvallisuuden joka päiväisessä toiminnassa. Absoluuttista turvallisuutta ei ole eikä täydellisiä systeemejä. Ihmiset tekevät virheitä ja systeemeissä on puutteita, mutta tämän ei pitäisi estää menestyksekästä toimintaa. Turvallisuutta ei ole olemassa ilman jatkuvaa toimintaa sen olemassa olon hyväksi.

Seuraavat osiot esittelevät lyhyesti tämän työn tutkimustulokset.

Turvallisuuden luonne

Viimeisimmät tutkimukset esittävät, että turvallisuus on kompleksisen systemin emergenttinen ominaisuus. Turvallisuus on jotain mitä ei voi saavuttaa ja olettaa sen olevan staattinen tila vaan jotain, jonka eteen tulee koko ajan tehdä töitä. Jokainen käsillä oleva hetki

eroaa toisesta vastaavanlaisesta ja yhteenkietoutuneet tapahtumat muuttuvat dynaamisesti sitä mukaan kun aktiiviset toimijat osallistuvat tapahtumien kulkuun. Turvallisuus syntyy systeemin erilaisten elementtien vuorovaikutuksessa tilanteessa jossa ne ovat aktiivisesti osallisia. Tämä tekee turvallisuuden luonteesta dynaamisen samoin kuin tilannesidonnaisen. Joskus kyseessä on vain tavallinen päivä töissä ja toisinaan taas turvallisuuskriiittinen tilanne, jossa tulee reagoida välittömästi. Syy, miksi merenkulussa tapahtuu onnettomuus määrätyssä ajassa ja paikassa ei kerro tyhjentävästi miten onnettomuudet voidaan varmuudella estää tulevaisuudessa. Tilanteet ovat hyvin harvoin identtisiä samoin kuin käytettävissä olevat resurssit kuten aika, saatavilla oleva informaatio, työvoima, osaaminen tai sääolosuhteet.

Riskikartoitukset ovat riskiehallinnan tärkeä työkalu organisaation turvallisuuden kehityksessä. Uhkatekijöiden ennakointi samoin kuin niiden vaikutus ja potentiaalinen ilmentymä kuitenkin sisältää faktojen lisäksi myös oletuksia ja arvioita tulevaisuuden tapahtumista ja huolimatta siitä, miten huolella me ennakointia pyrimme tekemään, emme siltikään tule tietämään tarkalleen miten asiat kehittyvät tulevaisuudessa. Tästä epätietoisuudesta syntyy epävarmuuksia, jotka aiheuttavat sen, että myös toimet joilla pyrimme tulevaisuuden riskejä hallitsemaan ja pienentämään myöskin voivat olla epätaydellisiä.

Tästä syystä tarvitsemme myös muita työkaluja turvallisuuden kehittämisessä kuin ainoastaan riskien kartoitusta ja hallintaa. Jotta ymmärtäisimme, mistä menestys syntyy tulisi meidän tutkia menestyksekästä toimintaa sen lisäksi, että tutkimme menneisyydessä tapahtuneita onnettomuuksia ja läheltä piti –tilanteita. Kuten Hollnagel (2014) argumentoi, suurimman osan aikaa ihmisten tekemä työ on menestyksekästä ja onnettomuudet ovat loppujen lopuksi hyvin harvinaisia. Samoin on merenkulussa, mutta siitä huolimatta focus on hyvin pitkälle tapahtuneissa onnettomuuksissa ja läheltä piti -tilanteissa kun puhumme turvallisuuden kehityksestä. Kompleksisissa systeemeissä tämä ei kuitenkaan riitä vaan turvallisuutta tulisi myös kehittää muilla keinoin.

Turvallisuuden taktinen näkökulma

Kompleksisessa ympäristössä turvallisuus on systeemin emergenttinen ja dynaaminen ominaisuus, joka merenkulussa korostaa merenkulkijoiden suorituskykyä. Turvallisuuskriittisessä tilanteessa resurssit ovat usein rajallisia, mutta merenkulkijat kompensoivat puuttuvia resursseja tiedoillaan ja taidoillaan sekä kyvyllä mukautua tilanteeseen. He käyttävät sitä, mitä on saatavilla ja suurimman osan aikaa onnistuneesti. Tämä kääntää katseen turvallisuuden taktiseen näkökulmaan. Strategisella tasolla fasilitoidaan turvallisuuden luominen, mutta itse turvallisuus luodaan taktisella tasolla. Strategisella tasolla määritellään yrityksen toiminnan tavoitteet, resurssit ja investoinnit, tekniset ratkaisut, säännöt ja määräykset jne. Merenkulussa esimerkiksi merenkulun liikenteen koordinointia suunnitellaan strategisella tasolla luomalla reittijakojärjestelmiä tai monitorointia, mutta nämä kuitenkaan eivät tyhjentävästi takaa turvallisuutta. Huolimatta parhaimmista yrityksistä koordinoida ja monitoroida liikennettä, laivojen karilleajoja ja yhteentörmäyksiä tapahtuu silti. Näissä tilanteissa turvallisuus on loppujen lopuksi merenkulkijoiden taidoista kiinni ja mitä kompleksisemmaksi navigointialueet menevät, kuten esim. Arktinen merenkulku tai jäänavigointi, sitä tärkeämmäksi turvallisuuden taktinen näkökulma tulee.

Turvallisuuden takaaminen kompleksisessa ympäristössä vaatii toimijoilta hieman erilaisia taitoja kuin ennakoitavissa olevassa ympäristössä, jossa turvallisuus voidaan taata sääntöjä ja toimintaohjeita noudattamalla. Tämä asettaa myös uusia haasteita johtajuudelle ja samalla myös korostaa johtajuuden tärkeyttä varmistamaan se, että yllättävissäkin tilanteissa miehistö osaa toimia yhtenäisesti ja kollektiivisesti tilanteen vaatimalla tavalla linjassa sovittujen arvojen ja tavoitteiden kanssa.

Jouston tarve

Kompleksiset ja ennalta arvaamattomat tilanteet tekevät tarkkojen toimintaohjeiden tekemisestä vaikeaa ellei mahdotonta. Jotta yllättäviin tilanteisiin voitaisiin reagoida ja vastata mahdollisimman tehokkaasti, tulisi toiminnan ohjeistuksessa, säännöissä ja määräyksissä olla joustoa ja päätöksenteko hajautettua. Usein he, jotka tekevät toimintaohjeita ovat erit kuin he, jotka niitä toteuttavat ja joskus näillä kahdella taholla on erilaiset näkemykset suoritettavasta työtehtävästä. Tutkimukset osoittavat, että merenkulkijat tekevät väliaikaisia oikoteitä (work-a-round) suorittaakseen työtehtävänsä, mutta kaikki eivät johdu välinpitämättömyydestä tai tietoisesta sääntöjen rikkomisesta. Välillä oikoteitä joudutaan tekemään turvallisemman tavan löytämiseksi tai rajallisten resurssien takia. Merenkulun turvallisuus on nähty hyvin pitkälle koostuvan sääntöjen, määräysten ja parhaiden toimintatapojen kurinalaisesta noudattamisesta. Kompleksisuus kuitenkin vaatii sääntöihin ja määräyksiin joustoa ja päätöksentekoon hajauttamista, jotta tilanteeseen voidaan reagoida sen vaatimalla tavalla. Säännöt, määräykset, parhaat toimintatavat ovat tapa kuvata yksinkertaisesti monimutkaisia asioita. Jos eteen tulee tilanteita, joissa etukäteen kirjoitetut toimintaohjeet eivät enää päde, päätöksiä tulee tehdä sen tilanteen vaatimalla tavalla ja toimintaa siihen sopeuttaen. Näissä tilanteissa liian tiukat toimintaohjeet voivat jopa heikentää turvallisuutta.

Jos päätöksiä joudutaan tekemään siitä, päteekö tilanteeseen jo sovitut toimintatavat vai vaatiiko kyseinen tilanne niiden sopeuttamista, tulee päätöksen tekijällä oltava vaadittavat kyvyt ensinnäkin tunnistaa nämä tilanteet, mutta myös kyky tehdä perusteltuja päätöksiä siitä milloin toimintatapoja noudatetaan ja milloin ei. Päätösten ja toiminnan tulee olla linjassa yrityksen määriteltyjen tavoitteiden kanssa. Yksi tapa hallita turvallisuutta joustavien määräysten alueella on sitouttaa ihmiset yritysten ydinarvoihin ja tässä taas korostuu johtajuuden merkitys. Johtajuus on avain asemassa kun pyritään kehittämään turvallisuutta kompleksisuuden ja epävarmuustekijöiden vallitessa, jotta voidaan varmistaa, että tehdyt päätökset ja toimet ovat linjassa kokonaisvaltaisten tavoitteiden ja periaatteiden kanssa.

Hyvä merimiestaito

Merenkulussa toimintaa ohjaavana ydinarvona voidaan pitää hyvää merimiestaitoa, joka on ollut osa merenkulkua aikojen alusta. Hyvä merimiestaito on tarvittavaa käytännön ammattitaitoa kuten aluksen hallintaa ja työtehtävien menestyksekästä hoitamista, mutta myös asioita kuten ammatillista ylpeyttä, kohteliaisuutta muita kanssakulkijoita kohtaan ja luonnonvoimien kunnioitusta jne. Hyvällä merimiestaidolla ei ole universaalia määritelmää, mutta sitä kuitenkin käytetään laajasti merenkulussa. Hyvällä merimiestaidolla katetaan jopa laissa kohdat, joita ei voida kirjallisesti määrittää. Tutkimukset kuitenkin osoittavat, että merenkulkijat kokevat, ettei heidän merimiestaitoaan aina arvosteta toivotulla tavalla. Turvallisuus on myös osa hyvää merimiestaitoa ja tämä tutkielma haluaakin korostaa, että mitä kompleksisemmaksi toimintaympäristö muuttuu, sitä tärkeämmäksi hyvä merimiestaito tulee. Tästä syystä hyvää merimiestaitoa ei saisi rajoittaa säännöillä ja määräyksillä vaan yrityksen tulisi luoda sellaiset puitteet, jossa hyvää merimiestaitoa kunnioitetaan, kehitetään ja vaalitaan.

Executive Summary

This study has the aim to understand the impact of complexity and unpredictability on maritime safety focusing on the human element. Recent safety studies highlight the importance of performance variance and adaptability to prevailing situational conditions as a key for operational success. These hypothesis and ideas are reflected into maritime domain in this thesis. Basically this thesis is looking for answers to the question, that how do we ensure safety if we do not know all the risks?

As safety and complexity are quite abstract concepts, the research methods and data collection relies mainly on theoretical and professional literature. The logic of reasoning to understand collected material has been abductive reasoning, which as such presents both strengths and weaknesses. This thesis is a construction of views of the author bringing insight to the concept of maritime safety and the importance of human element in the process of creating safety. This however is not the absolute truth, but a starting point for further discussion and research. Abductive reasoning gives the freedom to interpret found facts and to come to a conclusion based on these facts, but also leaves the door open for another interpretation as new facts appear. Hence, this thesis does not claim that the presented issues are the absolute truth, but highlights the point, that there are larger issues to consider in safety development than just investigating past accidents and creating new regulation or requiring compliance to established procedures. Safety is also about leadership. It is about leading the people living and working at sea, their empowerment towards safety and continuous development. There are no such things than perfect systems or absolute safety. Humans make mistakes and systems fail, but that should not hinder overall successful operations and sustainable shipping. Safety needs constant striving and effort, it does not just exist.

The following sections will shortly present the main findings of this thesis.

The nature of safety

The nature of safety in the recent studies introduces safety as an emergent property of a complex system. Safety is not something that is once achieved and then left alone, but something that requires constant striving and effort. Each situation at hand is most likely different from the next and the intertwined events of our reality change as we intervene with our own actions. Safety is something that is created in the interconnection of different components in a situation that the components are dynamically part of. This makes safety also dynamic in nature as well as situationally bound. Sometimes it can be just another day at

work, sometimes responding to a highly safety critical incident. Why a maritime accident happens in a certain space and time does not sufficiently tell how we can avoid such an event in the future as no circumstances are absolutely the same neither are the exact resources at hand such as available information, manpower, tools at hand or weather conditions.

Risks assessments are an important tool to improve and manage safety. However, predicting possible hazards, their probabilities and impacts is not exact science. Risk assessments include facts but also assumptions about the future events and regardless of our best efforts, we still do not for sure know what is going to happen in the future. This introduces uncertainties and therefore also our exact measures to mitigate, control and eliminate risks are also often approximate.

In order to understand how safety is created in the every day actions, we need to study also success and not only failures as in past accidents or near misses. If we want to understand where success originates from, we need to study success. As argued by Hollnagel (2014) mainly the accomplishment of everyday work by humans is a success and rarely a failure. Still our efforts to improve safety relies on studying past incidents, near misses and accidents. In complex systems that is not enough. Safety should also be improved with other methods.

Tactical aspect of maritime safety

Safety as a emergent and dynamic property of a system highlights the importance of the seafarer's performance. In a safety critical situation, resources at hand are often limited, but the seafarers use their skills, knowledge and available resources to over come any shortages that might exist as accidents still are a rare event. This also sheds light on the tactical aspect of maritime safety. Safety is facilitated on a strategical level, but created on a tactical level. Strategical level defines business operation strategies, resourcing, technical solutions, legislation and needs for example training. On this level the general maritime traffic is coordinated such as Vessel Traffic Services and Traffic Separation Schemes, but this alone does not ensure safety. In spite of the best effort to monitor and coordinate the traffic, there are still groundings and collisions at sea. In these situations it is still the skills and competence of the seafarers that makes an action safe or unsafe. And the more complex the environment, e.g. Arctic shipping and navigating in ice, the more important will the tactical aspect be in creating and ensuring safety.

Complex environment sets a bit different requirements for the human element than operating in a predictable environment, where safety can be ensured by compliance to rules, regulations and established ways of working. This will pose new challenges for leadership and at the same time also highlights the importance of leadership, so that even in ad hoc situations the crew can collectively manage the needed tasks according to overall goals and principles.

The need for flexibility

Complex and unpredictable situations makes it difficult to define in detail which course of action to take in each situation. In order to efficiently respond to situational needs, question current ways of working for continuous improvement and make improvement suggestions some level of flexibility is needed along with decentralized decision making. Often those who make the work procedures are different from those who actually implement them and at times, these do not meet. Studies show, that work-a-rounds exist also in the maritime world and it is not always about negligence but sometimes a necessary act to successfully accomplish the task at hand with limited resources. Maritime safety has been quite far compliance to rules, regulations and established work procedures, but complexity requires a level of flexibility and decentralization of decision making to efficiently respond to ad hoc situations. Regulations and work descriptions are simplified description of reality. If events occur, that fall outside the described ways of working and the written instructions do not sufficiently tell anymore which course of action to take, decisions need to be made and actions adjusted to the prevailing situational needs. In these situations two strict operational guidelines can even deteriorate safety.

Those seafarers who are self-regulative, are empowered towards constant improvement of safety and operate within flexible rule making need also to have the skills and knowledge to operate within the area of flexibility. Their decision making needs to be directed towards the common objectives of the shipping company and general principles of sustainable shipping. They need to have mental core values that guide the operation as well as the right attitude towards safety. These are subject of leadership. Leadership is one of the key issues in complexity to ensure that the actions done are in line with the overall objectives and principles.

Good Seamanship

One of the core values within maritime domain is “Good Seamanship”. Seamanship has been recognized as a core value of seafarers for centuries. Good seamanship has no universal definition, but still it is widely used even in legislation to cover areas that can not be defined with written word. Studies also show, that seafarers perceive that their seamanship is not valued and excessive needs for documentation, rules and regulation override their professionalism. In a complex and unpredictable operational environment seamanship is something that can be used as a core value to direct action. Therefore, this thesis strongly emphasises the importance of Good Seamanship. The more compelex the environment, the more important good seamanship becomes. Therefore, good seamanship should not be constrained by too strict rules and regulations. The organization should establish an climate where good seamanship is respected, developed and maintained as a part of a successful shipping.

Content

PART I

The Theory

1 Introduction

According to International Chamber of Shipping (ICS) around 90% of world trade is carried by the international shipping industry. There are over 60 000 merchant ships sailing internationally transporting all kinds of cargo and are manned by over a million international seafarers from cross the globe. The way we know our world today would not be possible without shipping and the industry is predicted to grow also in the future. (ICS; Grech, 2016, 2) Still shipping is considered to be a high risk industry becoming more complex. Increasing automation, growing vessel size and specialization of vessels put pressure on the crew to acquire new skills and knowledge at the same time the traffic density is increasing. Economical pressure for productivity and cost reductions exists due to fierce competition within the industry. Fatigue of seafarers raise concerns and the recent studies show that compliance in meeting the regulatory requirements of rest and work hours in general are poor. Minimization of crew size is used to seek economic efficiencies leaving fewer crew members to deal with more demanding work conditions. Intensive shipping operations increases irregular and sometimes long working hours, interrupts sleeping hours and increases work load. Crews are often multicultural where cultural and language barriers exist with possible social isolation. (Grech, 2016,1)

Working at sea is also considered to be one of the most dangerous professions. Walters & Bailey (2013, 1) write in their book about statistics where the: "… *relative risk of mortality caused by accidents at work is 26 times greater than for all workers in the UK (Roberts and Marloe, 2005), while in the Danish merchant fleet the fatal accident rate was 11 times higher than for shore based industries…*" Berg (2013, 344) again states maritime transport system to be: "*…25 times riskier than the air transport system according to the accounts for deaths for every 100 km.*" And through the intensification of sea trade in the future, also the potential risk to ship safety is increasing (Berg, 2013, 344). European Maritime Safety Agency, EMSA, published key figures of Marine casualties and accidents in 2014 (EMSA, 2015, 3). In total there were 3 399 ships involved in the accidents (including fishing vessels), 51 ships were lost, 1075 persons were injured and 136 fatalities. During the years of 2011-2014 there has been more than 390 persons who have lost their lives at sea and 3 250 have been injured. Also around 2/3 of total occurrences involved damage to the ship and the remaining 1/3 were accidents to persons on board. So regardless of the continuous safety improvement work and increasing amount of rules and regulation, accidents still happen, lives are lost at sea and damage to the environment occur.

1.1 Aim of the study

Human error (errors made by the seafarers) as a cause of accidents at sea is counted to be around 80% (Berg, 2013, 344). At the same time the new safety thinking argues, that the human element is vital for successful operation due to their ability to adapt and adjust their performance according to situational needs. The concept of human error is stated to be too simplified reason for accidents and in order to improve safety, there is a need to look at safety from a more holistical point of view.

Therefore the research questions are:

1. What does it mean for safety management and leadership, that our systems are becoming increasingly complex making them intractable and unpredictable to various extents in their behavior.
2. What is the role of human element in these complex systems in relation to maritime safety

The aim of this study is to understand more deeply safety as a phenomena and the role of human as in seafarers in safe maritime transportation rather than search direct answers to the question how to eliminate human error. The aim is more to search new paths towards improving safety, to raise discussion rather than give only solutions. Safety is quite complex and abstract phenomena as is the concept of human error. After all, to quote Alexander Pope: "*To err is human*".

1.2 Structure of the study

This study is divided into two parts. The first part is the general introduction to the subject, with general presentation of the theoretical background and explanation of definitions used in the study (chapter 2). Chapter 3 is explaining the changing safety thinking and the guiding thought in this work has been Erik Hollnagel's theories about Safety-II (Hollnagel, 2014). His argument about the need for human performance variability in complex systems to ensure safety and success has been the starting point and initial idea of this study. Therefore, these principles will follow throughout this work. Chapter 4 will explain the research design, the methods used and logic behind this study. Chapter 5 will introduce the articles and reveal the main findings. The part II are the actual articles.

1.3 Limitations

Safety and human error are complex subjects and solutions how to eliminate human error in order to improve safety are not simple or straight forward. Therefore, this study does not give direct answers, but more as stated above, aims to find new paths towards improving safety. The focus of this thesis is also on seafarers as in human element living and working at sea faced with a complex and unpredictable situation or shipping in a high risk area like Arctic and not focusing on shipping in a stable, well established routes where the seafarers are very familiar with the route, ship and navigational area. There are routines in shipping and standardized work procedures, which have been established due to experience, learning and predictability, but the aim of this study is to focus on situations when these do not apply.

Today the development of autonomous ships is a hot topic. One of the arguments of digitalization of knowledge, autonomous unmanned ships and for example enhanced monitoring of maritime traffic has the objective of improve safety by eliminating human error of seafarers (for further information, please see e.g MUNIN brochure, 3; AAWA Position Paper, 73; Burmeister et al., 2014, 5). However, there is also critique towards this kind of arguments. This critique state that even though autonomous shipping might reduce certain type of human error in the traditional sense (e.g. lack of vigilance and loosing situational awareness, errors due to fatigue), the new technological development both onboard the ship and in shore control room might create new types of errors (Hogg and Ghosh, 2016, 207). Even though unmanned shipping is a hot topic, it is not in the scope of this study to take a stand whether autonomous shipping will eliminate human error as such. The objective is to bring into light the strengths of human element and address the fact that the concept of human error is far more complex than simply state that autonomy of vessels will decrease human error. Thus also points out that there is a need to further research on things like competitive advantage of companies, which can be created through collective learning of employees and their expertise to face safety critical, emergent ad hoc situations and successfully adjust their performance for operational success.

2 General background and definitions

The objective in this chapter is to open up some of the definitions and principles covered in this thesis. These definitions are the basis for the articles reflecting the Safety-II and Resilience Engineering principles into maritime domain.

2.1 What is safety?

'Safety' is a common word, which we use in our everyday life in many different contexts and is quite recognizable to us. We say things like: "*Drive safely*" or "*Your secret is safe with me*". We all have an understanding of what is safe, but still safety does not have a single, universal definition. Reason (2000, 4; referring to The Concise Oxford Dictionary) gives the definition of safety as "*freedom from danger and risks*", but later substitutes it with definition (Ibid, 5): "*the ability of individuals or organisations to deal with risks and hazards so as to avoid damage or loss and yet still achieve their goals*". Hollnagel (2014, 2) gives also a more detailed generic definition: "*Safety is the system property or quality that is necessary and sufficient to ensure that the number of events that could be harmful to workers, the public, or the environment is acceptably low.*" Commenting the vagueness of definitions 'harmful to workers' and 'acceptably low' of their subjective nature. So what is meant by 'being safe' is generally that things will turn out the way they are expected to and whatever is being done is a success. In other words, it is things going right where safety is the absence of whatever could hinder us from achieving whatever we want to achieve. So in this sense, 'safety is the freedom from unacceptable risk'. (Hollnagel, 2014, 3-5)

This is not, however, the way we measure safety. Safety is very commonly measured by how many accidents and incidents has happened, using these as the yard stick in determining whether something is safe or not. Therefore, safety management is focusing very much on what did *not* happen. Hollnagel (2014) uses the term dynamic non-event in his book. He is referring to Karl Weick, a professor who introduced the idea of reliability as a dynamic non-event (Hollnagel, referring Karl Weick, 2014, 5):

Reliability is dynamic in the sense that it is an ongoing condition in which problems are momentarily under control due to compensating changes in components. Reliability is invisible in at least two ways. First, people often don't know how many mistakes they could have made but didn't, which means they have at best only a crude idea of what produces reliability and how reliable they are. […] Reliability is also invisible in the sense that reliable outcomes are constant, which means there is nothing to pay attention to.

The word dynamic in this context means that the outcome, the non-event, cannot be guaranteed in a way that we could be sure that nothing *will* happen. Therefore, safety is not a state that is once achieved and then left alone, but a condition of the system that needs constant monitoring and management. Due to the nature of safety as a dynamic non-event, we will always know how many accidents and incidents did happen, but how many accidents and incidents did not happen (i.e. the non-events) due to different actions we took, is much more difficult to measure if not impossible. Therefore, the traditional way of defining if something is safe or not, is to calculate how many accidents and incidents did happen. But, if the number will go down, say a company improves its processes and the accident rate goes down 50% and stays that way for a period of time. Can we really be sure, that an accident will not happen in the future? Safety as a concept is complex, as it is dynamic, nonlinear and a non-event. Due to this dynamic complexity, it can also create safety paradoxes.

2.2 Defining complex socio-technical systems

A system consists of dynamically interacting components, which are interweaved together in such a way, that it maintains its structure. A system can be for example a human body, a society, ecosystem, a city or a ship. It can exists on many levels and when studying a system, it needs to be seen as a whole. The individual elements cannot be studied in isolation, but in relation to its overall operational environment. (Rosnay 2011, 307) Like a ship as a system needs to be seen as a whole operating in its surroundings consisting of technological solutions, construction of the ship, engine, type of cargo it carries, the crew and their skills and knowledge, operational environment like route, sailing area, the regulatory framework, organizational factors, economical situation of the market, cultural and political factors etc. The number of elements that the system consists of and the nature of interaction between these elements define how complex the system is. A complex system functions in a nonlinear, dynamic way, which makes predicting the outcome of functioning unpredictable to different degree, depending on the system. (Ibid)

Technology is playing an integral part of our today's society and that is no different in shipping. Automation and technological solutions in navigation, machinery, ballast and other ship operations is increasing at a rapid pace and unmanned ships are already being design to sail in the future (for further details see e.g. MUNIN). Still, no matter how automated a system is, humans are still a part of the functionality. All technological systems are seen in a socio-technical context, because these systems are designed by people for a purpose, hence to people for an intended use and user. They are built, tested and maintained by people as are their risk assessments, training and manuals done by people. So the human element is present in the technological system in one way or another. (Hollnagel & Woods, 2005, 4)

New technological solutions are usually introduced to for example reduce production cost (e.g. in shipping using automation to cut down crew size), improve product quality and safety (to eliminate human error due to fatigue and lack of vigilance), increased speed and efficiency in production (faster ship unloading/loading and minimizing time in ports), maintenance (remote supervision and maintenance from remote land-based operators) etc. But introducing new technological solutions, in spite of the business benefits does sometimes come with a cost. According to Hollnagel & Woods (2005, 4) as technology is put to use, the benefits of it are not always certain. The benefits in one area can simply result problems in another and leading the general system functionality towards further complexity. Hence, the inescapable side effect of improved efficiency or versatility is further system complexity, possible growing task and performance demands and unpredictability to some extent.

Nicolis and Nicolis (2012, 4) state that nonlinearity is a necessary part of complexity meaning that different couplings within the system are not necessarily tractable. The fast pace of new technological innovations and solutions as well as their couplings and replacements in the old systems result in new unknowns emerging from our systems. Due to this there can be reduced ability to learn from past accidents as the possible paths to failure might not be valid anymore nor are they as predictable as before. The rapid development of new technologies might also be shortening the time for testing, design and in general reduce learning and understanding of the systems behavior as a whole. Hence, leaving also gaps in complete understanding of all possible risks and weaknesses of the system. (Levenson, 2012, 3-6)

The complexity in our human-machine interfaces also introduce new human errors like mode confusion and over-reliance on automation. Inadequate communication between humans and machines introduces new types of errors. It is becoming increasingly important factor in accidents and current approaches to safety engineering. (Levenson, 2012, 4) Skitka et al. (1999, 992) points out similar issues stating that even the objective of introducing automation is to reduce human error, remarkably few studies have been made whether or not this is a fact. Skitka continues also, that there has been some evidence suggesting that the introduction of automated decision aids does not unilaterally lead to reduction in human error. It just introduces different types of errors.

Department of Transportation Office of Inspector General (OIG) of United States of America issued a report stating similar concerns about over-reliance on automation of aircraft pilots, where several accidents have shown that pilot relying too much on automation can make errors when confronted with an unexpected event or when switching over to manual mode of flying. They also questioned whether pilots receive enough training and experience to maintain their skills in manual flying. (OIG, 2016, 1) Therefore, this also indicates another possible safety paradox, where increasing automation in the cockpit to improve safety has actually resulted in the decreasing ability of the pilots to actually fly a plane.

It is clear that automation enhances safety in general as stated also in the above mentioned report, but does not necessarily eliminate errors. It can create new types of errors. This does not undermine the importance of automation as means to develop better safety, but points out from a systemic point of view that the dynamic nature of complex system makes safety improvement a living, dynamic and continuous process. When improving safety in one area eliminates certain types of errors, new ones can emerge in another part of the system. These complex systems change with new technological innovations and solutions, training and skills of people, new legislation, operational environment etc. Complex systems are dynamically stable where instability emerges from simultaneously occurring functions and events in time and not only from an interconnection of components. (Hummerdal, Dahlström & Dekker, 2007, 22)

Therefore the same way the whole system of a ship can change when making changes in one area of the system. There are new rules and legislations introduced resulting in new processes and technological solutions to be added to existing structures and functions. Members of the crew change along with the cultural aspects, language and social relations. Varying weather conditions, routes and sailing areas change, and so does the possible economical pressure towards production efficiency according to market situations, profitability needs of the company and so on. With these dynamical changes, so does the possible paths to failure. Hence, efforts to create safety is an ongoing process that requires constant monitoring, management, adjustment and adaptation. Safety is an emergent property of the system which is continuously created again and again. And hence, failure also has the same emergent property of the same system. This way the path to success and failure has the same origin. Systemic perspective on safety sees that simply human error as the culprit of an accident is too simplistic. Human behavior cannot be separated from its context neither can focus be on one failing component. According to systemic thinking of safety, in order to improve safety, we have to dig deeper to understand the motivation of certain human behavior within the systemic context. (Levenson, 2012, 5; Hummerdal, Dahlström & Dekker, 2007, 37)

3 Changing safety thinking

The traditional safety thinking has been focusing on identifying all possible risks and creating safety guards against them thinking that when safety guards for known risks are in place, operations are considered safe. This way the objective is to reduce unpredictability in technological solutions as well as eliminate variability in human behavior by requiring that established processes and best work practices are followed. This kind of thinking is restricting the behavior of humans in such a way that it is impossible to behave unsafely. (Hummerdal, Dahlström & Dekker, 2007, 5)

Resilience and Safety-II thinking again is about giving room for well-trained and skilled employees to perform the job safely instead of making it impossible to complete the job unsafely (Hummerdal et al. 2007, 2). This kind of thinking originates from the fact that in complex socio-technical organizations focus should be on resilience due unpredictability and uncertainty. In complex, safety critical industries it is not possible to reduce uncertainty to such a level that all possible paths to failure are known. Hence, resilience is about enhancing the capacity of people to work successfully, adapt and respond to challenges that occur outside the described and designed processes. The objective in resilience is to enhance the adaptive capacity of people and enable them to cope with uncertainty and vary their performance according to situational needs to get the job done. Resilience is the capacity of handling and recovering from events which are emergent, unanticipated and surprising. (Hummerdal et. Al, 2007, 2 – 5)

As an example from the maritime world, according to the ICS (2013, 5) when analyzing serious accidents in shipping, it has been shown that the personnel involved are usually highly trained, competent and experienced, and the underlying cause of the accident *was a failure to follow established procedures*. To counter balance this statement, Seahorse Project is a consortium focusing on achieving safety enhancements in transport by achieving human orientated resilient shipping environment. They are focusing on human factors in shipping safety and had their kick-off meeting in November 2013. (for further details, see www.seahorseproject.eu) In one of their workshops in Rotterdam, October 2015, Kurt et al. (2015, 14-17) presented research results regarding seafarers workarounds (Workaround defined as a changes to the procedures and equipment by the crew due to practical or other reasons). They sent questionnaires to 451 SEAHORSE Project partners crew and after data cleaning listed 110 workarounds. In their questioners measuring attitude, the question: “related procedures required to be followed on ships are factually incorrect” got the answer “Often” 48% and “Sometimes” 24%. Same with the question: “Some procedures that crew need to follow as part of their job tasks make the job less efficient” received answers of “Often” 11%, “Sometimes” 35%, “Rarely” 20% and “Never” 4%. And the question: “In shipping companies, it is common that procedures are not always followed” got the answers “Often” 33%, “Sometimes” 37% and “Never” and “Always” both 5%.

In this light, the seafarers who participated in this research seem to adjust their performance for some reason or another to get the job done. Surely part of the above can be things like laziness to cut corners, but it also could indicate a gap between what is actually happening on a ship and what has been written in the procedures. Hence, it raises the question that how much do the seafarers globally use workarounds in shipping in order to get the job done due to deficiencies and shortages in the written work processes and “best practices”?

3.1 Work-as-done and work-as-imagined

Hollnagel (2014, 40 – 59) writes about the sharp end and the blunt end when looking at a work place regardless whether it is a hospital, supermarket or a government agency or in this thesis, a ship. Here the sharp end is the implementation level referring to the situation where the actual work is being carried out by people. Blunt end again are the ones, who do not directly participate in what is done by the sharp end, but still influence the people by e.g. management allocating resources and/or writing procedures, designer of used systems, policy makers and regulatory parties etc. The implementation of the actual work is done by the sharp end, called the ‘work-as-done’ and the blunt end mostly focus on how work should be done, called the ‘work-as-imagined”. The blunt end is giving some general assumptions how the work should be carried out, what working conditions should be like and basically looking at the implementation of work from the outside and from a distance.

In the traditional way of thinking about human element and human error, humans are seen as a component of a system equal to machines, which are meant to work in a certain, predesigned way called the work-as-imagined. As machines, humans either work as stated in the work-as-imagined or fail to follow procedures. Now, usually the people who actually do the work (work-as-done) are different from those who write the work procedures (work-as-imagined). The more complex the operational environment is, the harder it will be to describe these work procedures and anticipate all possible conditions that might exist. Therefore, most likely people who actually do the work face situations where work cannot be carried out like work-as-imagined. And, when variation is between the work procedures and reality, if things go wrong, it is easily assumed that the reason for accidents is because work procedures were not followed. (Hollnagel, 2014, 44-46) Like Hollnagel says (2014, 44): “*This is due to ex post facto reasoning, which says that if only person X had done Y´ instead of Y, then the outcome would have been different.*” This way of thinking does not exclude creating best practices and writing work procedures, but questions the fact it suits perfectly for all environments, especially the complex ones. Hence, it can be argued that safety cannot only be improved by solely following procedures.

3.2 The driving forces of complexity

Our systems are becoming more and more complex, hence more difficult to describe and intellectually manage (Levenson, 2011, 4-6; Hollnagel & Woods, 2005, Chapter 1). The driving forces for this complexity (Levenson, 2011, 4-6; Hollnagel & Woods, 2005, Chapter 1) are the fast pace of technological change, digitalization and computerization resulting in growing complexity of socio-technical systems changing the way we work and creating new fields of activity. Along with automation humans are increasingly sharing control with automation and/or moving to higher positions of decision making leaving the automation to implement the decisions. Increased complexity in couplings between different systems and the fast pace of technological change reduces the time of the users learning curve and increases the complexity of tasks and performance demands. These changes also introduced new paths to failure and new types of hazards. As the technological improvements are often driven by the need for further business gains like efficiency and profitability, the new technological solutions also have decreased the tolerance towards single accidents due to the scale of our systems and the impact of their failure to harm increasing number of people or economical loss.

As an example from shipping in the growing of size of vessels are one of the world's biggest cruise ship, Harmony of the Seas, that can carry nearly 6 000 passengers and 2 000 crew members or one of the world's largest cargo ships Emma Maersk that carry 12 000 containers, cargo that is worth half a billion dollars.

At the same time as companies are dealing with the increasing potential losses of one single accident they are coping with an aggressive and competitive environment where cost and productivity play an important role in decision making. This is resulting in the difficulty of selecting priorities between trade-offs that Hollnagel (2009) is describing as the Efficiency-Thoroughness Trade-Off, the ETTO –principle.

3.3 The ETTO –principle

Hollnagel (2009, 19) defines ETTO –principle at its simplest as follows: "*If demand for productivity or performance are high, thoroughness is reduced until the productivity goals are met. If demands for safety are high, efficiency is reduced until the safety goals are met.*" People make these decisions often, but the question is how to balance between being efficient and being thorough?

The definition of Efficiency is about resources and how much are used in order to achieve a goal. These resources can be time, money, materials, workload etc. with the objective to keep the amount of resources used as low as possible. The criteria which is the appropriate level of used resources can come from external demands or requirements or individually from habits, social norms or established practices. Thoroughness again is about making sure that the activity to be taken, and the prevailing conditions, are such that the achievement of the goal will be met without any unwanted side-effects. It is to ensure that the needed resources are in place e.g. enough time, tools at hand, needed money/funding ensured, manpower sufficient and the performance is monitored and controlled in order to verify that the outcome is as intended. (Hollnagel, 2009, 16). Sometimes these goals between thoroughness, as in safety, and efficiency, as in production efficiency, is seen as conflicting ones. These two conflicting goals are a primary concern for any organization. Then again, considering an organization being just one and not the other, i.e. being only thorough or only efficient, will not most likely be successful in the long run. Therefore, successfully balancing between safety and production efficiency is crucial for organizational success. In complex systems, there is no single solution how to balance successfully between safety and production efficiency. It is an integral part of continuous decision making. (Hummerdal et. Al, 2007, 4-6)

Connected to this problem is the gap between work-as-done and work-as-imagined. The workers at the sharp end often have to make trade-offs to meet both the safety goals and the production goals. As an example of this is to do something fast due to time pressure (being efficient), but at the same time safely according to procedures (being thorough). Therefore, if both goals cannot be met (e.g. due to time pressure in a safety-critical situation), the operator at the sharp end needs to make a balancing decision i.e. adapting to the prevailing conditions in order to successfully accomplish the work task. Therefore, in order for an organization to be resilient, the workers at the sharp-end, sometimes have to move away from being reliable (as in strictly following procedures) in order to be both efficient and safe. (Hummerdal et al. 2007, 4-6; Hollnagel, 2009, 27-30). Therefore, quoting Hummerdal et. Al, (2007, 4):

"*In advanced socio-technical organizations, with high competency demands on employees, safety leadership is more about providing the room to perform a job safely than about making it impossible to do the job unsafely. To assume that people will do things wrong if they are not told exactly how to do things, is not the point. The assumption should rather be that people will do things safely unless the conditions for this are unfavorable*."

One of the objectives of safety improvement is to close the gap between what is done in reality at the sharp end and what is imagined at the blunt end. It is also necessary to understand that some degree of variability, flexibility and adaptability is needed for the system to work. Performance adjustments and performance variability is needed to ensure successful operation of the system, thus constraining it will inevitably affect flexibility to react and adapt to situations, and therefore also constraining is affecting the ability to achieve desired targets. Constraining performance can be done in many ways e.g. strict training, rules, regulations, guidelines, supervision, standardization and other barriers of various kinds. Successful outcomes are the result of the ability of people to adjust their work to prevailing conditions and to react also to what others do. These adjustments are becoming more and more important as the system grows more complex. (Hollnagel & Leonhardt, 2013, 14)

The need for adaptability, flexibility and variability of performance does not exclude compliance to rules and regulations, but is more about giving room to react to emerging situations which fall outside the written procedures. As Kotter (2001, 103-104) points out that management i.e. rules and procedures, best practices and compliance is about control, order and consistency which is preventing the organization from becoming chaotic and disoriented in such a way that would threaten its existence. In the same way legislation protects humans, property and the environment in shipping as does established best practices enhance safety e.g. regarding crew living conditions, safety rounds, entering closed spaces or eliminating oil spills in the sea by ships. Shipping needs international rules, regulation and control. But, in order to cope with uncertainty, a certain level of flexibility is needed to correctly respond to sudden, unexpected ad hoc situations (Grote, 2015, 72-73; Knudsen, 2009, 302).

3.4 The element of uncertainty

Complex systems are not linear cause-effect systems, therefore cannot be taken apart into individual components to understand its functioning. Complex systems consist of both tractable and intractable, interweaved couplings where the safety and failure are more of an emergent nature. Due to this, we need to accept that there will be parts of its functionality which are both unknown and unpredictable in nature. (Uncertainty being basically ‘not knowing for sure’ what is going to happen, when and how, therefore decisions are made knowingly based on incomplete set of facts.) Therefore writing detailed work instructions about how work should be done will be difficult, if not impossible. (Hanén and Huhtinen 2013, 9-11; Hollnagel, 2014)

When all possible situations cannot be anticipated and the linear cause-effect relationships are no longer necessary valid, the challenge of increasing safety is related to the ability to cope with uncertainty (Hummerdal et al., 2007, 37). In complex systems it cannot be assumed that failure is resulting only from malfunctioning components, bad behavior or failure to follow procedures. Performance variability is not only normal and necessary, but also indispensable. Humans on every level of the organization in one point of another needs to adjust their ways of working to meet the needs of existing conditions regarding resources, requirements, tools at hand, manpower, time constraints etc. And because most of the time these resources are often limited also the adjustments are approximate rather than perfect. Usually these adjustments, regardless of the limitation of resources, enable the work to be completed successfully by humans. Therefore, the way work most of the time goes right and very rarely goes wrong originates from the same source. The need for performance variability. And that is why performance variability should not be interpreted negatively as ‘performance deviations’, ‘violations’ and ‘non-compliance’. (Hollnagel, 2014, 120-122)

In the traditional safety and risk management thinking, risk has been seen in decision making something that should be avoided, eliminated, reduced to acceptable level or transferred to external parties like for example insurance companies. And as “*Uncertainty is at the heart of risk*” (Grote, 2015, 71) so has the objective been the same for uncertainty. As the traditional approaches to safety has been focusing on reliability, focus has been to reduce unpredictability in technological functioning as well as in human behavior (Hummerdal et al., 2007, 5) Uncertainty is often perceived as a negative thing, but Grote (2015, 71-72) argues, that safety can be promoted by increasing uncertainty. Reason (2000, 3-4) argues also, that the line, the “edge” between the relative safety and unacceptable danger is the zone of greatest peril and greatest profit. It is as in ETTO –principle, the skill to balance between safety and profit.

3.5 The reasoning behind Safety-II

Safety-II is the ability to succeed under expected and unexpected conditions. The principles of Safety-II are based on resilience engineering, where resilience has been defined as: “*The intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions.*” (Leonhardt et al., 2009, 2; Hollnagel, 2014, 134)

Traditional way of safety thinking, predicting risks and their probabilities are still valid to some extent depending on the complexity of the system. Some accidents and incidents do happen due to linear cause-effect model, but some do not. In complex systems, accidents can happen without a component failing, without mistakes or human error, with operations according to design and well maintained. These disruptions are emergent. Emergent outcomes arise from unexpected and unintended combination of performance. The emergent outcome just existed in one point of time and left without any trace. Therefore, the outcomes cannot be traced back to specific component or function neither are they necessarily proportional to the input i.e. the output is not proportional to the input e.g. the butterfly effect. (Hollnagel, 2014, 132)

Hollnagel et al. (2013, 6) discuss the difference in focusing on things that go right and things that go wrong as an example between the difference between Safety-I and Safety-II thinking. Safety –I thinking is based on the absence of unwanted outcomes like incidents and accidents defining safety as: "*The state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management*."

The development has been in general focusing on accidents and incidents, finding the root cause and building safety guards against them in order to ensure they do not happen again. The other one has been to identify risks, making risk assessments, predicting risk probabilities and their impacts in order to avoid, reduce, retain or transfer risks and uncertainties by building different barriers. According to Safety-I things go wrong usually due to technical failures or malfunctions, human error or misbehavior and/or due to different organizational factors. The purpose of accident investigation is to find the root cause and contributory factors, while the risk assessments aim to predict the likelihood and impact of risk. As an example, is to consider a task that is performed 10 000 times. This performance usually goes right 9 999 times, but fails one time. The focus on finding why this happened is on the one very rare occasion. This one occasion is investigated, the work performance is assessed and reviewed and finally as root cause is found for the accidents, safety barriers and possibly new regulations and guidelines are put in place. But this analysis of that one time does not tell us why the 9 999 times have been a success. Therefore, in order to improve safety, we need to focus on both sides of story. We need to understand both why things succeed and why they fail. (Hollnagel et al., 2013, 6)

4 Research Design

This chapter describes the design of this study, data collection process and logic of understanding to analyze this collected data. This study and the outcome is not built as a linear process, but more like a continuous spiral, that starts from a preliminary idea or an opinion of the subject and starts to evolve towards deeper understanding of the whole with literature research and reflections into the maritime world. These reflections have been articles with the aim to understand deeper a particular subject, a real life issue of the maritime world like e.g Arctic shipping or a chemical accident in a ship.

One motif runs through all of the papers, the seafarer and the role of human element in shipping with the elements of complexity and uncertainty present. The end result of this study has been constructed from different parts of the articles presenting not the absolute truth but an interpretation of the studied literature and experience, both to understand theories and reflect them into maritime examples. Examples of real life has been used to illustrate the research questions and to bind the theories from literature into shipping on a practical level.

To make a synthesis of it all and to bind these articles into the whole, abductive reasoning has been used as the logic of understanding. The reason to base the research mainly on literature review, theories and hypothesis that are reflected to the maritime world via examples. As the subject is about understanding a phenomena of safety, interviews and questioners was not seen as a way to uncover the essence of safety, where it originates from and how it is created. The same was to understand complexity. These are quite abstract concepts, which can be understood in many different ways by people. In order to study a phenomena of complexity and safety, literature review and analysis simply seemed to be the best option to gain deeper understanding.

The logic to interpret the collected material has been abductive reasoning. Abductive reasoning studies the given data and comes to a hypothesis about the given facts. Abductive reasoning is also called “best explanation” (Walton, 2005, xiii). The process starts with a basic idea or understanding of the subject, but this can change along the way. It can be abstract or even intuitive thought that guides the work. Collecting material can be loosely connected, even though logical, in the beginning. Notes can be separate occasions, still connected to the guiding thought and at some point things start to intertwine together. (Virtuaali Ammattikorkeakoulu)

4.1 The process of understanding – the methodology

The process of understanding started of with the basic idea and a research question of the subject. In the beginning it was simply: “How can we lead and manage safety if we do not know the risks?”. The theory base for the starting point was Erik Hollnagel’s Safety-II thinking (Hollnagel, 2014). Hollnagel (2014) argue a hypothesis, that the ability of humans to adapt and adjust their performance to occurring needs is vital to ensure safety and operational success. There are no perfect systems nor is there rarely situations, when people need to accomplish their work tasks, they would have all needed resources available. Often resources like time, tools, information, manpower etc. are incomplete and human compensate to these shortages by adapting to the situation and use resources available to get the job done. This idea was reflected in the first article into Arctic Shipping to gain deeper understanding of the role of human element in an complex, high risk environment.

4.2 Data collection

Data collection has been mainly literature forming the theoretical base line which are reflected to real life subjects like Arctic Shipping and seamanship. The literature search started with Erik Hollnagel, his books and articles about the principles of Safety-II and Resilience Engineering. Scientifical databases were searched with words like Maritime Safety, Human Element, Maritime and complexity, unpredictability, safety and leadership. Some of the included articles were as references in another article used and guided forward to research a particular subject. The articles also included words specific to their topic like Arctic shipping and safety, Arctic shipping and human element, risk assessments and unpredictability, seamanship and dynamic risk assessments. To bind the theories to practical examples of real life, different maritime reports were used and maritime related books like books about seamanship, ice navigation or Polar Code.

Literature type	
Peer reviewed scientific articles	32
Maritime Journals and White Papers	10
Books	19
Dissertions	2
Others e.g. IMO web -pages	18

Table 1. Total data collection

4.3 The articles

The first article was a literature review and a conference paper. It studied the Arctic shipping in the light of Safety-II principles and as such, was the beginning of this research process. The literature review consisted of peer reviewed scientific articles, books, maritime journals and white papers and official web –pages like IMO.

Literature type	Amount
Peer reviewed scientific articles	12
Maritime Journals and White Papers	4
Books	5
Others e.g. IMO web -pages	4

Table 2. Literature used for the article 1.

The second article was again part of WINMOS II project, that studies the tacit knowledge of professional ice breakers with the objective to preserve the high level of skills and knowledge of Finnish and Swedish Ice Breaking profession. In the near future a big amount of professional ice breakers will retire and the risk is that a lot of valuable knowhow will be lost (WINMOS). This article is also leaning on the Hollnagel's (2014) Safety-II principles reflecting the idea that we cannot only develop safety through hindsight or predictions of the future, but more to study and understand why things go right as well as why things go wrong. Therefore, this article reflects these safety development principles into understanding tacit knowledge as professionalism which is to understand how things go right. The article was done as a literature review. It formed also theoretical background for further research within the project.

Literature type	Amount
Peer reviewed scientific articles	12
Maritime Journals and White Papers	4
Books	6
Others e.g. IMO web -pages	4

Table 3. Literature used for the article 2.

The third article is an essay discussing risk assessment as a way to improve safety and introduces a method called Dynamic Risk Assessment. The systematic methods and tools to address and support decision making in a dynamic, safety critical situation are limited in the maritime world. During the writing of this thesis and working with the maritime project, especially ChemSAR (ChemSAR) dealing with chemical accidents at sea, one comes across often with instructions to assess the risks in a particular situation. But, what actually is lacking, is the *How* to assess the risks in a dynamic situation. The essay discusses the need for new tools and methods for safety development in a unpredictable and dynamic situation. It brings together the results and argues for the tactical aspect of maritime safety highlighting the need for new methods and tools to ensure safety.

Literature type	Amount
Peer reviewed scientific articles	12
Books	7
Others web –pages, white papers, reports	4

Table 4. Literature used for article 3.

5 Results from the articles

This chapter will discuss the research results from different articles where the above mentioned issues are reflected into shipping. The main idea in them all is complexity, uncertainty and unpredictability and how to cope with these elements present. The first article is about Arctic shipping, the second about Seamanship as a source of resilience and the third about risk management in an emergent situation.

5.1 Arctic Maritime Safety – The Human Element seen from the Captain's Table

The global climate change has opened up new routes in the Arctic. The attractiveness of the new routes derives from economical gain by cutting down the distance between the Pacific and Atlantic oceans. But, navigating in the Arctic is not without risks. The extreme climate of low temperatures, sudden storms and icy conditions as well as shortages in the navigational aids pose challenges for the Arctic making it a complex and high-risk area to navigate. One simple mistake can escalate fast into a safety-critical problem and help is possibly very far away.

At the same time, as the Arctic routes are new, there is not much experience of navigating these areas amongst global mariners, therefore navigating in the Arctic will include uncertainties to different levels. The International Maritime Organization (IMO) recognizes the need for further training for seafarers and therefore requires that all ships operating in the polar ice-covered waters should carry at least one Ice Navigator. (IMO 2010) However, this paper argues, that more is needed than just theoretical knowhow and compliance to the Polar Code.

For safe, sustainable and profitable shipping in the Arctic, the attention needs to be paid to human resources, because with the uncertainties present, the crew will most likely end up facing emergent ad hoc situations, that fall beyond the written procedures and face risks which could not be anticipated. The high performance of the ship is the high performance of its crew, and the whole crew as one, not the action of separate individuals. This will highlight the team unity and collective performance as a critical success factor. Working for the team unity, their trust in each other and empowerment towards constant improvement will enhance team performance. The crew needs also to believe, that what they do and say matters and is valued, therefore psychological safety to promote speaking up and appropriate communication within the team is essential. This puts the Captain of the ship, as a leader of the crew, in a key position. The hard and soft skills of the Captain, the abilities to lead, motivate, inspire and empower the crew are vital for safe and sustainable shipping in the Arctic.

High performing crew needs a level of flexibility to cope with uncertainties and occurring ad hoc situations. Flexible rules are a strategic safety and risk management question of the shipping company, but also a question for the legislative authorities. It is also about training, because once the crew is put in a position with flexible regulatory framework, it should be ensured that the persons are capable of taking advantage of the flexibility and not get disoriented or misuse the given freedom. And as the crew, their skills and knowledge develop and accumulates within the shipping company, the management should ensure that these skills stay with within the ship and the company. This will enable the ship to develop as an organization, learn from experience and constantly improve its performance towards safer Arctic shipping. This will be a question of leadership and management, because the execution of safety measures lie within the seafarers and Captains working at sea. It is about the people living and working in the ship, facing sea originates risks on daily bases, using their skills and knowledge to adapt to situational need, compensating for shortages in resources to get the job done and in the end fight for their survival in case of an accident.

5.1.1. Discussions

Shipping in the Arctic represents quite well the ideas of Safety-II by Hollnagel (2014), because the passageways are new, which means that there is not much experience amongst seafarers about navigation in the area. There are shipping companies who successfully sail in the Arctic area (for further see e.g. Fednav, Arctic Oy, Hurtigruten), but if the Arctic routes open up in such a way, that the Arctic routes are attracting to many shipping companies, the is a high risk that unexperienced seafarers will be navigating the high risk areas of the Arctic. This will mean, that these unexperienced seafarers are subject to uncertainty and unpredictability. They will not know exactly what lays ahead, even they have studied it according to the Polar Code course. Therefore, it will come down to the abilities of these seafarers to respond to emerging situations as they appear. Not all will be safety critical, but surely some will. High-risk areas with harsh weather conditions like the Arctic does not give a lot of room for mistakes. Therefore, what ever is being done, should be done right the first time. There will not be much room for trial and error or experimenting.

This indicates that safety has two dimensions, strategic and tactical dimension. Strategical dimension is about the strategical safety framework done before entering the Arctic shipping passages. This strategical framework can also be called the Safety Management System, that is nothing new in the Maritime domain. It is about strategical decisions made on the company management level, complying to international and national legislations, ship construction decisions, decisions about recruiting and training, risk assessments done before entering the Arctic passages etc. It is about creating a safety framework for the ship and its crew to enter the Arctic. But, when the ship and its crew are in the Arctic and something happens, it will become a question of tactical decision making on the spot. This is the dimension of tactical safety. It is about navigating the way between icebergs, at which point to reduce or increase speed in ice, how to respond to engine failures or to failure of navigational instruments etc.

These decisions can be addressed in beforehand on theoretical basis, but the true decision making will be done as the situation occurs. In order to improve safety, both of the dimensions have to be addressed appropriately. The emphasis has been on strategical safety, such as increasing legislations, increasing external monitoring (e.g. Vessel Traffic Cervices), increasing automation to reduce human error etc. This thesis argues, that the tactical dimension is at least as essential as the strategical dimension and will even be highlighted with the increased complexity, unpredictability and uncertainty. This is because at some point it might be, that the rules do not apply, best practices fall short and the seafarer is in an ad hoc situation required to make a decision about a situation where s/he has never been in before. The time is running out fast and risks are high. A decision has to be made whether to follow written procedures or does the situation require the decision maker to ignore them and innovate something new. This is a skill that training should focus on. How do we teach seafarers to make a correct decision about when to follow rules and when to discard them?

Hanén and Huhtinen (2011, 13) state that due to the interweaved interconnections within our systems, our reality is situationally bound. This makes safety bound also to the decisions made and actions taken in each situation in a certain space and time. Safety needs to be weaved into our actions, decisions and thinking, because safety dynamically recreates itself in the everyday work at the sharp end that is enabled and controlled by the overall strategical safety framework done by the blunt end.

To describe in beforehand, when to comply to rules, when to bend them and when to ignore them, is not necessarily an easy task. Neither is teaching adaptability, innovative problem solving and tactical decision making under high pressure or coming up with new ways to gain experience without actually gaining it in real life through working. Safety-II thinking and to cope with complexity and uncertainty will also raise questions about whether there should be some new, innovative ways to teach and learn skills needed to cope with situations that can not be predicted. This could be an area for further research in order to improve safety of shipping.

5.2 Seamanship as a source of resilience

The previous article expressed the need for more flexible rulemaking in relation to complexity and unpredictability and highlights the fact that it is important to ensure also, that the people who are required to work within more flexible legislative framework also know how to take advantage of it to ensure successful completion of work tasks. This paper takes a deeper look into this more flexible area by addressing the issue of how to ensure that when compliance does not give direction to decision making, how to ensure that the decisions made are correct ones.

Seamanship is a common expression, but it does not have any universal, specific definition. It is like the expression “good manners”. Most likely most of us will know, what are good and bad manners, but to really specify them is much harder. In general, seamanship is about being able to maneuver the ship and take care of it. It is the crew’s professional and practical skills which are needed to get the job done well at sea. (Borg and Åkerblom 2012, 4-5) Knudsen (2009, 295) defines seamanship as a: “blend of professional knowledge, professional pride, and experience-based common sense.” The definition of good seamanship is much more than just practical skills or what can be learned at school. It is about experience gained by working at sea, abilities to work independently and safely according to ones own judgement, intuition and adaptation to situational needs. Good seamanship also covers the shortages in legislation like COLREGS, which do not contain answers to all possible encounters (Suppiah, 2007, 19). Hence, good seamanship does include the compliance to legislation, but also, within fact based good reasoning, deviation from rules are accepted when referring to Good Seamanship (Ibid, iv-v).

Hollnagel et al. (2013, 6) give the example of a work task which is accomplished 10 000 times. 9 999 times this work task will be a success, but for one time it fails. All the effort will be put on the one failure leaving the 9 999 times uninvestigated. This resulting in the increase of knowledge about what went wrong, but leaves a big gap in understanding about what actually makes the accomplishment of the work task a success. Hindsight of past accidents and their causes tell only what went wrong, but does not tell where safety originates from or why accomplishing a work task most of the time succeeds. Therefore, in order for us to truly understand where safety originates from, we should concentrate also to understand these 9 999 times of success.

Hummerdal et al. (2007 2-5; 12-13) also state by providing employees a framework that allows them to do their work safely is much more efficient than constraining behavior to ensure that employees do not do their work unsafely. People usually do their job well and safely when given the room and opportunity. As safety is a dynamic and emergent property of our systems and is constantly created again, success depends on flexible, adaptive, empowered and proactive people actively anticipating different paths to failure and adapting to emerging situational needs to get the job done (Hollnagel, 2014, 119). In complex and safety critical problems however, expertise and experience is highlighted. As safety and risk management is fundamentally about decision making, often with the element of uncertainty present, expertise enables to make sense of, and develop solutions quickly by recognizing key information in a certain situation. (Mauelshagen et al., 2013, 1187)

Some studies show, that there is a lack of respect towards seamanship of professional, experienced seafarers. They however, are a valuable asset to companies especially from the resilience and Safety-II point of view. The more complex and dynamic the situation, the more will the safety be dependent on professional seafarers and their expertise. In order for a company to fully utilize the expertise of their employees, they should firstly express respect by decentralizing decision making to enhance communication and closing the gap between reality and assumed reality. Secondly, for an organization to actually understand where success and safety originates from, they should concentrate on studying why things go right instead of concentrating only why things go wrong. To understand success, one have to study success. But, success is often hidden in the minds of the experts as tacit knowledge. Therefore, using the definition of Knudsen (2009, 295) about seamanship being about professionalism of seafarers and the fact from studies, that professional seafarers do use workarounds i.e. adapt and adjust their performance to get the job done, which usually is a success. Hence, they are the source of resilience.

5.2.1 Discussion

This paper showed too that there is a lack of respect towards professional seafarers and their seamanship or at least it is perceived that way. Seafarers do deviate from rules and regulations, which shows a gap between the work-as-done and work-as-imagined, but to really understand the reason why, further studies should be conducted. Statistics still show, that the accomplishment of their tasks is usually a success. At the same time, complexity creates uncertainties that are difficult to address from risk management point of view. We cannot anticipate all possible paths to failure and hence, we will not be able to create safety guards against them in a way that we can ensure safety. Resilience is the ability to cope with uncertainty, to regain balance if balance is lost, create innovative solutions to sudden failures and ensure that the operation of a ship continue regardless of some disturbances. Within flexible rules, Good Seamanship is a code, a set of core values that guides the professional seafarers even though it cannot be specified in detail. Good Seamanship can be used, when written rules do not cover every possible situation and still ensure, that the decision within flexible framework are done according to the greater good.

Disrespect towards professional seafarers and their seamanship deteriorates their respect towards their own work and motivation. If they feel that their experience and work input is not valued, it could affect safety in a negative way. If they need to find workarounds to compensate for shortages in processes and resources to get the work done, and still do it successfully, they are a source for safety development. It might be, that the professional seafarers really do know how to make the work better, faster and safer only no-one has really taken the time to ask them about it.

5.3 Dynamic Aspect of Maritime Safety

This paper discusses a risk assessment method called the Dynamic Risk Assessment. It was developed by UK Fire Service as a result of several firefighter fatalities. It is a mental method to assess risk in a dynamic environment, where the operational environment is dynamic, rather than the actual risk itself. Traditional predictive risk assessments are too time consuming for a dynamic situation and due to complexity, they might not cover all possible situations. Therefore, the DRA is a method to support decision making in an environment that is fast paced and changing. It is about assessing the situation when the written procedures and best practices might not be applicable, and performance adjustments are needed to ensure safety in a dynamic situation.

The main findings of this paper was that the tactical (when the situations is already at hand) aspect of risk assessment is not really addressed in the maritime world. Risk assessments are generally predictive, done in before hand on a strategical or operational level but fail to address the need for systematic risk assessment in ad hoc situation on the tactical level. There is a need for further research to understand tactical safety and what kind of methods and tools could support decision making in a dynamic situation. Compliance to rules and best practices is emphasized in the maritime world, but the resent study indicates that in order to cope with uncertainties, this might not be enough. In order to enhance safety, the people need to know how to operate within flexibility and make decisions, which are in line with core safety values of the company and the whole operational system.

5.3.1 Discussion

To ensure safety correct decisions at a certain time and space are required, but there might be more solutions to a problem and paths to ensure safety than just one. Sometimes what is described as a failure to follow procedures might just be a necessary “work-a-round” to make the job more safely in a unforeseen situation as pointed out by Okoli et al. (2016). Several authors () also pointed out that uncertainties need to be included in risk assessments. If these uncertainties need flexible rules, decentralized decision making and performance adjustments, then there might be a need to address these issues in training and educational sectors. This will most likely have an effect also on leadership, because in the area of uncertainty safety needs to be lead and managed in other ways than compliance to rules. Whether or not current maritime education sufficiently addresses these issues needs more research.

5.4 Suggestions for developing maritime safety

This section draws together the research results into suggestions for safety development for shipping companies.

Also the appendix 1 and 2 are real life cases in ongoing projects and research. WINMOS II project has the aim of studying the tacit knowledge of experienced icebreaker officers to preserve valuable knowhow and skills in the profession, which can be related to the point 2 below. Understanding where success originates from is as essential as understanding incidents and near misses. One way to do this is to study skilled employees performing daily tasks. The other is ChemSAR project, where workshops to enhance and train decision making and test operational procedures have been done by decision games. In a chemical accident, it is most likely certain, that available information will be limited as will time be. Still decisions need to be made and actions started. The same is in the Arctic. Complex and high risk environment, harsh weather conditions and unpredictability will call for rapid decision making with limited amount of resources. Even though we can not predict all risks, we can train to make decisions and take action with the resources that are available.

1) **Closing the gap between work-as-imagined and work-as-done** to understand how the work actually is done in real life context. This also relates to workarounds. If employees need work-arounds to get the job done due to for example shortages in resources or inaccuracies in work procedures, reasoning behind their decision making should be understood which can point towards safety development areas. This will ensure also that both the shore based personnel and crew onboard have the same view about work performance.

2) Hollnagel (2014) and Safety-II thinking emphasises also that it is **important to understand why things go right as well as wrong**. Maritime domain focus a lot on studying past accidents, incidents and near-misses, which naturally is important for safety improvment, but understanding failures does not give sufficient answer to where safety originates from. If the company does not have an understanding also where safety and success originates from, this could be an area for further safety development. Collective learning of employees and their expertise are often hidden as tacit knowledge in the minds of the professional seafarers. If a vessel sails in complex navigational areas, keeps its timetable and/or successfully transports goods from year to hear, it might be that there is hidden knowledge which could be shared within the whole shipping company.

   For example WINMOS II is an ongoing project which studies the tacit knowledge of icebreaker officers. This knowledge has been gained through experience and working at sea in ice condition for years and is quite difficult to pinpoint or write down into educational material for the next generation icebreaker officers. By using simulators with ice scenarios, interviews and observations in real life context it has been possible to gain understanding of the decision making of ice breakers in action, the way they ”read” ice conditions and make judgement calls about favourable route in ice. Ice navigation in general can be seen as a competitive advantage of shipping companies, but if this intangible asset of knowledge stays on in the mind of individuals, it can be lost as the persons leave.

3) A captain of a vessel can be seen as a leader of his/her crew and is a key person in safety development. Whenever there is a need for development, new ways of working are sought and old ones left behind, it is question of change. Things like empowerment and motivation of the crew towards continuous safety development calls for **leadership skills** as does for example ensuring psychological safety to support spea-

king up and efficient communication and team work within the whole crew of a vessel. Even the captain can be seen as a key persons in safety development, literature and research in the area of maritime safety leadership is quite limited (Theotokas et al. 2014). This could be an issue addressed both to the maritime academies as well as shipping companies jointly to develop already existing training to face future needs, create new leadership training to ensure that the intangible assets through which the shipping company and the vessel gains its competitive advantage stays within the company and the vessel.

To lead people also in an area of flexible rule making and culture of self-regulation might need a different kind of approach than the traditional leadership to ensure compliance to rules and regulations. If the seafarer is expected to question superior officer decision making or question the ways of working, the climate of a vessel needs to support this kind of action. A vessel is traditionally quite hierarchical, which has its reasoning, but self-regulative crew that constantly seeks for improvement and thinks about safety might present new challenges for leadership. And research in this area is still quite limited.

4) Research has shown that seafarers feel their **seamanship** is not valued (Antonsen 2009, 123; Knudsen 2009, 297; Lappalainen 2016, 89). This seamanship however can be seen as a core value of seafaring which can positively influence safety and direct action in the area of unpredictability that requires some level of flexibility in rule making. A company should create such an environment, where good seamanship is valued and nurtured. In order to know how the seafarers perceive the importance of good seamanship in their vessel, some research could be done to understand the current situation and find out possible development areas.

6 Conclusion

Due to the fact that the environment we operate in in today's world is getting more complex, it has been found that traditional means of safety management and risk assessments are not sufficient anymore to ensure safety. This research has pointed out that safety is bound to a particular situation, which can change from one moment to the next especially in complex systems. Even though one situation might be similar to another, the available resources like time, skills and knowledge of people, information at hand, location, time of day, technological solutions etc. can all vary from one moment to the next. Performance adjustments are needed and this requires flexibility and resilience in the operational environment. Safety is created again and again as the situation evolves from one moment to the next. Also, the operators and decision makers in a particular situation influence the nature of the event and paths of its evolvement as they make decisions and take action. Safety is dynamic, not static and it does not automatically exist, and therefore, requires constant striving towards creating and maintaining safety.

As Grote (2015) stated uncertainty being in the heart of risk and safety should be promoted by not only reducing, avoiding, maintaining and transferring risk and uncertainty, safety should be promoted by increasing uncertainty in order to pursue opportunity. These similar conclusions were made by Limnell et al. (2014) where pointing out that we highlight too much the threats and risks that the cyber space represents and forget the possibilities it provides us. Hence, ensuring safety and security is about balancing between threats and possibilities.

Hollnagel again introduces us to the ETTO –principles by discussing the trade-off's between efficiency and thoroughness. We make these decisions on a daily basis whether at work or at home. We choose to be fast instead of thorough, we take short-cuts to win time and experiment new ways of working to save resources. As situation change, so does the way people work. People learn to accomplish work tasks with conflicting rules as they can see what is essential and what is not, and regardless the fact that rules and procedures are not always followed, work is usually completed in a successful way. Therefore, Hollnagel argues that understanding how work is carried out on daily basis, is the source of understanding how something usually works and rarely fails.

Changing safety thinking is about seeing the glass half full instead of seeing it half empty. It is about seeing the human element as a source of innovative development and competitive advantage. Conflicting rules and emerging ad hoc situation push people to come up with new ways of working to get the job done making them a crucial part of successful operations due to their capacity to vary their performance. Therefore, this performance variability should not be constrained. Work processes in a complex environment cannot be described in detail, which means that some level of flexibility is needed for adjustments and performance variability. And as Hummerdal et al. stated, it is more about providing the room for people to complete job tasks safely than making it impossible for them to do the job unsafely. This way thinking is also a beginning to see, that safety and production efficiency are not that contradicting, but more of a question about balance where one cannot be successful without the other.

There is no such a thing than absolute safety, nor should there be. In order to learn and pursue opportunities, we need to step outside the comfort zone and face ad hoc situations. The uncertainty that we face contains both threats and opportunities. In order to tolerate the fact that not all will necessarily go as planned, we need resilience to ensure that when disturbances occur, operations and system functioning will carry on. Correct balancing between flexible rules and compliance to best practices are needed. This requires also that the people are able to work with flexible rules, face safely new emerging ad hoc situations and make decisions which are in line with overall company policies and principles, the core values and needed safety standards. This raises the questions about education and training and further research in the field of maritime safety, because as the times change, our safety thinking has to change with it.

PART II

The Articles

Arctic Maritime Safety – The Human Element seen from the Captain’s Table

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Sustainable Shipping in a Changing Arctic

Arctic Maritime Safety – The Human Element seen from the Captain's Table

Johanna Salokannel, Harri Ruoslahti, Juha Knuuttila

Abstract The maritime industry is safety critical, where the element of uncertainty is present especially when entering high-risk shipping areas like the Arctic. The element of uncertainty increases, as the working environment gets more unpredictable and systems more complex. Unpredictability and complexity is making it difficult to define comprehensively and in advance which exact courses of action one should take when facing challenging ad hoc situations while navigating the Arctic. The human element is a vital part of successful and safe shipping in the Arctic. Resent resilience engineering and safety studies see the human element and their ability to adapt and adjust their performance to situations and to inaccurate work descriptions as a key to successful operations. High performance of the crew strongly contributes to the high performance of the ship where the captain plays a key role. This chapter addresses the safety issues in a more holistic way including uncertainty and unpredictability as a part of safety management in the Arctic shipping.

Keywords Maritime Safety, human element, shipping, arctic shipping, safety management

Introduction

The global climate change and melting sea ice has opened, at least for part of the year, new routes for shipping in the Arctic. The attractiveness of the new routes is in cutting the distance between the Pacific and Atlantic oceans enabling ships to save a considerable amount of time between ports, but navigating in the Arctic is not without risk. As a business case that saves time and resources on every journey makes the route attractive. But risks, if realized, might end up being more costly in increasing insurance premiums, damage to the ship, environmental pollution and putting crews at risk reducing profitability. However, regardless of the risks, the Arctic routes are an opportunity and shipping in the Arctic will most likely increase in the future.

In the maritime accident investigation, human error has been counted to be the cause in around 80-90% cases. Crews are still needed to sail ships and deal with daily challenges in high risk areas making the human element of a great interest from a safety management point of view.

This chapter focuses on the human element in the Arctic, where not all risks can be predicted and requirements for safety are high. Detailed descriptions of which action to take in occurring ad hoc situations are difficult, if not impossible to make. This means also that safety needs to be ensured with other means than just compliance to rules and/or best working practices. The objective of this chapter is to study how to ensure safety of navigation in the Arctic in situations where the exact risks are not known or when faced with safety critical situations that require rapid reaction and responding to when there are no sufficient instructions or experience to rely on.

The Arctic shipping routes are still unfamiliar and even there is information available, there is not that much experience amongst seafarers, if the routes open up for greater traffic. With time there will be experience based learning and shared information and lessons learnt. Before this happens, the safety of Arctic shipping needs to be created with seafarers who most likely face unexpected and unpredictable situations. Compared to other high-risk areas like those with for example high traffic density or pirates, the exposure to the risks are usually much shorter compared to the Arctic where the journey can last around two weeks

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depending on the speed. Due to the remoteness of the area and lack of infrastructure, if something happens, help can be very far away.

1. Risks of Arctic Shipping

Working at sea, the seafarers are faced with various risk factors on a daily basis from harsh storms at sea to loading in ports. On the Arctic routes, risks are even higher. The extreme climate of the Arctic with its low temperatures, extraordinary light conditions and sudden storms as well as magnetic phenomena make the area quite distinctive. Navigating in the Arctic can pose challenges due to, for example magnetic compasses becoming unreliable at such high latitudes. GPS and GALILEO have reduced coverage, radio, satellite and communication signals are less reliable in such remote areas. Navigational charts and navigational information can be inaccurate and limited in number (Jensen 2007; Carpenter and Wyman 2014; Wright and Zimmerman 2015).

The International Maritime Organization (IMO), responsible for creating regulatory framework for international shipping industry, adopted the Polar Code (the International Code for Ships Operating in Polar Waters) in November 2014 and related amendments to the International Convention for the Safety of Life at Sea (SOLAS). This, however, does not solely ensure the safety of life, property and the environment while sailing in the Arctic. Restricted visibility due to fog and darkness, harsh weather, cold and violent storms still put serious demands on the crew. If a ship encounters difficulties, help, like Search and Rescue, repair and salvage services, can be very far away. In addition, if a crewmember is injured or becomes seriously ill, hospitalization poses challenges due to the remoteness of the Arctic routes.

As an example, the MV Clipper Adventurer cruise ship ran aground on 27th of August 2010 in the Coronation Gulf, Canada. Canadian Coast Guard dispatched on 28th the nearest icebreaker, Amundsen, to assist the ship that was 500 km away. The icebreaker was estimated to arrive at the scene at 09:00 next morning on 29th. Luckily, weather conditions were good, which made the ship stay safely stuck on a rock until help arrived. (Stewart and Dawson 2011)

Not so fortunate, T/S Maksim Gorkiy, sailing from Iceland to Spitsbergen, collided with ice floe in heavy fog close to midnight between 19th and 20th of June, 1989. She was damaged as the ice ripped holes the hull, one of 10 meter long and some smaller ones to the bow. The ship started to sink. The first distress call was sent shortly after the accident. Even though a Norwegian Coast Guard rescue vessel, Senja, arrived at the scene within a few hours at 4:15 am, around 1.000 people had to abandon ship into lifeboats near freezing temperatures while 120 crewmembers stayed onboard fighting to keep the ship afloat. (The New York Times; Marchenko 2015)

Floating ice poses also challenges for navigation. Small icebergs like growlers and bergy bits are difficult to detect with satellites and radar especially during rough weather as they are mainly submerged. Ice formation on deck and hatch covers can create problems for ship stability and deck equipment, which needs to be removed regularly. Entering an icy ship deck in darkness and harsh weather places the crewmembers at risk. Harsh conditions can also make the crew members more fatigue and affect daily work. Extreme cold can cause problems to the engine, fuel transfer and pumps needed for firefighting, which could freeze from excess water inside. Lacking or limited external facilities to repair breakdowns pose challenges and therefore many kinds of spare parts needs to be carried aboard. Whatever the situation or combination of the above mentioned and more, the crew is required to handle it. If help is far away, any small incident might escalate into bigger problems, therefore reaction time is of high importance. Any salvage operation in harsh, cold and dark weather will not be easy to complete. Therefore, having a qualified, well trained, and experienced crew becomes more important than ever. (Carpenter and Wyman 2014)

The Polar Code recognizes that in the safe operation of a ship in the Arctic waters attention needs to be paid to the human element regarding their skills and knowledge. Therefore, all ships operating in polar ice-covered waters should carry at least one Ice Navigator. IMO defines the Ice Navigator as: "*any individual who, in addition to being qualified under the STCW Convention, is specially trained and otherwise qualified to direct the movement of a ship in the ice-covered waters*" (IMO 2010)

2. The human element and human error

The safety management of shipping has been focusing on unwanted outcomes, by investigating past accidents and predicting future risks and their probabilities. Naturally, it is important to understand what has gone wrong, and what could go wrong in the future in order to create safety guards to prevent these from happening again, or to protect against their outcomes. However, the increase of automation and digitalization in our socio-technical systems has created processes and interconnections that are starting to be intractable making it both difficult to describe and predict all possible scenarios that might go wrong. (Hollnagel Pariés and Woods 2011) Considering for example a ship that has interconnections from automated doors to navigational instruments and possible engine room systems that are connected to a remote service. The equipment can be installed at different times and new software integrated to old one. The complexity of these systems is making it difficult to know exactly to which all areas and how one failure affects. The complexity is also making it harder to detect failures.

When future risks are not entirely known, the element of uncertainty will enter the picture and managing it becomes of interest. The new Arctic shipping routes represent a high-risk area with the element of uncertainty present, as all possible scenarios of what could go wrong cannot, at least not yet, be comprehensively predicted. Grote (2014 p. 71) writes, "*Uncertainty is at the heart of risk*". She argues that on top of acknowledging existing uncertainties one needs to understand that uncertainty cannot always be reduced completely. Therefore, uncertainty becomes a strategic question for a company dealing with risk management. With the understanding that uncertainty cannot be reduced entirely, maintaining a level of uncertainty, managing it and occasionally even increasing it, should be included in the decision-making of risk management in order to improve safety and pursue opportunity.

Aven and Krohn (2013) discuss probability and risk. They point out that probability is just one way to describe uncertainty, and that understanding risk should not be limited only to probabilities as it is too narrow view. They point out that when predicting the probability of a certain risk, a hazard or unwanted event, the probabilities can be the same for two different cases, but what is emphasized is the level of knowledge and data available regarding the phenomena. The "unthinkable" or the "unlikely" can be ignored due to assessments based on assumptions or beliefs, that these kinds of phenomena are not likely to happen. They argue, that a broader risk perspective is needed that go beyond the probabilities and avoiding only the undesired events. The perspective should also include how to improve performance with desired outcomes.

The safety of Arctic shipping, therefore, should not only rely on predicting risks and their probabilities, as the list will most likely be incomplete. Neither will investigating past accidents tell the whole truth about how to improve safety. To improve performance in order to improve safety requires understanding of what kind of performance to improve. Therefore, more research on what kind of performance leads to success, thus to better safety, is needed. To study shipping companies that have operated in the Arctic waters successfully could give maritime safety development very valuable input. Research on what makes them successful in the Arctic conditions, how their ships and crew manage critical situations and where their success originates from, surely will enlighten the safety development as much as studying past accidents and incidents.

Besnard & Hollnagel (2014) explain this idea quite well while arguing about some myths about safety and criticize the concept of human error. They give an example where a system is considered to be safe with a very low probability of failure of e.g. where 9 999 times out of 10 000, everything will go well. Then there is one unacceptable performance, an accident. The "human error" is considered to be the cause of that one accident, but attention is not paid to the 9 999 times where the same course of action has been a success. The human error has been seen to be the "cause" of the one unwanted event, but at the same time also humans are the source of the 9 999 times of success.

This principle applies to the Safety-II principles by Hollnagel (2014) and Resilience Engineering (Hollnagel Pariès and Woods 2011), where the focus on improving safety should be on actions that go right as well as understanding what rarely goes wrong. Performance variability and the normal functioning of a system should be studied also in order to understand why the same behavior that usually goes right occasionally makes things go wrong.

Hollnagel (2009; 2014) argues also, that in the traditional way of looking at the human element and human error, humans are seen as the fallible component of a system like machines, where they either work as stated in work procedures or fail to follow them. The principle behind this is that written procedures are seen to be correct and the function of a system is predictable. Now, usually those who execute the work described in processes and work descriptions are often different from those who design the system, create and describe the processes and regulatory work. The more complex the working environment becomes, the harder it will be to describe the work procedures and anticipate all conditions. Hence, the execution of work tasks exactly as described in the processes and work descriptions cannot always be done in all circumstances.

The decisions humans take in order to accomplish current work tasks, whether during normal operation or emergent disturbances, can often be based on limited resources like time, information, tools at hand etc. The decisions are made when if more time would have resulted in more information gained, lack of spare parts or tools at hand calling for improvisation or lack of manpower possibly relying on less qualified persons to do the work. The decisions and courses of action are done based on some level of uncertainty, hence the adjustments done in imperfect circumstances to complete work tasks are inevitably approximate. Reasons why performance mostly is a success is much the same as why performance at times may fail. People in general do not choose failure. Success to complete a task, due to incomplete work procedures and uncertainty, needs performance adaptability and variability. Therefore, this cannot be prevented in order to eliminate failures and hence, managing safety cannot only be by constraining daily work and decision making. (Hollnagel 2009; Hollnagel 2014)

Best practices and written work procedures are important and the above does not exclude them. However, especially in high risk areas and when the element of uncertainty is present, merely following best practices and following rules, regulations and procedures does not always ensure safety.

Taking uncertainty into risk management and overall safety management of a ship means firstly that managing uncertainty will be part of strategic and operational decision making. In addition, the operation of a ship and its navigation cannot always be broken down into work procedures written in detail. Therefore, safety cannot be managed only by reducing uncertainty through standardization of work, routines, automation and stability. High level of routine, standardization and formalization requires that evolving events are predictable, that systems can be controlled and are tractable (Grote 2014)

3. The element of uncertainty

As uncertainty cannot be completely reduced from Arctic navigation, it should be included in the safety management and seen both as a positive and negative issue. Grote (2014) introduces a general framework to manage uncertainty where uncertainty is reduced, maintained or increased. In the traditional risk management, the objective is to reduce uncertainty, to stabilize, standardize and automate. Here control is centralized. Maintaining uncertainty again has the objective to be flexible and resilient towards uncertainty. It is understood that uncertainty cannot be completely reduced in complex environments. Leonhardt et al. (2009 p. 2) define Resilience Engineering: '*Resilience is the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions*.' The objective of maintaining uncertainty is that the system is tolerant to disturbances and can recover from them. In these kinds of environments, control needs to be decentralized, for example by empowering people.

Increasing uncertainty becomes relevant for example in the case of innovations and new ways of working, when better ways are sought and new ideas encouraged. When this happens, existing routines need to be left behind. Therefore, when innovation is needed in high-risk settings, uncertainty has to be increased, at least temporarily. Hence, stability and control will naturally be reduced. Also, when questioning authority or courses of action, uncertainty will be momentarily increased as questioning raises doubts about the current situation, and as new ways and possibilities are sought after. Often these doubts are also the reason why people may stay silent. The positive side of increasing uncertainty in decision making is seeing new angles and solutions to problems. This can lead to more successful end results or even prevent accidents from happening. However, when uncertainty is increased in critical situations by e.g. questioning decision making, it is important to know how to reduce uncertainty and regain control of the situation. (Grote 2014)

High levels of routine, standardization and formalization are needed to create stability, predictability and control. This again reduces the need for ad hoc operations when courses of action are well enough known and described beforehand in work processes (for example the checklists ensuring that the important tasks have been included). In order to manage situations where uncertainty needs to be increased, control has to be decentralized to self-organizing units and performance is not controlled but shaped and directed. Also to increase learning, ad hoc situations should be favored. In these situations, humans are faced with uncertainty and new occurring needs to which they have to react. (Grote 2014)

Doz and Kosonen (2008) write about strategic agility and leading with values. In traditional hierarchical, bureaucratic organizations, people were led by compliance to rules and regulations. However, when quick decisions and the agility to react fast are needed, the traditional way is a hindrance. A company should be lead collectively with normative, internalized operational framework and shared values. This way, quick decisions can be made when they need to be made in line with the overall principles, policies and values of the company.

The maritime domain is quite regulated and therefore cannot totally be run like an agile, constantly changing company. However, lessons can be learned on how to succeed with uncertainty and unpredictability by benchmarking the best companies operating in fast changing and turbulent environments. Further studies could include how these people are lead in areas with flexible, value-based rules and how the efforts of employees are directed towards the same goal. In addition, despite the importance of the master as the leader of the ship, research in this area is very limited (Theotokas et al. 2014). Martínez-Córcoles et al. (2012) state that hardly any literature can be found regarding team leadership in safety performance settings. These are also issues that could benefit a more holistic view of safety management in the Arctic that cannot be based only on compliance to rules and working practices due to the unpredictability and uncertainties.

Standards and procedures are important and the maritime domain is quite regulated, therefore a balance between stability and flexibility in high-risk areas is a strategic risk management question of the company. Naturally it is important to follow the rules regulating the maritime industry: Safety of Life At Sea (SOLAS), The International Safety Management Code (ISM Code) and the Polar Code etc. However, IMO also states that there are areas that require continuous improvement and a culture of self-regulating.

IMO (IMO Safety Culture) defines safety culture as an organization that "*gives appropriate priority to safety and realises that safety has to be managed like other areas of business*." IMO states also, that "*culture is more than merely avoiding accidents or even reducing the number of accidents, although these are likely to be the most apparent measures of success. In terms of shipboard operations, it is to do the right thing at the right time in response to normal and emergency situations*".

According to IMO, safety culture is to take root in the professionalism of seafarers, in their attitudes and performance; and highlights key activities "*to recognise that accidents are preventable through following correct procedures and established best practices, constantly thinking safety and seeking continuous improvement*." The objective of safety management work should also be to "*inspire seafarers towards firm and effective self-regulation and to encourage personal ownership of established best practice*" (IMO Safety Culture). Clearly, there is a need for compliance to rules and regulations, but also when seeking continuous improvement, sometimes the old ways of working need to be left behind and new ways are introduced.

Balancing between compliance to rules and following best practices, and the flexibility to seek continuous improvement is important. Flexibility responds to uncertainty and stability answers to the need for control (Grote 2014). When entering areas like the Arctic where changing demands and unforeseen situations occur, the crew needs to have some room to operate, more decentralized authority to make decisions and adapt their behavior when facing ad hoc situations and to learn to gain experience. This requires flexibility and resilience to tolerate performance variability and disturbances. At the same time, when flexibility exists, individuals who are required to follow flexible rules should be well trained, educated and possess the right attitude of good Arctic seamanship. This needs to be supported by the organizational culture to ensure, that those who are performing under flexible rules can take advantage of the needed flexibility and not get confused, disorientated or violate the rules. The organization needs to build a culture, which is also in balance with control and accountability. (Grote 2014)

4. Human resources

Progoulaki and Theokas (2009) state that human resources are considered to be very crucial to shipping companies in creating a competitive advantage. The high performance of a ship is the result of high performance of the crew. They emphasize the fact that high performance is a result of successful performance of the whole crew working as a team and not just the performance of individuals.

Theotokas, Lagoudis and Kotsiopoulos (2014) strongly emphasize the role of the ship master as the leader of a ship. Seafarers are living and working in a restrained space being long time away from home, continuously exposed to sea originated risks. The ship master as the leader of the ship and its crew is the key person for successful operations and hence leading also the safety of a ship which has been highlighted also by Martínez-Córcoles et al. (2012)

Liu et al. (2009) argue that team agility and rapid reaction is important to efficiently respond to the turbulent, competitive, and ever changing needs of the business environment. Also from a business perspective, Doz and Kosonen (2008) emphasize strategic agility as an answer to constant change, uncertainty and unpredictability. Successful, agile companies learn to operate in turbulent environments and under constant change where the achieved status is never taken for granted but must be constantly worked for. One aspect of agility is the collective commitment to goals, where the success of operations is the success of the whole company and not just the success of individuals.

5. Multicultural shipping

Shipping has a global labor market, which also leads to multiculturalism onboard. To succeed in creating a high performance crew, the company should recruit high quality employees from the global labor market. They should be lead and motivated and the company should make an effort to ensure that they will stay with the company. Frequent turnover of crew can lead to loss of important human resources and tacit knowledge. (Progoulaki and Theotokas 2009; Theotokas et al. 2014)

If crew turnover is high, rules and formalized working procedures are needed to ensure that the job gets done as required when one seafarer is changed for another. Formalization of work and work roles, written and enforced rules and procedures, high levels of routine can affect both flexibility and the social interactions of the crew. Social isolation and discrimination can occur onboard when seafarers are not trained to handle multiculturalism. Social and intercultural confrontations influence team cohesion negatively, affecting the performance of a crew as a team. To operate successfully, the crew, the people who live and work together, should have both the necessary official certificates and the personal ability to work as a member of the ship's team. When the crew consists of different nationalities with different cultural backgrounds and experiences, the role of the ship master as the leader of the ship becomes very important. The hard and soft skills of a master, the abilities to lead, motivate, inspire and empower the crew are vital for safe, effective and efficient operation of a ship. (Progoulaki and Theotokas 2009; Theotokas et al. 2014)

Bergheim et al. (2014) studied the relationship between psychological capital (PsyCap), job satisfaction and safety perceptions in the maritime industry. PsyCap consists of four dimensions. Firstly one's belief to successfully execute and accomplish tasks. Secondly optimism, the tendency to have positive attitude towards the future events. Thirdly hope and a tendency to persistently pursue goals and change paths if needed to succeed. Fourthly resiliency, the ability to positively cope, tolerate and bounce back when faced with problems and challenges.

Their results indicated that PsyCap in the maritime industry, is positively correlated with safety climate when both personal and situational factors were relevant regarding workplace safety. They also argued, that safety climate perceptions could be more than just reflections of formal education and training in the job. It could reflect the individual motivational state of seafarers, which "*could be subject to training and leadership processes*" (2014 p. 31). They also argue, that PsyCap represents a new perspective for leadership and safety management to improve safety. The cultural backgrounds of the crew should also be taken into consideration, as different factors that influence safety climate could be dependent on the culture.

6. Continuous improvement of safety and crew involvement

Getting crewmembers to participate in safety related issues and activities are important. Safety participation of the crew, a proactive behavior towards safety, makes it possible to identify and detect non-conformities in processes, practices and the entire system. This is essential for continuous improvement and developing a good safety culture defined by IMO (IMO Safety Culture). Safety compliance is following rules and regulations, wearing personal protection equipment and performing activities needed to ensure workplace safety. Safety participation again is more of voluntary nature where the crewmembers for example voluntarily take initiative in safety tasks and safety improvement work. Personal motivation to participate in safety activities and safety knowledge are significant indicators of safety participation. It can be enhanced and significantly influenced by empowering leadership style. (Martínez-Córcoles et al. 2012)

Murphy (2014) emphasizes the importance of leadership also. He is reflecting the principles from military world into the modern, complex business world with the elements of uncertainty and unpredictability present. Murphy (2014) emphasizes leadership, because it affects all aspects of a high-performing team and ensures their success as a team. Effective leaders do not only order, but also listen actively to ideas of their team members. This enables creative thinking and problem solving from new directions.

Unpredictability in the Arctic shipping routes can require at times creative thinking, fast responding and performance adjustments to occurring ad hoc situational needs. Team coherence, proactive behavior towards safety and continuous improvement can all be influenced by leadership. In these situations, also communication is highlighted, especially in safety critical situations.

7. Communication

Mazaheri et al. (2015) state in their case study on accident and incident reports on grounding, that appropriate communication and cooperation in studied incident cases stopped the situation from becoming serious. When inappropriate communication is present at the ship's bridge, information flow is interrupted. This will increase the likelihood of errors. They also point out that there is a strong link between inappropriate communication and personal factors in the incident reports in general, showing that the personalities of the crew affect safety through inappropriate communication. They also highlight proper interaction between the crewmembers.

Chauvin et al. (2013) highlights the same, where they state that most collisions are due to decision errors. Inter-ship communication problems and bridge resource management deficiencies are closely linked to collisions in restricted waters while having a pilot onboard. In cases of collision with another vessel while having a pilot onboard, 43 cases were linked to breakdowns in communication on the bridge, between the vessels or in the teamwork on the bridge.

Appropriate communication and speaking up, as in expressing one's mind or concerns aloud, are important for safety, as they open up new perspectives for decision-making and action. The master of the ship is in a key role to create an atmosphere and culture on the ship, where crewmembers feel free to express their minds, speak up and feel that their contribution is valued and appreciated. They also need psychological safety, where team members do not fear punishment or embarrassment when they question certain courses of action or come forward with new ideas for improvement. In time-critical situations, speaking up is emphasized. As pointed out earlier, appropriate communication could have prevented many accidents and near miss situations. However, speaking up should be done in a constructive, non-threatening way. Crewmembers should be encouraged to speak up, but at the same time understand that it is a two-way street. It is also important to be able to receive feedback and adequately react when spoken to. (Grote 2014)

Grote (2014) points out too, that appropriate communication between the team and speaking up needs a general culture of trust, psychological safety and systematic training. These are organizational actions to support the teams and especially team leaders to create such a culture and routines that enable appropriate behavior to speak up and adequate reacting when spoken to.

Palttala and Vos (2012) have a Strategy map for crisis communication supporting crisis management, which can also be used to understand communication in the framework of continuous improvement and safety participation.

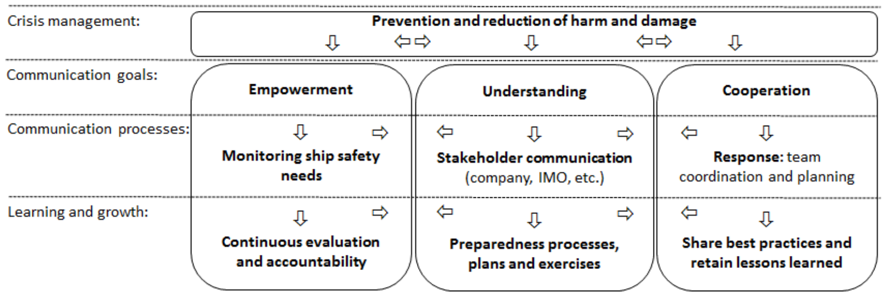

Fig. 1 Onboard crisis management communication framework (based on Palttala and Vos (2012) : Strategy map for crisis communication supporting crisis management by public organisations).

In the figure 1. Above, communication goals are divided into three: empowerment, understanding, and cooperation. On the communication process level every crewmember is empowered to actively participate in the monitoring of the ship's safety needs, while at the same time understanding the framework of company guidelines and formal regulations. Their successful cooperation is demonstrated in efficient and cohesive responses to changes in the environment. Team agility and rapid reaction, for example, are important to efficiently respond to the changing needs in the ship's environment. On a learning and growth level continuous evaluation, preparedness, and best practices promote accountability and retention of lessons learned.

As an example of this could be team work at the bridge with increased look out for growlers and submerged icebergs that are hard to detect. A multicultural crew with different cultural backgrounds, language barriers and difficulties in interpersonal cooperation can create challenges for efficient communication. Training and leadership can help to overcome these challenges.

8. Conclusion and discussion

The Arctic is an environment where uncertainty and unpredictability are present. Hence, not all can be described in best practices to be followed neither can all risks be reduced, at least not yet. The human element is still needed to get the job done in all circumstances from normal operation to handling incidents and surviving accidents. IMO states that, safety culture should take root in the professionalism of seafarers, where competency, training and attitudes are important.

For the safe, sustainable and profitable shipping in the Arctic, attention needs to be paid to human resources. Hiring high performing seafarers from the global labor market to create a high performance team, and working for team unity and trust will enhance team performance and constant improvement. Strengthening the belief in safety-oriented actions and empowering every crewmember towards safety participation and constant improvement are important in creating a self-regulating culture. The crew also needs to believe that what they say and do matters and is valued.

Trust and psychological safety are important in promoting speaking up and appropriate communication within a crew team. In the modern multicultural environment of shipping, the hard and soft skills of a master, the abilities to lead, motivate, inspire and empower the crew are vital for safe, effective and efficient operation of a ship. As the seafarers are not usually trained to handle multiculturalism onboard, it is left for the captain of the ship to create such an environment, which promotes appropriate communication and teamwork.

In order to work with uncertainty, a high performing self-regulating crew needs a level of flexibility to cope with occurring ad hoc situations, to question current ways of working, and to make suggestions for continuous improvement. Making flexible rules is a strategic risk and safety management question of the company, because also compliance with official rules and regulations as well as best practices are still needed to ensure safety of Arctic shipping.

It is essential to ensure that the skills and knowledge of the crew develops and that the accumulated knowledge is kept within the ship and the company. This will enable the ship as an organization to learn from experience and improve constantly its performance and safety of Arctic shipping.

To lead and manage the safety of a ship is leadership and management of the people living and working in the ship. The execution of safety measures lies within the seafarers and their masters working at sea. They are the ones who react to and manage situations as they occur. They use their skills and knowledge to adapt to shortcomings in processes, work descriptions, equipment, and tools. They are the ones who face the sea-originated risks on a regular basis and fight for their survival in case of accidents. This chapter argues that from the captain's point of view, excellent seafarers, their competence, skills, collective attitudes and good Arctic seamanship are the key to a safer and more sustainable Arctic shipping.

References

Aven T, Krohn B S (2013) A new perspective on how to understand, assess and manage risk and the unforeseen. Reliability Engineering and System Safety 121 (2014) 1-10

Bergheim K, Nielsen M B, Mearns K, Eid J (2014) The Relationship between psychological capital, job satisfaction, and safety perceptions in the maritime industry. Safety Science 74 (2015) 27-36

Besnard D, Hollnagel E (2014) I want to believe: some myths about the management of industrial safety. Cognition, Technology and Work, Springer Verlag (Germany), 2014, 16 (1), pp.13-23. hal-00720270

Carpenter G, Wyman O (2014) Arctic Shipping: Navigating the Risks and Opportunities. MARSH Risk Management Research http://www.safety4sea.com/images/media/pdf/Arctic_Shipping_Lanes_MRMR_August_2014_US.pdf . Accessed 25 May 2015

Chauvin C, Lardjane S, Morel G, Clostermann J-P, Langard B (2013) Human and organisational factors in maritime accidents: Analysis of collisions at sea using the HFACS. Accident Analysis and Prevention 59 (2013) 26-37

Doz Y, Kosonen M (2008) Fast Strategy – How strategic agility will help you stay ahead of the game. Wharton School Publishing

Grote, G (2014) Promoting safety by increasing uncertainty – Implications for risk management. Safety Science 71 (2015) 71- 79

Hollnagel E (2009) ETTO Principle: Efficiency – Thoroughness Trade-Off: Why Things That go Right Sometimes Go Wrong. Ashgate Publishing Limited, Surrey

Hollnagel E (2014) Safety-I and Safety-II: The Past and Future of Safety Management. Ashgate Publishing Limited, Surrey

Hollnagel E, Pariès J, Woods D D (2011) Resilience Engineering in Practise: A Guidebook. Ashgate Publishing Limited, Surrey

International Maritime Organization (IMO) (2010) Guidelines for Ships Operating in Polar Waters. Resolution A.1024(26)

International Maritime Organization (IMO) Safety Culture http://www.imo.org/en/OurWork/HumanElement/SafetyCulture/Pages/Default.aspx Accessed 1 June 2015

Jensen Ø (2007) The IMO Guidelines for Ships Operating in Arctic Ice-covered Waters. From Voluntary to Mandatory Tool for Navigation Safety and Environmental Protection? FNI Report 2/2007. The Fridtjof Nansen Institute

Leonhardt J, Macchi L, Hollnagel E, Kirwan B (2009) A White Paper on Resilience Engineering for ATM. European Organisation for the Safety of Air Navigation (EUROCONTROL)

Liu M-L, Liu N-T, Ding C G, Lin C-P (2014) Exploring team performance in high-tech industries: Future trends of building up teamwork. Technological Forecasting & Social Change 91 (2015) 295-310

Marchenko, N. (2015) Arctic Safety Issues. http://umanitoba.ca/faculties/management/ti/media/docs/N_Marchenko.pdf
Accessed 10 July 2015

Martínez-Córcoles M, Schöbel M, Gracia F J, Tomás I, Peiró J M (2012) Linking empowering leadership to safety participation in nuclear plants: A structural equation model. Journal of Safety Research 43 (2012) 215-221

Mazaheri A, Montewka J, Nisula J, Kujala P (2015) Usability of accident and incident reports for evidence-based risk modeling – A case study on ship grounding reports. Safety Science 76 (2015) 202-214

Murphy J D (2014) Courage to Execute: What Elite U.S. Military Units Can Teach Business about Leadership and Team Performance. John Wiley & Sons, Incorporated, New Jersey

Palttala, P. and Vos, M. (2012), Quality Indicators for Crisis Communication to Support Emergency Management by Public Authorities. Journal of Contingencies and Crisis Management, Vol.20, Issue 1, pp. 39-51.

Progoulaki M, Theotokas I (2009) Human resource management and competitive advantage: An application of resource-based view in the shipping industry. Marine Policy 34 (2010) 575-582

Stewart E J, Dawson J (2011) A Matter of Good Fortune? The Grounding of the Clipper Adventurer in the Northwest Passage, Arctic Canada. Arctic Vol. 64, NO. 2 http://pubs.aina.ucalgary.ca/arctic/Arctic64-2-263.pdf Accessed 8 July 2015

The New York Times, All Safe in Soviet Ship Drama. http://www.nytimes.com/1989/06/21/world/all-safe-in-soviet-ship-drama.html Accessed 8 July 2015

Theotokas I, Lagoudis I N, Kotsiopoulos N (2014) Leaders Profiling of Ocean Going Ship Masters. The Asian Journal Of Shipping and Logistics, Vol. 30, Number 3, pp. 321-343

Wright G R, Zimmerman C M (2015) Vector Data Extraction from Forward-Looking Sonar Imagery for Hydrographic Survey and Hazard to Navigation Detection. Oceans 2015, Washington D.C.

SEAMANSHIP AS THE SOURCE OF RESILIENCE

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SEAMANSHIP AS THE SOURCE OF RESILIENCE

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ABSTRACT: It is difficult to design complex systems that are fully predictable. This is leading inevitably to some level of uncertainty and unpredictability in operating such systems. This paper aims to understand the need to change our safety thinking, how it relates to shipping and find ways to address the issue of safety improvement from a new point of view based on the principles of resilience engineering and Safety-II by Erik Hollnagel (2014) as well as to understand seamanship and particularly the element of uncertainty in safety. This paper reviews literature of Safety-II and Resilience Engineering reflecting these principles into shipping focusing on seamanship of seafarers. The results indicate that performance variability is at the core of resilience, that hindsight is not enough to improve safety or determine the source of successful and safe operation, hence expertise is an important part when operating with the element of uncertainty present. The results are, consistent with previous research highlighting the importance of human capital in successful operations. This study contributes to the existing literature by adding a positive emphasis where empowerment of seafarers towards better safety could start from looking at things that go right, with acknowledging and sharing the seafaring excellence as well as the lessons learned from near-misses, incidents and accidents. It also suggests that research on tacit knowledge is one way towards proactive safety improvement.

Keywords: Seamanship, resilience engineering, Safety-II, Maritime Safety

1. INTRODUCTION

1.1 Introduction

Shipping industry transports around 90% of world trade and caries all different kinds of cargo from all parts of the world. Our society highly depends on shipping and maritime transportation of goods. Over one million seafarers and approximately 50 000 merchant ships ensure the operation of ships around the clock every day of the year. Chauvin et al. (2013, 26) claim that shipping is a safe and economical form of transport (Chauvin et al., 2013, 26), but also high risk industry with considerably higher mortality rates than shore based occupations (Jepsen et al. 2015, 106; Knudsen, 2009, 295; Hänninen, 2014, 308). In total there were 3 399 ships involved in the accidents (including fishing vessels), 51 ships were lost, 1075 persons were injured and 136 fatalities (EMSA 2015, 3). Allianz Global Corporate & Speciality in turn reports in their Safety and Shipping Review (2015, 2) that 75 large vessels were lost world wide, which was the lowest in 10 years and 2 773 casualties (incidents). Statistics show the declining trend of accidents, but despite the positive trend in safety improvements, accidents still happen and lives are lost at sea, and as the number of accident decrease the potential financial loss of one accident is increasing.

The human performance variability and adaptability are at the core of resilience engineering and Safety-II responding to the varying conditions of the system ensuring that things go right. Hollnagel et al. (2013, 6) give an example illustrating the reasoning behind understanding both failures and success. Considering that there is an event that is carried out for 10 000 times, of which 9 999 times are a success and 1 time a failure. The efforts and resources are mainly put to understand the one failure occurred leaving much less attention to understand why the 9 999 times were a success. He argues that by preventing things going wrong is not sufficient enough to ensure that things will go right. We need to know *how* and *why* they go right. Hollnagel (2014) suggests that in order to improve safety, we should focus both on the things that have gone wrong i.e. failures as well as on success as things going right.

Therefore, this paper looks at the need for performance variability according to the reasoning of Safety-II and resilience engineering. Hindsight drives also the current safety development, but in complex, intractable systems might not be sufficient enough to proactively improve safety. Therefore, this paper looks also at tacit knowledge as a source of safety improvement and resilience. Seamanship is basically the professionalism of seafarers that is created through work experience at sea. Professionalism and experience contribute significantly in decision making especially when involving dynamic and complex risks as well as ad hoc situations. As our operational systems get more complex and unpredictable, understanding how things go right, studying and capturing the tacit knowledge of seamanship could point us to a new direction towards improved safety at sea and give us more understanding of where success originates from. The paper aims to understand the need to change our safety thinking, how it relates to shipping and find ways to address the issue of safety improvement from a new point of view based on the principles of resilience engineering and Safety-II by Erik Hollnagel (2014).

2. NEW SAFETY THINKING

2.1. Definition of resilience

In align with the definition of resilience by Leonhardt, Macchi, Hollnagel and Kirwan (2009, 2), this study refers it as: "*Intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions*".

Resilience is seen as a quality of a system, that has four premises (Leonhardt, Macchi, Hollnagel and Kirwan, 2009, 2), where 1) performance conditions are always underspecified. This is due to the complexity, interconnectivity and intractability of our systems. This makes it difficult to specify in detail which actions to take in every possible situation. Therefore, people adjust their performance to match the occurring needs. As resources like time, information available, tools at hand, are finite, the adjustments are inevitably approximate. 2) Some adverse events can be attributed to a breakdown or malfunctioning of components and normal system functions, but some are the unexpected combination of performance variability. 3)

Safety management needs to be both reactive and proactive and not rely solely on hindsight, error tabulation and failure probabilities. The past is not necessarily sufficient enough to tell how safety should be improved in the future and how safety is created. 4) Safety is a part of core (business) operations hence achieving safety should be done rather by improvements than constraints. Safety should be seen as a means for better productivity rather than seeing them as contradicting issues.

2.2. The ETTO -principle

Hollnagel (2009) introduces the ETTO – principle, which is about the trade-offs' humans need to make as a part of everyday performance. ETTO stands for Efficiency-Thoroughness Trade-Off. In an ideal world, when making decisions, there would be enough time, resources needed available and information sufficient and correct, but often this is not the situation. Most common shortcoming is the lack of time, but shortage of other resources as information, materials, manpower equally could exist. People still manage to accomplish their work tasks by adjusting how they do them to meet the current conditions. Regarding safety, the trade-offs' are often seen as production efficiency versus thoroughness. Hence, for example short-cuts are done due to time pressure, to do things faster with the objective to be more efficient. By understanding how things are a success and by doing the right thing at the right time, safety and production efficiency might not need to be trade-offs' anymore.

2.3 System complexity and performance variability

Technology plays an integral part of our today's society, and in shipping.
Automation and technological solutions in navigation, machinery, remote maintenance and monitoring, ballast and other ship operations is increasing with a rapid pace and unmanned vessels will sail in the future. Despite how automated the system is, humans are a part of its functionality in one way or another. Systems are designed, built, maintained and tested by people, risks assessments, training and manuals are done by people. The systems are designed by people for a purpose, for an intended use and user. Therefore, the human element and the potential of human error will be almost impossible to eliminate from the equation, neither should it be. (Hollnagel & Woods, 2005, 4)

Technological systems often function autonomously in a stable environment, where the environment is specified in detail and nothing unexpected variability will not happen. In contrast to that, some environments cannot be specified completely where humans are needed to operate the system, its subsystems and the operating environment. Human, as the buffer for changes in the operational environment adjusts his/her performance to provide stability for the system to work as needed. (Hollnagel, 2014, 119).

In the traditional safety thinking, the systems can be taken apart to understand the cause-effect relationships, where components either work or they don't and the functioning is predictable. This predictability again made it possible to create detailed instructions and work procedures. Therefore, people were seen as the weak link, where performance variation needed constrains and controlling, because deviation from procedures caused malfunctioning. But the modern socio-technical systems are not decomposable, bimodal or predictable anymore.

The operational, socio-technical systems are becoming more complex making it difficult to understand them, what will happen, how it will happen, or why it will happen and, this complexity can be defined as intellectual unmanageability In order to improve safety in the era of complexity with the elements of unpredictability and uncertainty, we need to find new ways to improve safety. (Hollnagel, 2014, 97-105; 112- 113; Leveson, 2012, 4).

2.4 Risk and hindsight

A risk and its analysis is often influenced by hindsight, by looking at the past mistakes, incidents and accidents and reflecting them into the future. Past accidents are investigated to find underlying reasons, decisions and sequence of actions made to understand what did happen and why. The understanding of past events, different defenses like new rules and regulations, may be put in place to ensure that this kind of accidents does not happen again. Our future safety is claimed to influenced the way past mistakes are understood, how far we have been able to reconstruct the events, their prevailing conditions, actions of people, organizational culture, procedures and managerial systems, weather, traffic etc. Then as the new defenses are put in place, it is seen that the future is protected to some extent from this kind of accident. The accidents are explained in linear cause-effect relationships and as we create an understanding of how accidents happen, we do not still have a sufficient understanding of how safety is created as it does not tell why things usually go right. Hindsight biases also the investigation as the accident investigator does most likely have a better understanding about the sequence of events leading to an accident, the results of actions taken and decisions made. We see the whole event afterwards in a more holistic way than those who were involved in the accident and making decisions based on the most likely limited resources available at that particular time. (Dekker, 2006, 23; Hollnagel, 2014, 23; Hollnagel et al., 2013, 3; Hollnagel, Woods & Levenson, 2006, 9)

Hindsight is important for safety and safety development, but in complex systems, not sufficient enough to create safety. Safety is dynamic in the sense that when something is safe now, there is no guarantee that nothing will happen in the future. Safety is not state that is once created and then maintained by establishing boundaries for performance. Safety in complex systems needs constant monitoring, adjusting and management and is created again and again usually by people through their capacity to adjust their performance to meet the occurring situational needs and multiple goals. Hence making success, and failure for that matter, an emergent phenomena. (Dekker, 2006, 65; Hollnagel, Woods & Levenson, 2006, 13)

Schröder-Hindrichs et al. (2013, 244) propose that even the information gained from past accidents and incidents is a valuable source of information, other sources should be sought after. They point out, that proactive safety requires actions to address safety issues and possible solutions before the accidents happen. Berg (2013, 344-345) also states that event though shipping is highly regulated, the desired level of human performance has not been achieved. Human errors still count for around 80% of marine accidents at sea world wide and the traffic at sea is increasing as is the potential to risk.

3. SEAMANSHIP

Who is a good seaman and what is seamanship about? There is no unified, specific definition what seamanship is. As one retired captain once said: “*It is much easier to say what is bad seamanship, than what is good. You do not really see good seamanship, because it means that everything is going well and the job is getting done. But if you see bad seamanship, you will recognize it.”*

According to Borg and Åkerblom (2012, 4-5), a ship’s captain is judged by his/her abilities to handle the ship and the reputation of the ship is judged by how well it is taken care of. Seamanship is about the practical and professional skills, but also about things like reading the weather, surrounding traffic situation, understanding the operational capabilities and limits of the ship and its crew.

A ship is often referred as a ‘total institution’, a closed entity, that is isolated, limited physical space and enclosed social system that has a various level of control of its members’ lives. At sea, the seafarers spend time together around the clock for weeks, even months. The ship becomes an alternative, miniature society and for some, another family. (Antonsen, 2009, 1121; Theotokas et al., 2014, 321)

Isolation from family and friends and limited physical space also influences the understanding of good seamanship. Many spoken and unspoken rules reflect the social behavior of seamen, as an example leaving the door open signals that one may be disturbed, while a closed door was a signal for privacy. (Antonsen 2009, 1122) Consideration to others is highly valued as are cooperation and trustworthiness in getting the job done, ability to deal with conflicts as to avoid them. Social skills are needed for a good atmosphere and general well-being of all.

Knudsen (2009, 295) defines seamanship as a: “blend of professional knowledge, professional pride, and experience-based common sense.” The definition of seamanship is much more than what can be learned at school. Experience brings abilities to work safely according to one’s own judgment, intuition and adaptation to situational needs. It is also about foresight to economize resources and time, as time is often a scares resource at sea. It is also about sometimes working with multiple and possibly also conflicting goals e.g. safety and efficiency. It means also capabilities to improvise and sometimes even deviate from rules and regulation in order to get the job done according to situational needs. It is about the skills needed for seafaring, both practical skills for job completion and 'soft skills' to manage life at sea in isolation, limited physical space constantly facing the sea originated risks.

According to Antonsen (2009, 1123) and Knudsen (2009, 297) the seafarers value their profession and are willing to work hard but resent when outsiders tell how the work should be done. Seafarers reluctance towards extensive paperwork and check lists is demonstrated in an expression (Knudsen, 2009, 297) as follows: "…*It is wearying, because you have to throw all seamanship away. You have to read and do precisely what is written. No matter if your own thought is better or not, you have to do what is written. That means, you stop any development, you stop thoughtfulness, and you stop seamanship*." This has been pointed out also by Lappalainen (2016, 89). In his study he referred to an interview with a master, who pointed out that older crew members were more negative towards ISM Code and felt that their skills and experience were not appreciated and seamanship is not trusted.

Reluctance towards e.g. increased paperwork, checklists and written procedures are usually due to the perception, that they are done by 'landlubbers' at shore who have no real idea about the life at sea. External pressure about how work should be done seems to be offending the pride of seafarers and their professionalism, as one of the features of seamanship is to pursue towards working safely. (Knudsen, 2009,297; Antonsen, 2009, 1124).

4. CONTINUOUS DEVELOPMENT AND INCIDENT REPORTING

Studies indicate that the implementation of ISM Code reduces accidents. However, the studies conducted to determine the impact of ISM Code have not produced conclusive evidence. Even though statistics show decrease in accidents and some studies indicate that operations of shipping companies have improved their performance due to ISM Code, there is still need for improvement. The main noncompliance with the ISM Code is related to the incident reporting, which is at least partly due to the prevailing 'blame culture' within the maritime industry. Incident reporting has been seen as the most significant indicator of an established safety culture. Incident reporting and investigations is seen to be an integral part of continuous improvement in the safety management system as it can point out the weaknesses and vulnerabilities that need addressing. (Lappalainen, 2016, 12; 140)

Lappalainen (2016, 136) states that Finnish maritime personnel have rather positive attitudes towards safety management and see it beneficial. However, they criticize the excessive documentation, unnecessary bureaucracy and poor incident reporting. In the case of Finnish maritime personnel, the insufficiencies in reporting were more due to lack of feedback from management and lost faith to the fact that the incident reporting actually will improve safety. The study also revealed, that even the reports are not made, the issues are discussed onboard and improvements are being made. This indicates, that development is happening aboard the ship even there is no paper trail to prove it.

Mazaheri et al. (2015) studied both grounding reports and near-miss grounding reports to find out what kind of knowledge can be extracted from such sources and the usability of the reports for evidence based risk modeling. They propose that accident reports provide evidence of contributing factors resulting in an accident but voluntary incident reports could not be seen a very reliable or useful source in their current form. Next, they suggest that voluntary reports could be used as alerts for possible hazards in the daily operation of shipping. In order to improve the near-miss reporting, reporting should be more systematic and consistent addressing causalities.

5. GOING FORWARD

Safety-II focuses on how things go right and how to manage performance rather than to constrain it, looking at opportunities as well as risks. (Hollnagel, 2014, 149) Hummerdal et al. (2007 2-5; 12-13) highlight the importance of enhancing people's adaptive capacity by giving them room to do the job safely rather than constraining and making it impossible for them to do the job unsafely. Hence, people will perform the job safely when the conditions are favorable, rather than perform the job unsafely unless told exactly what to do. It is becoming more and more difficult to foresee all possible paths to failure as a level of complexity in systems increase. Safety is a dynamic and emergent property of our systems which is constantly created again and again. Therefore, the emergence of safety depends on flexible, adaptive, empowered and proactive people actively anticipating different paths to failure and adapting to emerging situational needs to get the job done. (Hollnagel, 2014, 119)

Risk management is fundamentally about decision making under the conditions of uncertainty (Mauelshagen et al., 2013, 1187). Experience and expertise is critical for risk management. Expertise is an ability to make sense of, and develop solutions by quickly recognizing key information in complex problems (Mauelshagen et al. ,2013, 1188 referring Case and Simon 1973). And as safety related decisions in ad hoc situations are made often with limited resources like time and information available, the solutions to problems are often approximate. Hence, a need to make decisions, intuition and experience based reasoning are often used and unavoidably involving subjective judgement. In order for an organization to utilize the professionalism of their employees, a key feature in risk based decision making is decentralized decision making expressing respect for expertise. A company that encourages the growth of expertise knowledge and sharing of it enhances interaction between operational and managerial staff. This helps to avoid rules that do not reflect reality. (Mauelshagen et al. ,2013, 1188)

The importance of understanding the different between work-as-done and work-as-imagined has been highlighted also by resilience engineering and principles of Safety-II. People at the sharp end are those who actually do the work. They are the closest to and in direct contact with safety-critical processes and also are the ones who create safety on a daily basis. The people who are at the blunt end are those who support and shape the activities at the sharp end. The blunt end consists of the organization, regulatory and administrative parties, governmental parties etc. Blunt end shapes, creates and directs the work being done at the sharp end indirectly by providing resources, training and establishing general conditions for those who work at the sharp end. Quite often there is a gap between the Work-As-Done and Work-As-Imagined due to different understanding of reality. (Dekker, 2006, 59-63; Hollnagel, 2014, 40-41)

From the perspective of resilience and safety the gap between Work-As-Done and Work-As-Imagined is of interest. A large distance between the two might indicate a misleading understanding of risks encountered in real operations. Hence, creating work procedures and guidelines might not suit the real situation and force the sharp end to vary their performance in order to get the job done. The way forward is to close the gap with the cooperation of both blunt end and the sharp end ensuring that they both are working for a common goal. As Fujita states in the book of

Hollnagel et. al (2006, 67) “A system should only be called ‘resilient’ when it is tuned in such a way that it can utilize its potential abilities, whether engineered features or acquired adaptive abilities, to the utmost extent and in a controlled manner, both in expected and unexpected situations.”

6. KNOWLEDGE

And as Mauelshagen et al. (2013, 1188) stated above, respect for expertise, shared experiences and trust in each other’s judgement enables effective communication and coordination. Shared experiences facilitate the common ground for sharing and understanding experimental knowledge (expertise), but knowledge sharing is not always that simple.

The role of knowledge and know how are considered to be important resources and a competitive advantage of organizations. The competition in the market place is transferring from a production economy towards knowledge based economy and from material property towards immaterial equity requires more efficient and effective use of personal knowledge and know how. This makes knowledge of interest. Knowledge as in the sense of expertise, is not easy to define. Knowledge is a multidimensional and ambiguous notion, roughly consisting of two main elements, explicit and implicit knowledge. Explicit knowledge is visible. It can be codified and transferred verbally, through documentation and various information management systems. Implicit knowledge again is hidden, so called “silent” or tacit knowledge. It is non-verbal knowledge, which is difficult to share, transfer or express verbally. It is something that we do not know, we know. (Puusa & Eerikäinen, 2010, 307)

Michael Polanyi introduced the concept of tacit knowledge in 1946, so it is not something new, but the interest of tacit knowledge has grown along with the understanding of the importance of knowledge capital and intangible competitive advantage. Expert knowledge is often seen as tacit knowledge, difficult to describe and verbalize by the experts themselves. (Haase et al., 2013, 236). Some knowledge we have are tied to senses, skills of bodily movement, perceptions, gut feeling and intuition. Such knowledge is hard to describe to others, but can be very important in safety critical decision making. Recognizing the value of tacit knowledge and how to use it is a key challenge in knowledge-creating company. It requires good communication, conversations and good personal relationships. And it also makes a powerful tool for innovation. (Von Krogh, Ichijo & Nonaka, 2000, 6-7)

Tacit or implicit knowledge and explicit knowledge are not separate categories, but an integral part of knowing. Tacit knowledge helps us to determine when to trust explicit knowledge. They are not counterpoints to one another, but sides of the same coin complementing each other. Tacit knowledge guides our decision making, is personal including subjective views, ideals, values and emotions. Tacit knowledge can be shared also non-verbally through practice and common experience. In order to deal with and develop explicit knowledge according to Puusa & Eerikäinen (2010, 309), we need tacit knowledge as backround knowledge.

Tacit knowledge is something that is invisible and difficult to address, but empirical studies show that tacit knowledge related to work life can be research and made more explicit. Tacit knowledge is also like an ice berg, on the tip 10% is above water and visible while the rest 90% remains hidden

(Bhardwaj and Monin, 2006, 72). One of the reasons why tacit knowledge has been research is the concern, that due to retirement of experienced people, valuable information will be lost. (Pohjalainen, 2012, 2). To share tacit knowledge is based on social interaction, which requires psychological safety for people to let down their guards and start to speak up freely (Suur-Inkeroinen, 2012, 24).

A very typical and traditional way of transferring tacit knowledge has been the master and apprentice, where knowledge is transferred both verbally and non-verbally via observations, participation in work tasks and social interaction. Other methods are e.g. storytelling, works shops, participation in development projects and interviews. Tacit knowledge can be reach best by observing a work and discussing it afterwards. By methodological interview, but not so much by traditional interviews or questioners. (Bhardwaj and Monin, 2006, 74, Pohjalainen, 2012, 9-10).

Further studying tacit knowledge could be a way to address safety issues according the new safety thinking, where the importance is to understand both failures and success. Tacit knowledge addresses expertise, which is developed through time and gained by work experience. Hence, this could also be a way to study seamanship and the reasons why accomplishing work tasks is mainly a success as incidents and accidents still are quite a rare event.

7. CONCLUTION

The importance of experience and professionalism can be seen from the studied literature, both for organizational success and for safety. And as stated before by Mauelshangen et al. (2013, 1187) the role of experience has been shown to be critical for risk management and decision making in ad hoc situations. In order for an organization to fully utilize the potential of expertise, they should express respect for expertise by decentralizing decision making. This will enhance the exchange of information and coordination between operational and managerial staff. Which again for its part will enable to avoid rules to be made that do not reflect reality.

This is supported by Resilience engineering and Safety-II thinking also. According to Hollnagel (2014) the work that is being done at the sharp end is often different from the people who write the rules and regulations at the blunt end. The bigger the gap between the work-as-done at the sharp end and work-as-imagined at the blunt end, the more difficult it will be address risks and create safety guards that actually do reflect reality. Hence, deficiencies in work processes puts even more pressure for people at the sharp end to adapt and vary their performance to get the job done.

Performance variability and adaptability of humans is in the core of resilience. Complex systems are starting to be quite intractable and therefore, also difficult to describe in detail. This makes also the descriptions and guidelines for which action to take in a particular situation incomplete. As decision making and problems solutions is often done with limited resources like time, information at hand, manpower etc. solutions to particular problems are also usually approximate. However, this usually results in successful operation. Hence, performance variability is an important factor in successful operation in complex systems. Expertise and professionalism contributes to decision making especially in safety and risk related emergent situations.

Expertise organisations should invest in sharing and transferring knowledge and knowhow and especially when there is a risk of losing a lot of knowhow with people who are leaving e.g. due to retirement. Acknowledging and respecting the importance expertise and reflecting it into the organizational culture will enhance sharing of critical information. At the same time the organization is ensuring its own knowledge capital and competitive advantage based on expertise in its field. However, transferring tacit knowledge is not easy and the social relationships, trust, psychological safety and good communication play a big role. Psychological is about not having to be afraid of punishment, rejection, or embarrassment after speaking up (Grote, 2015, 75).

Research shows that there is a lack of respect towards seamanship to some extent or at least it is perceived that way by the seafarers. They are however, a valuable asset to their organizations as a source of expertise and from the point of view of resilience, a source of resilience due to their capacity and ability to adjust and vary their performance to the occurring needs. The more complex and dynamic the situation the more will the good safety related decisions rely on professionalism and expertise of the experienced, skilled seafarers. As safety in interconnected and complex systems is an emergent and dynamic phenomena, safety is created again and again by the seafarers at sea on regular basis.

Investigating tacit knowledge will give the opportunity to focus on what is actually done at the sharp end, as highlighted by Hollnagel (2014). Understanding the work-as-done and comparing it with the work-as-imagined, will have the opportunity to close the possible gap between these two and therefore also ensure that risks and their safety guards are reflecting the reality. Studying tacit knowledge also sometimes points to needs for unlearning, and therefore not all information and knowledge is of use. Neither can all the made explicit. Some information will stay hidden forever. (Suur-Inkeroinen, 2012, 89)

REFERENCES

Allianz Global Corporate & Speciality. *Safety of Shipping review 2015*. http://www.agcs.allianz.com/insights/white-papers-and-case-studies/safety-and-shipping-review-2015/ (accessed 12.6.2016)

Antonsen, S. (2009) *The relationship between culture and safety on offshore supply vessels*. Safety Science 47 (2009) 1118-1128. Elsevier Ltd.

Berg, H.P. (2013) *Human Factors and Safety Culture in Maritime Safety (revised).* The International Journal on Marine Navigation and Safety of Sea Transportation.

Bhardwaj, M., Monin, J. (2006) *Tacit to explicit: an interplay shaping organization knowledge.* Journal of Knowledge Management. Vol. 10, no. 3, pp. 72-85. Emerald Group Publishing Limited.

Dekker, S. (2006) *The Field Guide to Understanding Human Error*. Ashgate Publishing.

EMSA. *Annual Overview of Marine Casualties and Incident 2015* http://www.emsa.europa.eu/news-a-press-centre/external-news/item/2551-annual-overview-of-marine-casualties-and-incidents-2015.html (accessed 1.6.2016)

Grote, G. (2015) *Promoting safety by increasing uncertainty – Implications for risk management*. Safety Science 71 (2015) 71-79. Elsevier Ltd.

Haase, T., Termath, W. Martsch, M. (2013) *How to Save Expert Knowledge for the organization: Methods for Collecting and Documenting Expert Knowledge Using Virtual Reality Based Learning Environments*. Procedia Computer Science 25 (2013) 236-246. Elsevier B.V.

Hollnagel, E., Woods, D., Levenson, N. (2006) *Resilience Engineering. Concepts and Precepts.* Ashgate Publishing.

Hollnagel, E. (2009). T*he ETTO principle: Effciency-Thoroughness Trade-Off. Why things that go right sometimes go wrong.* Ashgate Publishing.

Hollnagel, E., Leonhardt, J., Licu, T., Shorrock, S. (2013) *From Safety-I to Safety-II: A White Paper.* DNM Safety. Eurocontrol.

Hollnagel, E. (2014) *Safety-I and Safety-II: The Past and Future of Safety Management.* Ashgate Publishing.

IMO, *Safety Culture*. http://www.imo.org/en/OurWork/HumanElement/VisionPrinciplesGoals/Pages/Safety-Culture.aspx (Accessed 1.9.2016)

IMO, *Safety Culture Leaflet.* http://www.imo.org/en/OurWork/HumanElement/VisionPrinciplesGoals/Documents/safetycultureleaflet.pdf (accessed 1.9.2016)

Jepsen, J., Zhao, Z., van Leeuwen, W. (2015) *Seafarer fatigue: a review of risk factors, consequences for seafarers' health and safety and options for mitigation.* International Maritime Health 2015; 66, 2: 106-117.

Knudsen, F. (2009) *Paperwork at the service of safety? Workers´ reluctance against written procedures exemplified by the concept of 'seamanship'.* Safety Science 47 (2009) 295-303. Elsevier Ltd.

Lappalainen, J. (2016) *Finnish Maritime Personnel's Conception on Safety Management and Safety Culture.* Publication of University of Turku. Sarja – ser. A II osa- tom. 316.

Levenson, N. (2011) *Engineering a Safer World. Systems Thinking Applied to Safety*. The MIT Press.

Mauelshagen, C., Denyer, D., Carter, M., Pollard, S. (2013) *Respect for experience and organisational ability to operate in complex and safety critical environments.* Journal of Risk Research. Vol. 16, No. 9, 1187-1207. Taylor & Francis.

Mazaher, A., Montewka, J., Nisula, J., Kujala, P. (2015) *Usability of accident and incident reports for evidence-based risk modeling – A case study on ship grounding reports.* Safety Science 76 (2015) 202 – 214. Elsevier Ltd.

Pohjalainen, M. (2012) *Hiljaisen tiedon käsite ja hiljaisen tiedon tutkimus: katsaus viimeaikaiseen kehitykseen.* Informaatiotutkimus 31(3)-2012.

Puusa, A.; Eerikäinen, M. (2010*). Is Tacit Knowledge Really Tacit?* Electronic Journal of Knowledge Management Volume 8 Issue 3 (307-318). www.ejk.com

Schröder-Hinrichs, J-U., Hollnagel, E., Baldauf, M., Hofmann, S., Kataria, A. (2013) *Maritime human factors and IMO Policy.* Maritime Policy & Management. Vol. 40, No. 3, 243-260. Taylor & Francis. http://www.tandfonline.com/doi/abs/10.1080/03088839.2013.782974

Suur-Inkeroinen, S. (2012) *Hiljaisen tiedon siirtäminen ja jakaminen – Case tutkimus mestarit ja kisällit.* ProGradu. Tampere University.

Thotokas, I., Lagoudis, I., Kotsiopoulos, N. (2014) *Leadership Profiling of Ocean Going Ship Masters.* The Asian Journal of Shipping and Logistics. Vol. 30 No. 3. 321-343.

Von Krogh, G., Ichijo, K., Nonaka, I. (2000) *Enabling Knowledge Creation. How toUnlock the Mystery of Tacit Knowledgeand Release the Power of Innovation.* Oxfor University Press, Inc. New York.

THE DYNAMIC NATURE OF MARITIME SAFETY
An Essay

Johanna Salokannel

"What is essential is invisible to the eye."
Antoine de Saint Exupéry

1 Introduction

Tens of millions of tons of chemicals are transported in the Baltic Sea on yearly basis and the traffic is increasing. Harsh winter conditions and dense traffic situations increase the risk of a largescale maritime Hazardous and Noxious Substance (HNS) incident and in the worst case, Search and Rescue (SAR) operations in worst conditions. The primary objective of SAR operations is to save human lives. (ChemSAR) For the rescue authorities the SAR process starts when they get a distress call from the vessel in distress. For the distress vessel crew it will start earlier, from the moment of detection of a chemical spill. Therefore, as an event that has a start and an end, the HNS incidents should be viewed from the moment of the incident discovery to the moment people are safe or otherwise operations concluded as ended. Even in the Baltic Sea, external help from rescue authorities does not arrive immediately. Hence, how the distress vessel crew response to the situation at hand before the external help arrives is essential and does have an impact on the whole SAR operations.

Shipping companies and ship crews are required by law to create their own emergency procedures, have regular drills and be as prepared as possible for a HNS incident. However, seafarers are not professionals in HNS incidents and face these situations very rarely in real life, if at all. External help, whether it is consultation via radio or telephone or physical intervention, is most likely needed. But, if an incident or an accident happens, whether external help available or not, seafarers are required to act and make decisions in dynamic, safety critical and hazardous situations.

In a HNS incident, the properties of the actual HNS involved has a great impact on the situation at hand making the premade emergency instructions quite general in nature. The Captain of a ship is left with many questions and decisions to make that might have limited amount of predefined answers. The preliminary assessment of the situation, information at hand and potential risks will determine the first response actions onboard that can have an impact for the success of whole SAR operation. The resources at sea are limited and time can be a critical factor. Still systematic, dynamic risk assessment tools for seafarers seems to be lacking to support decision making under high level of stress in a safety critical, dynamic situation.

Many risk assessment methods focus on preventing accidents and/or ensuring that the disaster recovery operations and disaster management is conducted in the most efficient and safe way possible. This forms a way for strategical organizational planning (Asbury and Jacobs, 2012). This is also essential for maritime safety management. However, many of these risk assessment methods are done in a static situation, where there is time to do research, have workshops, discussions and calculations to identify the hazards and assess their probabilities and impact. They are often time consuming and sometimes complex. These methods and techniques lack the ability to take into account the need for assessing risk in a dynamic, changing situation of an operation where new knowledge emerges from one moment to the next, the situation can evolve in an unpredictable manner and ways of working need to be adjusted accordingly to the ever changing operational environment. (Asbury and Jacobs, 2012)

There is very limited amount of literature regarding the concept of tactical aspect of safety in the maritime world even though elements like training and skills are acknowledged to have an impact of safety. There are references in the ice navigation for tactical planning while navigating in ice. In ice navigation, the general route from A to B is planned on a strategical level, but while navigating in the ice, tactical decisions need to be made in order to find the most favourable route through the ice. Tactical planning is about reading the equipment and available resources on the bridge like satellite-based ice charts, radar and look out (Kjerstad, 2011, 133). There are also tools like check lists, emergency procedures and exercises to address safety in a ad hoc safety critical situation, but these might not cover all needed aspects to ensure safety in a emergent situation like an accident. Many of these address the question of *What* needs to be done? But fail to address the *How?* of a particular situation. How to assess a situation and how to detect the correct risks of the actions we are about to take? How to choose one path from another or make sense of the constant information flow? Part of these skills comes also with experience and is regarded to be professionalism and tacit knowledge, but by developing methods and tools to support decision making when there is not experience about a certain issue would enhance safety also.

Maritime domain is quite regulated and safety is often seen to about compliance, even though constant improvement and self-regulation is acknowledged. According to IMO, safety culture is to take root in the professionalism of seafarers, in their attitudes and performance; and highlights key activities "*to recognise that accidents are preventable through following correct procedures and established best practices, constantly thinking safety and seeking continuous improvement*." The objective of safety management work should also be to "*inspire seafarers towards firm and effective self-regulation and to encourage personal ownership of established best practice*" (IMO Safety Culture). But, what happens when the established correct procedures have shortages and limitations?

The objective of this Essay is to address the dynamic and emergent nature of safety and its implications of on the maritime world, specially the human element at sea, the seafarers. The following chapters have the aim to open up the thinking behind complexity and unpredictability. Why, in spite of our best efforts to ensure safety, we still have difficulties to predict the future and hence also, create safety guards to all possible situations. The future contains uncertainties, but we still need to ensure safety also in situations where we do not know the risks.

2 Safety Paradoxes

James Reason discusses safety paradoxes (Reason, 2000) that arises from our complex systems and interweaved connections within the system and its surroundings (Hanén and Huhtinen, 9-11). Paradox can be defined as "*a statement contrary to received opinion; seemingly absurd though perhaps well-founded*" (Reason 2000, 9 referring to Concise Oxford Dictionary). As we pursue to achieve better safety for example by constantly increasing the amount of rules and regulations, we ourselves contribute to increasing complexity. When e.g. the legislative system we create reaches a certain point of complexity, the rules we have increased inevitably start to contradict. For us to improve safety, it is essential that we acknowledge the existence and understand these paradoxes. (Reason 2000, 3; Hanén and Huhtinen, 9)

The roots of International Regulations for the Prevention of Collisions at Sea (COLREGS) goes back to early 1800's. As the first steam ships started to appear, the risk of having a collision with traditional sailing vessels emerged. To respond to this emerging new risk, some rules to avoid collision were formulated in 1840s and in 1864 the main regulations to avoid collision at sea were codified. These rules have been modified during the years, last time in 1995, and we know them now as COLREGS. (Belcher 2002, 213-214)

The situation at sea, the ships, their speed and amount of traffic has changed since 1840's and as the COLREGS have evolved over time some conflicts and paradoxes has emerged. COLREGS apply well for encounter of two vessels, but for more than two the COLDREGS rules can start to contradict. An example of this is an encounter of three or more different vessels, where one vessel A is taking over another one, vessel B. Both having the same heading. At the same time there is crossing traffic, which needs to be taken into account. This overtaking vessel A will be in position, where she is the give-way vessel i.e. to keep clear from the vessel being overtaken, the vessel B. The responsibility of vessel B is to keep its heading and speed. However, due to the encounter of a third vessel C from port side, that has the responsibility give way to vessel A, the vessel A ends up in a situation where she both needs to give-way and keep her speed and heading. As the rules are starting to be contradicting, the navigators are required to solve the situation in an independent way. (John et al. 2013; Belcher 2012) The more traffic situation becomes dense and as long as there are no traffic separations schemes to direct traffic, contradictions in COLREGS start appear. Hence, to avoid collision will become independent interpretation of the situation by different ships and their navigators with the attempt to apply COLREGS with their best abilities according to their skills and situational awareness. The written rules are not necessarily capable anymore to cope with the increasing number of variables in the situation.

Another example from shipping is the "Lifeboat Imbroglio" (Drouin, 2008). Drouin writes that since 1990's with alarming regularity lifeboat accidents started to occur. (It is compulsory to have lifeboat exercises on a ship with regular intervals.) Even though some development work was done along the way, it took around 10 years before the matter was truly understood. In 2001, the UK Marine Accident Investigation Branch (MAIB) studied the UK's merchant fleet accident reports over the years and concluded that with entering confined spaces and falling overboard, lifeboat drills counted for 16% of all lives lost at sea in merchant ships within the UK database. During the investigated time of 1989 – 1999, 12 professional seafarers had lost their lives and 87 persons were injured. All accidents occurred during compulsory training exercises with experienced and qualified seafarers performing or supervising operations. Ironically, over the same period there was no record of someone being saved by a lifeboat. Hence, the compulsory lifeboat drills statistically had killed more people than they had saved in an emergency. (Drouin, 2008, 9; MAIB, 2001) The MAIB report was backed up by Australian authorities and Norwegians estimating that globally there are about 214 000 drills a year causing 1 000 accidents and as many as half causing fatalities. (Marsk Training, Launching a revolution)

Another safety paradox has been pointed out by Reason (2000, 5), that when the safety development work is ongoing, the well-defended and safe systems can become victims of their own success. The system safety has improved by learning from the negative data collected, but as the amount of negative incidents decline, the development slows down as there is no data to steer towards a safer state. Things like “learn from your mistakes” becomes obsolete if there are no mistakes to learn from. But this still does not mean, that accidents will not happen.

There is no absolute safety nor are there perfect systems. Safety is not a state that is once achieved and then left alone, but something that needs to be created again and again in constant striving. The situation at hand is different from the next, which makes safety also dynamic in nature. As the reality we live in is created of events interweaved together and their constant change and interaction, the causes and their effects are not always evident. The way we respond to an event changes the nature of the event, therefore the actions we take in a situation has consequences. It changes the way the situation evolves, which again affects the way we respond to it. This makes safety also situationally bound. (Hanén and Huhtinen, 13)

Change does no always appear as a consequence of actions taken. It can also emerge due to complexity and interconnectivity of different elements in a certain time and space. We create rules and regulations to ensure safety, but end up in a situation where the rules we create start to contradict with each other and suddenly blindly following the written rules will eventually decrease the level of safety. There are the paradoxes of safety and without accepting them as a part of safety development work, it will be hard to achieve true safety culture. (Hanén and Huhtinen, 2013, 13; Reason 2000, 3-14)

3 Assessing risk

Safety development relies quite far on risk assessments. Risk assessment is a systematical way to assess risks related to an activity. It includes steps to identify possible and relevant threats and hazards as well as opportunities, understanding and calculating the potential causes, probabilities and consequences. Risk assessment is a supporting tool for decision making to select the appropriate course of action to confront the potential future events while keeping the relevant requirements in mind. It is about probabilities of the future specifying what is at stake while pursuing a certain goal. Risk assessment is also about gathering data and transforming the learned information into an input that can be used in decision making in order to manage and control these risks. (Aven et al., 2014)

Formal Safety Assessment (FSA), originally influenced by offshore platform explosion in North Sea, the Piper Alpha disaster in 1988, aims at enhancing safety in the maritime domain. FSA is using risk analysis and cost benefit assessment in a structured and systematic way to support decision making weighting risks and risk control measures against cost effectiveness and safety regulations, proposed changes and existing standards. FSA is an important tool for maritime industry to enhance maritime safety. International Maritime Organization (IMO) defines it as: “*rational and systematic process for assessing the risks associated with shipping activity and for evaluating the costs and benefits of reducing the risks*”. (IMO, Formal Safety Assessment)

However, predicting possible hazards, their probabilities of occurring and the impacts, if realized, is not exact science. Risk assessments include facts but also assumptions about the future events. Also the complexity and intractability of systems introduce uncertainties and in spite of the best effort to make sense of and predict system operations in detail, it often turns out that the predictions are imperfect to some extent. Uncertainty arises from not knowing exactly what is going to happen and what kind of impact will there be. Hence, creating exact measures for mitigating, controlling or eliminating risk are often also approximate. (Aven, 2015; Aven and Krohn, 2013; Hollnagel, 2014; Grote, 2015; Gregory and Shanahan, 2010).

4 Risk management and uncertainties - The Black Swans and Perfect Storms

The severity of a risk is usually calculated by probabilities i.e. how likely it would happen and what kind of impact it could have. Aven and Krohn (2013) argue, that probability is just one way to describe uncertainty and that is too narrow. Aven and Krohn (2013) also continue, that probabilities for the same event could be the same, but what could result in a different outcome is the knowledge available when making safety critical decisions. Calculating probabilities includes assumptions about the future and judgements based on these assumptions, but they are still predictions and assumptions, not absolute facts.

Last decade of research on risk and uncertainty has also been influenced by Nassim Taleb and his book "The Black Swan" (Grote, 2014). Taleb's Black Swan is an event, that emerges as a surprise, has major effects and due to our human nature, we tend to make simplistic explanations afterwards with the benefit of hindsight (Taleb, 2007, p. xviii). The idea of Taleb's Black Swans is not all about negative events like the 9/11, but also about the ability to exploit positive opportunities like the success of Google or the World Wide Web. According to him, we should not try to predict Black Swans, but to build robustness towards negative events arguing that: "*what we do not know is far more significant than what we do know*" (Taleb, 2007, p. xix).

Aven (2015) discusses also the concept of the Black Swan. He argues that these surprising extreme events called Black Swans should be included in risk management. Aven (2015, p. 84) sees Black Swans as three different types: a) the unknown unknown (where no-one knows nor can anticipate or imagine), b) the unknown known (where we do not know but someone else does) and c) events that are judged to have negligible probability of occurrence and thus are not believed to occur. He argues, that we need new principles and methods to cover also the black swans. We cannot build a perfect system nor is there such a thing than absolute safety. Surprises always occur. Safety has to be managed another way than only compliance.

Paté-Cornell (2012) again describes "Black Swans" as unthinkable and the extremely unlikely events that cannot be anticipated and adds "Perfect Storms" that are a combination of knowns that occur regularly, but their conjunction is very rare. An example of these Perfect Storms could be the Japanese tragedy of Fukushima Daiichi nuclear plant. She comments (2012, p. 1824) that these can also be seen as lack of proactive risk management and raises the question how to address these rare events which cannot be foreseen based on signals and existing knowledge.

In the recent years the importance of including uncertainties into risk management has been acknowledged. Different methods how to understand complex socio-technical systems and uncertainties arising from their operation have been developed such as the Bayesian networks (for further details see e.g. Hänninen, 2014), STAMP (see e.g. Levenson, 2012) and FRAM (see e.g. Hollnagel, 2012). However, these methods allow to study the systems and their operation as well as possible hazards and risks with the luxury of time. They build a stock of common knowledge about system safety, create operational framework and guidelines for action in a critical situation, but lack to address sufficiently the risk assessment in a dynamic and emergent (as in unpredictable), safety-critical situation, when the black swans have landed and perfect storms are blowing at sea. Therefore, the following chapter will discuss the concept of dynamic risk assessment and the need for it in the maritime domain.

5 Dynamic risk assessment

In the 1990s, followed by high-profile fire-fighter deaths in service, Health and Safety Executive (HSE) in London, United Kingdom started to develop risk management of the firefighting operation. The deaths of firefighters in service highlighted the need for better risk assessment while at the field working in hazardous situations. Differing from the traditional, predictive risk assessment, dynamic risk assessment is supporting decision making on the spot when the decision maker is in a changing, unpredictable situation. (Jacobs, 2010)

Shipping is considered to be quite safe form of transportation, but seafaring is still seen as one of the most hazardous occupations with mortality rates considerably higher than for land based occupations (Kudsen, 2009; Hänninen, 2014). European Maritime Safety Agency (EMSA) states in their annual overview (EMSA, 2015, p.16), that for example in the year 2014 there were 99 very serious casualties with a total loss of a ship or a death or severe damage to the environment. In 2014 there were 765 serious casualties involving e.g. fire, collision, grounding, hull damage resulting in the ship being unfit to proceed, pollution or need for external assistance. And the number for less serious casualties and incidents was over 2000. The number of serious casualties has risen in the resent years and it is expected to possibly rise in the year 2015. (EMSA, 2015 p. 14-16) So even the number of ships with very serious and serious accidents is not high compared to the amount of ships sailing at sea on a yearly basis (approx. 60 000 ships), the numbers tell that seafarers do face hazardous situations, whether resulting in casualties or being near miss situations.

DRA is a tool for rapid decision making in an operational environment where the risk arises and the environment is dynamically changing rather than the actual risk itself (Asbury and Jacobs, 2014). As an example of this could be the chemical spill on a vessel at sea. The risk being the threat towards human health, environmental pollution and damage to property stays generally the same, but the environment changes over time due to actions taken, weather conditions, ship status, the development of a chemical spill and resources available in each moment. Hence, also decisions and performance are adjusted to occurring situational needs.

The operation of an organization is influenced by the environment it operates in. Understanding the business operations holistically is essential for assessing the risks faced by the organization. Asbury and Jacobs (2012, 22) divides risk management into three different levels introducing the 3-level risk management model for making decisions and assessing risks. The more time consuming levels are done first at a strategical and operational level. Risk assessment at the dynamic level is about real-time decisions in ad hoc situations. The strategical and operational levels create a framework within which to operate and guide decision making on the ground. The workers are empowered to make decisions, but are also expected to explain them. The risk assessments and decisions done at this level are usually done under time pressure taking only seconds to minutes (possibly hours) to decide which course of action to take. (Asbury and Jacobs, 2012) Even though these levels are clearly different, they should all contribute to one and other. Decisions made at the dynamic level should contribute to the defined business conduct done on the strategical level and the operational level should adequately ensure that the employees are empowered and trained towards the common goal. Therefore, efficient and correct feedback is important between the all tree levels. The risk assessments and decisions done on a dynamic level are responding to the uncertainties arising from a situation, which the two levels above have not been able to foresee, address or control (e.g. such as time and magnitude of an accident).

Hanén (2017, p. 104-105) also point out self-organization in complex systems. He states, that emergence brings out self-organization in a complex system even in situations with no control. This is enabled by the interaction of different components of the system. Different interactions and decisions done on the local level makes the system or situation unpredictable to a certain extent, but as the local decision making and action evolves through learning and interaction between different components, order starts to appear to the whole. The system responds to the needs of operational environment by attempting to adapt to prevailing situational needs and tries to control operation through acquiring information and feed-back loops. In order to survive in a complex environment, the systems needs to imitate its operational environment by becoming complex itself and through self-organization gains more adaptability. Therefore, decentralization of decision making and responsibility are needed all through the organization from the top down highlighting the need for experience based professionalism. Dynamic situations call for flexibility and self-organization, decentralization of decision making and feed back loops for successful operation in complex systems.

The strength of DRA is in its flexibility. DRA method allows to make decisions such as whether to comply with existing ways of working or make adjustments when and if the situation calls for it. (Okoli et al. 2016; Jacobs, 2010). International Maritime Dangerous Goods Code (IMDG) is a code for ships transporting packed dangerous goods. It has guidelines for emergency operations, first response, emergency first aid and general information about chemicals. IMDG Code is compulsory and acts as a guideline for shipping companies, when making their ship specific emergency procedures. But, in an chemical accident, even though all the correct procedures in place, captain of a vessel is still left with ad hoc decision making. Most likely these decisions are made under high level of stress on a short time scale often with a limited amount of factual information about the incident and its proceeding. Even the risks of such an incident can be predicted to some extent, predicting the true development of such a situation is difficult due to many different variables from weather conditions to HNS properties, location at sea to resources available and so on. Therefore, due to unforeseen situations and high level of uncertainty, flexibility is needed which allows adaptation and modification of behavior and decision making to situational needs as they arise (Grote, 2015).

This flexibility has implications. Decisions in a situation that has a high level of routine, standardization and predictability can be covered with compliance to established ways of working. But, when decisions are made under high level of uncertainty in ad hoc situations, performance adaptation, improvisation and sometimes even ignoring the rules might be needed. Okoli et al. (2016) conducted a research about experienced firefighters problem-solving strategies at an incident scene. The results show that decisions made are mainly adaptive and skill-based, where modifications and refinements to standard ways of doing are needed. The fire fighters reported, that sometimes they need to neglect or adapt firefighting rules to suit the current circumstances in order to ensure safety. Therefore, Okoli et. al (2016, p. 17) also state, that "*adaptive decisions extend beyond merely 'knowing that' to also include, more importantly, 'knowing how' and/or 'knowing when*'". These kind of situations both offer a place for learning, but also require appropriate skills and knowledge of operator to choose the correct course of action. It is important that the decision maker firstly recognizes the essential cues and information from the environment as well as has the capability to make sense of them, to interpret and use them to determine the right courses of action in a timely manner (Grote, 2015; Okoli et al., 2014).

Similarly for the DRA to be effective and actually result in the right courses of action, the crew using DRA need to understand and recognize the correct cues and stimuli in the situation at hand. They need to understand what is a hazard and a risk and what is not as well as make correct judgement calls about when to comply with rules and existing best practices and when to adjust performance and improvise, if needed. Understanding the limits of oneself, the physical and psychological strength, is also highlighted. Employees need to have understanding about when the risk is unacceptable and to remove themselves from the situation and report it further. Therefore, the behavior and competence of employees are a vital part of successful implementation of DRA (Spencer, 2005; Jacobs, 2010). The questions of what is seen as a risk, what kind of risks are acceptable and when to retrieve from the situation are a question of risk perception, the way an individual subjectively judges and understands risk. These can be influenced by safety culture and organizational core values. (Asbury and Jacobs, 2014)

6 Core Values

Core values are usually the way an organization wants to conduct business. They are about the operational philosophies and principles that guide the internal conduct, influence the organizational culture and how the organization relates to the outside world. The core values and operational philosophies also define what is accepted and what is not as well as what kind of risk taking is expected in a safety critical situation of an employee. Therefore, the core values help to establish risk tolerance levels specifying what kind of risks to take within certain operational boundaries. These core values need to be understood and acquired well by the whole organization, which supports a shared understanding of what kind of behavior is expected in relation to risk. (Okoli et al. 2016; Asbury and Jacobs, 2012) As an example of this in a HNS SAR operation is that the primary objective is to save human lives, which as a statement directs decision making and resource allocation towards saving people and if needed, places secondary priority to environment protection. An example is in IMDG Code, where emergency procedures suggest jettisoning chemicals over board to save human life if there is no other alternative. (IMDG Code Supplement, 2014, p. 57)

At sea, there is something that can be related to core values, but which often goes beyond the organizational business conduct. This is Seamanship. ‘Seamanship’ is in general the art of handling a ship in all conditions and weather, having the skills specific to seafaring and it is used in rule making to cover in the areas of uncertainties and encounters of unforeseen. Good seamanship is a fundamental principle, a core value of seafarers, still research show that seafarers feel that their seamanship is not necessarily valued (Antonsen, 2009; Knudsen, 2009; Lappalainen 2016). The International Regulations for Preventing Collisions at Sea (COLREGS, Rule 8) define also in rules to avoid collision to take any action according to rules and if circumstances admit, be positive, maneuver in ample time and “*with due regard to the observance of good seamanship*”. What actually is good seamanship has no specific universal definition, but Knudsen (2009, p. 295) defines seamanship: “*as a blend of professional knowledge, professional pride, and experience-based common sense*” that can be seen more than what is learned in school. They are the skills and knowledge of a seafaring profession, but also a question of attitude, intuitive decision making and accepted behavior. Therefore, they are values that guide seafaring and could be used in flexible rule making to guide and constrain human behavior and decision making.

7 Discussion and conclusions

Safety has two different aspects that are both vital and should equally be addressed in maritime safety development. The strategical aspect, including issues like international and national legislative framework, training and human resource issues, company policies and strategies, technological development and solutions, developments in physical operational environment etc. These all influence, facilitate and resource the decision making and action on a tactical level. At this level the seafarers face and respond to emerging situations ad hoc, whether being just another day at work or safety critical situation. Seafarers use their skills, knowledge and given resources to overcome emerging obstacles ensuring safety at the same time as they are striving to successfully accomplish the task at hand. The better their work is facilitated from a safety point of view, the better it will be for them to ensure and implement safety on daily basis. Therefore, without fully focusing on both aspects of strategical and tactical aspect of safety, true safety will be difficult to accomplish.

Safety is dynamic in nature. It emerges in the interaction between the components, between the operational environment of the situation and the actions of the crew. The particular situation at hand evolves as the crew takes action and the feed back signals guide next steps which again have an impact on the whole situation. Safety is also situationally bound. Action again follows decisions, whether rationally planned or rapid and intuitive. Well working equipment is important, but it is vital also to understand how to use it correctly. Available information is of no use, if there are no skills to make sense of it. Safety is only partially in the written word, in the legislation, rules and regulations or in the physical surroundings. The rest simply comes from the actions of the operators in a given moment, in the interaction between different components of a system and their ability of make use of what is at hand. And, the as we strive for safer systems, increasing complexity inevitably introduces safety paradoxes where what we have done to improve safety might end up deteriorating it.

Safety being an emergent property of a complex system, dynamic and emergent in nature that needs constant striving for, there might be a need for new tools and methods to ensure safety. Dynamic Risk Assessment could be a useful method being fast and flexible, which is needed in a fast evolving safety critical situation. However, it does need further research and studying, as what suits the firefighters, might not automatically suit the seafarers. If the uncertainties of maritime safety needs to be addressed, they cannot be covered with the same predictive and time consuming, traditional risk assessment tools.

When considering the use of DRA and principles of a effective way to respond to a complex situation, one cannot ignore the fact that it does support decentralization of decision making and emphasizes the need for flexibility to correctly respond to the situation at hand. But it is also needed to ensure that the energies are directed towards a common goal. How do we ensure that the decisions made are correct especially if there are no specific guidelines to direct the action? For example, vessels do have check lists for emergency procedures, which are based on regulations, therefore there are answers to questions on *What needs to be done*. In an incident, there are check lists, which can contain a point: 1) Make an initial assessment of the situation and analyze risks. But, what is lacking is the *How?*. How to continuously assess the hazardous situation at hand and analyze the risks from an evolving situation. How to be creative and improvise when needed and make the correct judgements about when to bend or even ignore the rules and when to comply. These could be the questions also for educational sector. How to educate self-regulative and empowered employees, who independently can make correct decisions in a emergent, safety critical situation under pressure and high risk. And this also inevitably leads to the question of leadership as empowered, safety conscious employees operating also within flexible rules might need another type of leadership than those working with high level of standardization and routines and compliance to established ways of working.

Striving for excellence and zero accidents is a worthy goal. However, hypothesis like we cannot create perfect systems and there is not such a thing, than absolute safety, cannot be ignored. To manage safety in an area of flexible rule making and performance adaptation could need new tools to ensure safety than what are used in a safety culture of compliance to established ways of working. Seafaring expertise called seamanship could be a key to manage flexibility and cope with uncertainties, as a core value to direct and control human behavior.

References

Antonsen, S. (2009) The relationship between culture and safety on offshore supply vessels. Safety Science 47 (2009) 1118-1128. Elsevier Ltd.

Ashbury S, Jacobs E (2014) Dynamic Risk Assessment The Practical Guide to Making Risk-Based Decisions with the 3-Level Risk Management Model. Routledge. London and New York.

Aven T (2014) Implications of black swans to the foundation and practice of risk assessment and management. Reability Engineering and System Safety 134 (2015) 83-91. Elsevier Ltd.

Aven T, Baraldi P, Flage R, Zio E (2014) Unvertainty in Risk Assessment: The Representation and Treatment of Uncertainties by Probabilistic and Non-Probabilistic Methods, First Edition. John Wiley & Sons, Ltd. United Kingdom.

Aven T, Krohn B S (2014) A new perspective on how to understand, assess and manage risk and the unforeseen. Reliability Engineering and System Safety 121 (2014) 1-10. Elsevier Ltd.

COLREGS (1972) Convention on the International Regulations for Preventing Collisions at Sea.

Duncan S (2005) Expect the unexpected. The Safety & Health Practitioner; Sep 2005; 23, 9; ProQuest pg. 43.

European Maritime Safety Agency (2015) Annual Overview of marine casualties and incident 2015.

Gregory K, Shanahan P (2010) The Human Element a guide to human behavior in shipping industry. The Stationery Office (TSO). www.tso.co.uk

Grote G (2015) Promoting safety by increasing uncertainty – Implications for risk management. Safety Science 71 (2015) 71-70. Elsevier Ltd.

Hollnagel E (2012) FRAM: the functional resonance analysis method. Modelling complex socio-technical systems. Ashgate Publishing Ltd.

Hollnagel E (2014) Safety-I and Safety-II: The Past and Future of Safety Management. Ashgate Publishing Limited. England.

Hänninen M (2014) Bayesian networks for maritime traffic accident prevention: Benefits and challenges. Accident Analysis & Prevention Volume 73, December 2014, pg. 305-312. Elsevier Ltd.

International Maritime Organization (IMO), Formal Safety Assessment http://www.imo.org/en/OurWork/safety/safetytopics/pages/formalsafetyassessment.aspx (Accessed 1.4.2017)

Jacobs E (2010) Take care of the hoof. The Safety & Health Practitioner; Jul 2010; 28, 7; ProQuest pg. 50.

Kjerstad N (2011) Ice Navigation. Tapir Academic Press, Trondheim, Norway.

Knudsen, F. (2009) Paperwork at the service of safety? Workers´ reluctance against written procedures exemplified by the concept of 'seamanship'. Safety Science 47 (2009) 295-303. Elsevier Ltd.

Lappalainen, J. (2016) Finnish Maritime Personnel's Conception on Safety Management and Safety Culture. Publication of University of Turku. Sarja – ser. A II osa- tom. 316.

Levenson N (2012) Engineering a Safer World. Systems Thinking Applied to Safety. The MIT Press.

Okoli J O, Weller G, Watt J (2014) Eliciting experts' knowledge in emergency response organizations. International Journal of Emergency Services. Vol. 3 No.2, 2014 pp. 118-130. Emerald Group Publishing Limited.

Okoli J, Watt J, Weller G, Wong W B.L. (2016) The role of expertise in dynamic risk assessment: A reflection of the problem-solving strategies used by experienced fireground commanders. Risk Management Vol. 18, 1, 4-25. Macmillan Publishers Ltd.

Paté-Cornell E (2012) On "Black Swans" and "Perfect Stroms": Risk Analysis and Management When Statistics Are Not Enough. Risk Analysis, Vol. 32, No. 11, 2012. Society for Risk Analysis.

Taleb N (2007) The Black Swan.

References

AAWA Position Paper. 2016. *Remote and Autonomous Ship – The next steps*. Jalonen, R., Tuominen, R., Wahlström, M. *Safety and security in autonomous shipping – challenges for research and development*. Pages 56-73. http://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/aawa-whitepaper-210616.pdf (accessed 15.2.2018)

Allianz Global Corporate & Speciality. *Safety of Shipping review 2015*. http://www.agcs.allianz.com/insights/white-papers-and-case-studies/safety-and-shipping-review-2015/ (accessed 12.6.2016)

Antonsen, S. (2009) *The relationship between culture and safety on offshore supply vessels*. Safety Science 47 (2009) 1118-1128. Elsevier Ltd.

Ashbury S, Jacobs E (2014) Dynamic Risk Assessment The Practical Guide to Making Risk-Based Decisions with the 3-Level Risk Management Model. Routledge. London and New York.

Aven T (2014) Implications of black swans to the foundation and practice of risk assessment and management. Reability Engineering and System Safety 134 (2015) 83-91. Elsevier Ltd.

Aven T, Baraldi P, Flage R, Zio E (2014) Unvertainty in Risk Assessment: The Representation and Treatment of Uncertainties by Probabilistic and Non-Probabilistic Methods, First Edition. John Wiley & Sons, Ltd. United Kingdom.

Aven T, Krohn B S (2014) A new perspective on how to understand, assess and manage risk and the unforeseen. Reliability Engineering and System Safety 121 (2014) 1-10. Elsevier Ltd.

Belcher, P. (2002) A Sociological interpretation of the COLREGS. The Journal of Navigation, 55, 213-224. The Royal Institute of Navigation.

Berg, H.P. (2013) Human Factors and Safety Culture in Maritime Safety (revised). The International Journal on Marine Navigation and Safety of Sea Transportation.

Bergheim K, Nielsen M B, Mearns K, Eid J (2014) The Relationship between psychological capital, job satisfaction, and safety perceptions in the maritime industry. Safety Science 74 (2015) 27-36

Besnard D, Hollnagel E (2014) I want to believe: some myths about the management of industrial safety. Cognition, Technology and Work, Springer Verlag (Germany), 2014, 16 (1), pp.13-23. hal-00720270

Bhardwaj, M., Monin, J. (2006) Tacit to explicit: an interplay shaping organization knowledge. Journal of Knowledge Management. Vol. 10, no. 3, pp. 72-85. Emerald Group Publishing Limited.

Brian, T., Laczko,F. 2014. Fatal Jouneys. Tracking Lives Lost during Migrantion. International Organization for Migration (IOM). Geneva. Switzerland.

Carpenter G, Wyman O (2014) Arctic Shipping: Navigating the Risks and Opportunities. https://www.marsh.com/uk/insights/research/arctic-shipping-navigating-the-risks-and-opportunities.html

ChemSAR project. https://blogit.utu.fi/chemsar/

MARSH Risk Management Research http://www.safety4sea.com/images/media/pdf/Arctic_Shipping_Lanes_MRMR_August_2014_US.pdf . Accessed 25 May 2015

Chauvin C, Lardjane S, Morel G, Clostermann J-P, Langard B (2013) Human and organisational factors in maritime accidents: Analysis of collisions at sea using the HFACS. Accident Analysis and Prevention 59 (2013) 26-37

Danton, G. (2009) The Theory and Practice of Seamanship. Eleventh Edition. Taylor & Francis e-Library.

Dekker, S. (2006) The Field Guide to Understanding Human Error. Ashgate Publishing.

Doz Y, Kosonen M (2008) Fast Strategy – How strategic agility will help you stay ahead of the game. Harlow: Wharton School Publishing.

Drouin, P.(2008) The lifeboat imbroglio. http://www.nautinst.org/filemanager/root/site_assets/forums/lifeboat_safety/the_lifeboat_imbroglio.pdf (accessed 1.5.2016)

Duncan S (2005) Expect the unexpected. The Safety & Health Practitioner; Sep 2005; 23, 9; ProQuest pg. 43. Wharton School Publishing

EMSA. Annual Overview of Marine Casualties and Incident 2015 http://www.emsa.europa.eu/news-a-press-centre/external-news/item/2551-annual-overview-of-marine-casualties-and-incidents-2015.html (accessed 1.6.2016)

Grech, M. 2016. Fatigue Risk Management: A Maritime Framework. International Journal of Environmental Research and Public Health. February 2016. Vol. 13(2), pp. 1-9.

Gregory K, Shanahan P (2010) The Human Element a guide to human behavior in shipping industry. The Stationery Office (TSO). www.tso.co.uk

Grote, G (2014) Promoting safety by increasing uncertainty – Implications for risk management. Safety Science 71 (2015) 71- 79

Haase, T., Termath, W. Martsch, M. (2013) How to Save Expert Knowledge for the organization: Methods for Collecting and Documenting Expert Knowledge Using Virtual Reality Based Learning Environments. Procedia Computer Science 25 (2013) 236-246. Elsevier B.V.

Hanén, T (2017) Yllätysten Edessä. Komleksisuusteoreettinen tulkinta yllättävien ja dynaamisten tilanteiden johtamisesta. National Defence Universtiy Series 1: Researdch Publication No. 11. Doctoral Dissertation.

Hanén, T., Huhtinen, A-M. (2011). Yhteenkietoutumisen teoria – Yllätysten ja sattuman tieteellinen selitys. Tiede ja Ase N:o 69 2011, 9-33.

Hollnagel E (2009) ETTO Principle: Efficiency – Thoroughness Trade-Off: Why Things That go Right Sometimes Go Wrong. Ashgate Publishing Limited, Surrey

Hollnagel E (2012) FRAM: the functional resonance analysis method. Modelling complex sociotechnical systems. Ashgate Publishing Ltd.

Hollnagel E (2014) Safety-I and Safety-II: The Past and Future of Safety Management. Ashgate Publishing Limited, Surrey

Hollnagel, E., Leonhardt, J., Licu, T., Shorrock, S. (2013) From Safety-I to Safety-II: A White Paper. DNM Safety. Eurocontrol.

Hollnagel E, Pariès J, Woods D D (2011) Resilience Engineering in Practise: A Guidebook. Ashgate Publishing Limited, Surrey

Hollnagel, E., Woods, D. D. (2005) Joint Cognitive Systems. Foundations of Cognitive Systems Engineering. Taylor & Francis Group. USA

Hänninen M (2014) Bayesian networks for maritime traffic accident prevention: Benefits and challenges. Accident Analysis & Prevention Volume 73, December 2014, pg. 305-312. Elsevier Ltd.

ICS - International Chamber of Shipping, IMO Symposium of the Future of Ship Safety. 2013. Implementing an Effective Safety Culture – Basic Advice for Shipping Companies and Seafarers

International Maritime Organization (IMO), Formal Safety Assessment http://www.imo.org/en/OurWork/safety/safetytopics/pages/formalsafetyassessment.aspx (Accessed 1.4.217)

International Maritime Organization (IMO) (2010) Guidelines for Ships Operating in Polar Waters. Resolution A.1024(26)

International Maritime Organization (IMO) Safety Culture http://www.imo.org/en/OurWork/HumanElement/SafetyCulture/Pages/Default.aspx Accessed 1 June 2015

IMO, Safety Culture Leaflet. http://www.imo.org/en/OurWork/HumanElement/VisionPrinciplesGoals/Documents/safetycultureleaflet.pdf (accessed 1.9.2016)

Jacobs E (2010) Take care of the hoof. The Safety & Health Practitioner; Jul 2010; 28, 7; ProQuest pg. 50.

Jensen Ø (2007) The IMO Guidelines for Ships Operating in Arctic Ice-covered Waters. From Voluntary to Mandatory Tool for Navigation Safety and Environmental Protection? FNI Report 2/2007. The Fridtjof Nansen Institute

Jepsen, J., Zhao, Z., van Leeuwen, W. (2015) Seafarer fatigue: a review of risk factors, consequences for seafarers' health and safety and options for mitigation. International Maritime Health 2015; 66, 2: 106-117.

John, P., Björkroth, P., Noble, A. (2013) Making SMCP count! Conference paper in International Maritime English Conference, IMEC 2013, Istanbul, Turkey.

Kjerstad N (2011) Ice Navigation. Tapir Academic Press, Trondheim, Norway.

Knudsen, F. (2009) Paperwork at the service of safety? Workers´ reluctance against written procedures exemplified by the concept of 'seamanship'. Safety Science 47 (2009) 295-303. Elsevier Ltd.

Kurt, R. E., Arslan, V., Turan, O. (2015) WP4: Dealing with Maritime Workarounds and Developing Smarter Procedures. SEAHORSE Project presentation. 13.10.2015 in Rotterdam. http://www.seahorseproject.eu/Portals/59/03_Introduction%20Smart%20Procedures.pdf (accessed 15.5.2016)

Lappalainen, J. (2008) Transforming Maritime Safety Culture. Evaluation of the impacts of the ISM Code on maritime safety culture in Finland. A 46. Publications from the Centre for Maritime Studies. University of Turku.

Lappalainen, J. (2016) Finnish Maritime Personnel's Conception on Safety Management and Safety Culture. Publication of University of Turku. Sarja – ser. A II osa- tom. 316.

Leonhardt J, Macchi L, Hollnagel E, Kirwan B (2009) A White Paper on Resilience Engineering for ATM. European Organisation for the Safety of Air Navigation (EUROCONTROL)

Levenson N (2012) Engineering a Safer World. Systems Thinking Applied to Safety. The MIT Press.

Liu M-L, Liu N-T, Ding C G, Lin C-P (2014) Exploring team performance in high-tech industries: Future trends of building up teamwork. Technological Forecasting & Social Change 91 (2015) 295-310

Limnéll, J., Majewski, K., Salminen, M. (2014) Kyberturvallisuus. E-Book. Docendo Oy. Jyväskylä

Maersk Training, Launching a Revolution. https://www.maersktraining.com/launching-a-revolution (accessed 3.5.2016)

MAIB. 2001. Safety Study 1/2001. Review of Lifeboat and Launching Systems' Accidents. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/377610/Lifeboat_Study.pdf (accessed 3.5.2016)

Marchenko, N. (2015) Arctic Safety Issues. http://umanitoba.ca/faculties/management/ti/media/docs/N_Marchenko.pdf Accessed 10 July 2015

Martínez-Córcoles M, Schöbel M, Gracia F J, Tomás I, Peiró J M (2012) Linking empowering leadership to safety participation in nuclear plants: A structural equation model. Journal of Safety Research 43 (2012) 215-221

Mazaheri A, Montewka J, Nisula J, Kujala P (2015) Usability of accident and incident reports for evidencebased risk modeling – A case study on ship ground-ing reports. Safety Science 76 (2015) 202-214

Mauelshagen, C., Denyer, D., Carter, M., Pollard, S. (2013) Respect for experience and organisational ability to operate in complex and safety critical environments. Journal of Risk Research. Vol. 16, No. 9, 1187-1207. Taylor & Francis.

MUNIN, http://www.unmanned-ship.org/munin/ (accessed 12.5.2016)

Murphy J D (2014) Courage to Execute: What Elite U.S. Military Units Can Teach Business about Leadership and Team Performance. John Wiley & Sons, Incorporated, New Jersey

Nicolis, G, Nicolis, C. 2012. Foundations of Complex Systems. Emergence, Information and Prediction. 2nd Edition. World Scientific Publishing Co. Pte. Ltd.

Okoli J O, Weller G, Watt J (2014) Eliciting experts' knowledge in emergency response organizations. International Journal of Emergency Services. Vol. 3 No.2, 2014 pp. 118-130. Emerald Group Publishing Limited.

Okoli J, Watt J, Weller G, Wong W B.L. (2016) The role of expertise in dynamic risk assessment: A reflection of the problem-solving strategies used by experienced fireground commanders. Risk Management Vol. 18, 1, 4-25. Macmillan Publishers Ltd.

Palttala, P. and Vos, M. (2012), Quality Indicators for Crisis Communication to Support Emergency Management by Public Authorities. Journal of Contingencies and Crisis Management, Vol.20, Issue 1, pp. 39-51.

Paté-Cornell E (2012) On “Black Swans” and “Perfect Stroms”: Risk Analysis and Management When Statistics Are Not Enough. Risk Analysis, Vol. 32, No. 11, 2012. Society for Risk Analysis.

Pohjalainen, M. (2012) Hiljaisen tiedon käsite ja hiljaisen tiedon tutkimus: katsaus viimeaikaiseen kehitykseen. Informaatiotutkimus 31(3)-2012.

Progoulaki M, Theotokas I (2009) Human resource management and competitive advantage: An application of resource-based view in the shipping industry. Marine Policy 34 (2010) 575-582

Schröder-Hinrichs, J-U., Hollnagel, E., Baldauf, M., Hofmann, S., Kataria, A. (2013) Maritime human factors and IMO Policy. Maritime Policy & Management. Vol. 40, No. 3, 243-260. Taylor & Francis. http://www.tandfonline.com/doi/abs/10.1080/03088839.2013.782974

Stewart E J, Dawson J (2011) A Matter of Good Fortune? The Grounding of the Clipper Adventurer in the Northwest Passage, Arctic Canada. Arctic Vol. 64, NO. 2 http://pubs.aina.ucalgary.ca/arctic/Arctic64-2-263.pdf Accessed 8 July 2015

Suppiah, Rakish, (2007). Departure from COLREGS infringement or good seamanship. World Maritime University Dissertations. 117. http://commons.wmu.se/all_dissertations/117

Suur-Inkeroinen, S. (2012) Hiljaisen tiedon siirtäminen ja jakaminen – Case tutkimus mestarit ja kisällit. ProGradu. Tampere University

Puusa, A.; Eerikäinen, M. (2010). Is Tacit Knowledge Really Tacit? Electronic Journal of Knowledge Management Volume 8 Issue 3 (307-318). www.ejk.com

Taleb N (2007) The Black Swan.

The New York Times, All Safe in Soviet Ship Drama. http://www.nytimes.com/1989/06/21/world/all-safe-in-soviet-ship-drama.html Accessed 8 July 2015

Theotokas I, Lagoudis I N, Kotsiopoulos N (2014) Leaders Profiling of Ocean Going Ship Masters. The Asian Journal Of Shipping and Logistics, Vol. 30, Number 3, pp. 321-343

Virtuaali Ammattikorkeakoulu, http://www2.amk.fi/digma.fi/www.amk.fi/opintojaksot/0709019/1193463890749/1193463919223/1193464257338/1193665362820.html (accessed 4.6.2017)

Von Krogh, G., Ichijo, K., Nonaka, I. (2000) Enabling Knowledge Creation. How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation. Oxfor University Press, Inc. New York.

Walters, D., Bailey, N. (2013) Lives in Peril: Profit or Safety in the Global Maritime Industry? Palmgrave Macmillan UK.

Walton, D. (2005) Abductive reasoning. The University of Alabama Press. Tuscaloosa, Alabama. United State of America.

Wright G R, Zimmerman C M (2015) Vector Data Extraction from Forward-Looking Sonar Imagery for Hydrographic Survey and Hazard to Navigation Detection. Oceans 2015, Washington D.C.

Tables

Appendix

Appendix 1

WINMOS II – Winter Navigation Motorways of the Sea

Research Plan

Within the next years, significant number of highly experienced icebreaker officers will retire with the risk of leaving a gap in the knowhow of ice breaking skills and knowledge in Finland and Sweden. Due to warmer winters in the Baltic Sea area as well as the generation change of ice breakers, the younger officers do not have similar opportunities to practise their skills in ice conditions. There is still a great need to maintain a high level skills and competencies of the icebreaker officers. Therefore, research and development is needed in the field to study the tacit knowledge of experienced icebreaker officers and to analyze the required motor and cognitive skills that enable creation of training material that focuses on the most important issues.

Ice breaker operations focus a lot on visual skills, on the ability to make sense of the situation and 'read' the surrounding ice conditions while operating an ice breaker. Therefore, Eye Tracker technology will be used. Eye tracking is a behavioral research tool measuring the point of gaze and the focus of attention of the employee while performing everyday work tasks. As ice breaking involves a high level of visual skills, eye tracking is used to understand how the icebreaker officers make decision, where they focus their attention and how they interact with their operational environment. Simulator environment is used as interference in real life icebreaking operations might compromise safety. Interviews are used to better understand their decision making and the reasoning, why some areas are the focus of their attention.

Video footage has been collected onboard ice breakers from various icebreaking operations, of which two has been transformed into simulator scenarios. These scenarios will be driven both by experienced ice breaker officers as well as unexperienced students for comparison, both with Eye Tracker glasses to capture their eye movements during icebreaking operations. All participants will be shown their own eye tracking video footage while conducting interviews about their decision making and judgement.

This is an ongoing research in Novia UAS / Aboa Mare Maritime Academy with cooperation partner Turku University, Eye-tracking Laboratories (Turku EyeLabs).

Appendix 2

ChemSAR - Operational Plans and Procedures for Maritime Search and Rescue in HNS Incidents

Plan to develop decision making in high risk situations

Tens of millions of tons of Hazardous and Noxious Substances (HNS) are transported in the Baltic Sea on yearly basis. With harsh winter conditions and increasing traffic the probability of a large scale accident increases and in the worst case, will be high risk search and rescue (SAR) operation in difficult conditions.

Even though all nations do have their own national practices for maritime chemical incidents, there is a lack of common operational plans and standard operational procedures for SAR operations between Baltic countries to address joint large scale chemical incidents. In these cases no country has sufficient resources to handle the situation alone, therefore they call for joint rescue operations and common guidelines.

SAR operations in HNS incidents is considered to be a high risk operation both for the rescue authorities and for the seafarers. For seafarers, external help will not arrive immediately unless they are in or near a port. Regardless the fact that seafarers are not professionals dealing with a HNS incidents having possibly no real life experience in SAR operations other than exercises, they do need to respond to the incident and make rapid decisions most likely in a safety critical situation under high level of stress and time limits.

In order to find methods to train rapid decision making, a method called Decision Games will be implemented in workshops with maritime students, professional seafarers and rescue authorities. Decision Games workshop is modified from Tactical Decision Games developed by Dr. Gary Klein when conducting research in military world and with firefighters to provide realistic training without loosing lives. Tactical Decision Games are designed to enhance non-technical skills needed in emergency management with the objective to improve efficiency focusing on decision making under pressure, situational awareness, communication and teamwork. As chemical accidents are very rare, decision games give the opportunity to both practice decision making in "simulated" environment, but also test the created standard operational procedures to find possible insufficiencies and shortages.

Decision Games are a paper and pen exercise, which are quite simple to arrange to compliment more resource-demanding exercises like large scale table tops and simulator exercises. They do require thorough scenario planning and research as the games need to be as realistic as possible to maintain effectiveness of training. When combining with methods like What If –method, the variety of games can be adjusted easily to suit the needs of a target group.

These Decision Games are arranged in Novia UAS / Aboa Mare Maritime Academy in cooperation with Turku University, Centre for Maritime Studies in relation to work package 3 (WP3).

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