New Fire Strategies in the Wake of Umoe Ventus

Annex C – Human Factors

DBI
FIRE AND SECURITY

Content

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"*Wisdom is an attitude taken by persons toward the beliefs, values, knowledge, information, abilities, and skills that are held, a tendency to doubt that these are necessarily true or valid and to doubt that they are an exhaustive set of those things that could be known*" (Weick, 2008, p. 12)

1 Introduction

Present maritime rules and standards are based on the premise that steel is the prevalent construction material in ship design. Nevertheless, since the beginning of the 2000s there has been a move towards the use of "alternative designs and arrangements" in regard to fire safety (DBI, 2016). The use of FRP (Fibre Reinforced Polymer) composites in design and construction falls into this category, but still the application of this new paradigm relative to construction material is perceived a challenge to both authorities and industry.

Besides the historical, financial and technical challenges a key issue regarding FRP ships is fire safety. FRP composites have poor fire properties compared to steel constructions. This is due to the material's low ignition temperature and its combustible character. There are two strategies to tackle this: to design FRP components that mirror the fire properties of steel or to design a holistic approach embracing both the properties of the material and the fire strategies on board (DBI, 2016). The latter is conceptualized as a move from prescriptive-based design towards performance-based design (DBI, 2016).

The accident on Umoe Ventus in 2015 illustrates these challenging aspects concerning FRP ships, both in regard to the material itself and in regard to fire strategies especially.

The 23th of December 2015 the prototype surface effect ship Umoe Ventus grounded due to a fire. It took 15 minutes from when the fire broke out until the ship was engulfed in flames, which is why the crew evacuated the ship without trying to fight the fire (DMAIB, 2016). The Marine Accident Report emphasizes the following aspects concerning the range of the accident: distributed authority, a tolerance towards safety alarms and fire protection strategies based on traditional ship design applied on a FRP vessel (DMAIB, 2016). One of the main conclusions is that static and prescriptive emergency procedures often stand in contrast to the inherently dynamic nature of emergency situations – an aspect, which was particularly crucial in the case of Umoe Ventus because of the limited time for firefighting and evacuation.

Based on the general challenges of going from a steel paradigm to a FRP paradigm and the specific accident on Umoe Ventus, there is a call for more empirical studies concerning how safety is *perceived* at an operational level alongside how fire safety is in fact *enacted* on FRP ships.

The present study of human factors, as part of the larger project "New fire strategies in the wake of Umoe Ventus", addresses this knowledge gap. Based on an exposition of perceptions and practices of fire safety at an empirical level, the report gives recommendations to fire strategies prospectively, herein to training practices.

Since the study is first of its kind to explore perceptions and practices from a human perspective, the empirical findings are to be read as initial findings that will need to be further explored and refined in future studies e.g. taking the wider context of seafaring, regulations and practises across vessel type into account.

2 Research Design

2.1 Objectives

The main objectives of the research are to:

- Gather expert knowledge on the domain of FRP ship accidents and fire safety.
- Obtain insights on the perception of fire safety among masters and crew on FRP ships.
- Increase knowledge on existing training programmes at maritime educations, with regards to decision taking and evacuation strategies.
- Give recommendations to future fire strategies and training programmes relative to FRP ships.

The study consists of three phases; desk research, an expert study and an empirical case study.

1. The desk research is based on key documents of the project "New fire strategies in the wake of Umoe Ventus", maritime rules and standards and research articles focusing on facts, perceptions of fire safety besides language usage concerning the domain under study. Furthermore recruiting criteria for the expert study were identified.

2. The aim of the expert study was to get varied perspectives on fire safety on FRP ships - from different and relevant actors. Also the study revealed the knowledge gaps of the field, and in this manner ensured that the empirical study focused on obtaining new knowledge and not reproduce existing data.

3. The desk research and the expert study lay the ground for the empirical case study; two field visits at FRP ships. A case study is relevant when exploring real-life settings and is as such a way to obtain rich data on the phenomenon under study (Silverman, 2011). In this context the main objective was to get a nuanced picture of crew behaviour and interpersonal aspects in regard to fire safety.

2.2 Methodology

In the following, the specific methods and the analytical strategy related to each are accounted for.

The data material of the desk research consisted of documents and articles related specifically to the project and the accident of Umoe Ventus, study programmes of relevant shipping schools and various homepages. The documents included in the study were mainly used and analysed as resources to understand the domain better and not as the research topic itself (Justesen and Mik-Meyer, 2012).

The expert study consisted of seven in-depth interviews with relevant actors. The informants represented the training perspective, the point of view of ship management and shipyards along with a view from The Danish Maritime Accident Investigation Board and The Danish Maritime Authority.
In regards to sampling considerations the interviewees were chosen according to their position – all had deep understanding of the operational level besides being part of strategic considerations within their institutions. The interviews were either conducted by telephone or face-to-face and took a semi-structured question guide as point of departure (Alvesson, 2011). The analysis was thematic, focusing on the main topics in each interview and how the topics were related across perspectives.

The case study was based on two field trips to the following FRP ships: Fob Swath 3 and Wind Crew 1. At Fob Swoth 3 there are three crewmembers besides the master, whereas there is one mate besides the master on board the Wind Crew 1. Both vessels sail with passengers, but do not exceed the total of 12 untrained passengers. At the field trips, observations of work conditions were made (Justesen and Mik-Meyer, 2012) - meaning that the researcher took notes, based on an observation guide, during and immediately after the visits. Furthermore unstructured interviews with both the master and crewmembers of each ship were conducted. The focus was on personal experiences and perceptions of fire safety besides the distribution of roles on board. Both the completed observation guide and interview notes were subsequently assessed as equivalent data material and analysed accordingly.

Table 1: Data material

Type of data	
Documents	• Reports: Compass (2016): the use of FRP for passenger ships, DMAIB (2016): Marine Accident Report - Umoe Ventus, Umoe Mandal (2016): The fire on Umoe Ventus 23rd December 2015 - and measures taken on Umoe Firmus, EMSA (2017): Annual overview of marine casualties and incidents 2016. • Codes and conventions: The SOLAS Convention (2005), The STCW Convention (1996), IMO High Speed Craft Code (2011). • Project description: New fire strategies in the wake of Umoe Ventus (2016). • Articles on the Umoe Ventus Accident. • Notes from meetings with the project team. • Research articles.
Field trip: Observations and unstructured interviews	• Observations at Fob Swath 3 and Wind Crew 1. • One interview with a master. • Two interviews with crewmembers. • One group interview with master and first mate.
Semi-structured interviews	• One interview with Chief Investigator at The Danish Maritime Accident Investigation Board. • One interview with Chief Ship Surveyor at The Danish Maritime Authority. • One interview with Ship Surveyor at Svendborg Søfartsskole. • One interview with Study Director at Svendborg International Maritime Academy. • Two interviews with top managers from Odfjell Wind and Valling Shipping respectively. • One group interview with a senior manager and a project manager at Umoe Mandal.

Since the research is qualitative, relevant quality criteria are: transparency (to ensure trustworthiness) and validity (the degree to which the concepts applied are suitable in the description of the phenomenon under study). Moreover, taking a single case as point of departure shall be seen as a means to get deep insight on the domain of fire safety on FRP ships. Thus, it is not possible to do statistical generalisability but solely analytical generalisability i.e. to either compare the findings to existing theory or to compare with case studies in the same field of research (Justesen & Mik-Meyer, 2012; Yin, 2014).

3 Theoretical concepts

In the following a short introduction to some relevant theoretical concepts is given. The main point is to draw on applicable literature and hence base the forthcoming recommendations on key concepts related to fire safety at sea.

Based on an empirical study focusing on decision-making processes among skippers in the fishing industry Morel, Amalberti and Chauvin explored the relation between safety and resilience (Morel, Amalberti and Chauvin, 2008). The research was based on an understanding of safety as consisting of both human factors and systemic factors. Thus, the authors stress that it is important to focus on the interactions between the two factors and not approach them as individual components (Morel, Amalberti and Chauvin, 2008, p. 2).

The motivation for looking into the domain of fishermen is that skippers are especially faced with the challenge of balancing between safety and performance criteria – being employed in a high-risk domain/demanding context. The researchers were particularly interested in the risk reducing strategies of the skippers, which make them continue fishing even though the conditions are highly risky. The conclusion was that the skipper is the sole decision maker/owner in regards to continue or not continue, but that the risk taken is based on know-how, skills, information and high-level technology. Hence the authors pinpoint that safety in the domain of fishermen is influenced by the schism between safety and production goals, but also by a high level of adaptability based on the very craftsmanship itself.

The question of adaptability and resilience are also discussed by Weick, but from an organizational perspective. Based on the Mann Gulch Disaster, where 13 smoke jumpers (firefighters with parachutes) died in a forest fire and only three survived. Weick introduces the notion; collapse of sense-making in organizations. The disaster as a case reveals how one smoke jumper made an escape fire i.e. sat fire to a small area so that when the big fire approached he could keep safe in the place already burned out. Thus, he acted counter-intuitively but highly creative and adaptive, to survive a life-threatening situation. The point is that the main part of the smoke jumpers did not follow his example but choose to do what seemed the natural procedure. Thus, Weick concludes that decision-making is a highly contextual activity and in regards to resilience he subsequently introduces four features to counteract vulnerability: improvisation and bricolage (the ability to use the whatever is at hand), virtual role systems, the attitude of wisdom (to know the limits of one owns knowledge) and respectful interaction (Weick, 1993).

Linking the empirical cases and the perception of safety to the concept of resilience, the point is that resilience addresses how people engage in relevant actions and strategies that are situated in the following three temporal horizons: before, under and after. Firstly to envision a catastrophe before it takes place (can be based on simulations), secondly to adapt to a critical situation and take reasonable solutions (can be based on both human and systemic factors) and the third temporal horizon is how an organization/company manage the outcome of the accident (Morel, Amalberti and Chauvin, 2008).

The sources of resilience presented by Weick address the "under" temporal aspect of resilience, whereas Cook and Woods, by introducing the concept of Distancing Through Differencing address the "after" temporal aspect of resilience (Cook and Woods, 2012). Cook and Woods (2012) focus on barriers for organizational learning following accidents.

The authors perceive accidents as profoundly unexpected events making it crucial to focus on what in fact happened and how it is possible to prevent it from happening again. The concept is developed from an empirical case where a chemical fire broke out at a high technology product manufacturing plant, and where the subsequent response from similar settings in other countries changed from understanding to distancing.

The point of Cook and Woods is that there is a temporal window where it is possible to ask questions and address issues not usually raised and explored. The challenge is that accidents might be caused by a complex combination of both human and systemic factors, which is why the recommendation is to extend the window of opportunity of learning – and not disregard accidents even though they at the surface seem to be different; be that surroundings, technical features or competences.

"Analysis of the case reveals a discounting or distancing process whereby reviewers focus on differences, real and imagined, between the place, people, organization and circumstances where an incident happens and their own context. By focusing on the differences, they see no lessons for their own operation and practices or only narrow well-bounded responses. We call this pattern-distancing through differencing" (Cook and Woods, 2012).

Despite being based in empirically slightly different domains, fishermen, fire fighters and product manufacturing, the concepts of resilience, sense-making and distancing through differencing can enrich the understanding of existing practices met in the case of fire safety at FRP ships - and help structure the recommendations to future training and procedures.

4 Empirical Findings

The desk research, supplemented by knowledge from the expert study, identified the following key aspects regarding FRP ships:

- We are in a paradigm shift from steel as the predominant construction material to an increasing use of FRP constructions.
- Current fire safety procedures and legislation are primarily concerned with type of vessel and to a lesser extent construction materials.
- Knowledge on the implications regarding fire safety for the crew is low.
- Fire safety guidelines specific designed to FRP ships have only just been introduced (June 2017).

The paradigm shift from steel to FRP is, for the moment, primarily related to the construction area and is to a much lesser extent spread to the operational level, where the paradigm shift as a mind-set regarding fire safety practices is yet to be reckoned. Also the legislation and the conventions concerning training of personnel have not been changed, since legislation is developing backwards.

To sum up, the paradigm shift is happening on a tactical level (and the main reasons to do so lies herein as well), but not on an operational or a strategic level. As such the empirical research supported the knowledge gap that the present study is going to address. In this context the tactical level refers to ship management, ship yards and maritime educations; the strategic level to the Danish Maritime Authority and International Conventions, whereas the operational level encompasses crew and students at maritime educations.

In the following, the findings from the desk research, the expert study and the field visits will be presented under the following four analytical themes; FRP ships and fire safety, The ship as organization, Behaviour on board and Existing training programs.

4.1 FRP ships and fire safety

Fire seems to be perceived as the main danger on board of ships and has chapters on its own in the various international and national regulations. This is both due to the fire itself and to the evacuation situation, which might be just as dangerous. When evacuating a ship engulfed in flames you rely on the lifeboat to function and on the ability to get away from the vessel – a situation that can be happening in high seas and bad weather, making the evacuation potentially fatal.

4.1.1 The introduction of FRP

The political agenda focuses on time and environmental issues. The urge to build ships in new materials is founded on this dual objective; to make the ships operate faster due to their light weight compared to steel vessels and to reduce the use of fuel. Also these types of vessels are easier to manoeuvre, which is why they can realize other operational tasks than steel vessels. If FRP ships become lighter they can eventually use batteries, which again opens a whole new challenge regarding fire safety on board.

Nevertheless, there is no systematic, collected and documented data on behavior of crewmembers in case of fires on FRP ships. And across informants, the shared perception is that no one really knows anything about FRP materials, and their properties when it comes to fire safety. This is interesting since the history of building in FRP materials stems from the 1980s. But at the moment the procedures rely on standards made for other vessel types and on the concept of equivalency. Often, FRP ships are managed relative to the HSC-code, but this is not necessarily anchored in practice and/or perceived as a relevant code among practitioners – for example some FRP ships have, as the ones in the presented research, status as cargo vessels. As cargo vessel they are allowed to carry up to 24 passengers as long as 12 of them are trained in firefighting e.g. technicians and engineers. But it is worth mentioning that despite the high level of training of these passenger types, they are not trained in firefighting on ships and hence the contextual conditions of fire incidents at sea.

4.1.2 The concept of equivalency

Among the informants the shared understanding is that the maritime field is characterized by traditional thinking. This implicates that new developments, such as the use of FRP material and change in fire strategies, are based on the assumption of equivalency instead of a radically re-thinking of the systems, the competences of the crew and the approach to evacuation and fire safety. The assumption at a strategic level is that equivalency according to traditional rules is key in fire safety on FRP ships. But among practitioners there is a concern regarding the balance between systemic and human factors. Especially since the consequence of this aspect of equivalency is that more actions and responsibilities regarding evacuation and firefighting are put in the hands of the crew – a development, which the informants perceive to be correlated with the increased application of structural designs. The paradox is that most FRP vessels are small ships and hence have a fairly small crew. This means that there are only a limited number of hands to conduct the procedures concerning both firefighting and evacuation. In this sense the concept of equivalency is hard to enact in practice, because the size of the crew and their individual competences might be a critical factor that is hard to establish.

4.1.3 Fire safety

All the participants have formerly been operating steel ships. Therefore they have a good outset for comparing the experience of being a seaman on FRP and steel ships respectively. Some are more skeptical than others, but this is not related to being either a master or a mate. Despite the awareness that the conditions are different on FRP ships no one knows what the implications are in emergency situations, or what to do differently.

The main focus of the crew is preventing fire ignition by keeping in mind what circumstances are the most risky. As such fire safety, as part of general safety, is top of mind due to the profession and the vessel as work place. However, despite the focus on fire prevention, there is also an everyday life on board that is filled with practicalities and structural settings. In the pictures below it is exposed how e.g. the muster list might not be fully accessible and that the vessel is indeed a workspace where daily routines are outlived.


Picture 1: Passenger seat in the rear


Picture 2: Office in the middle of the ship

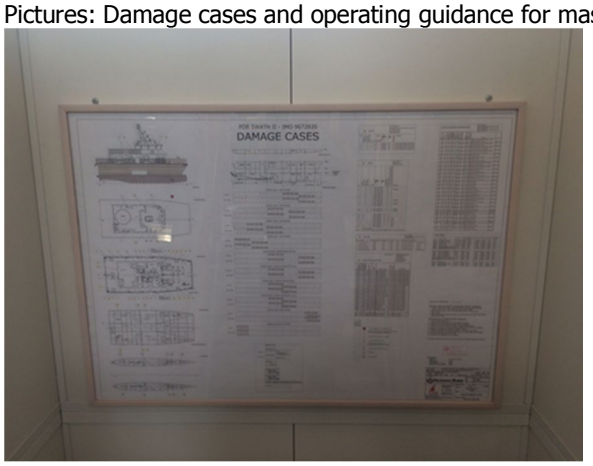

Picture 3: Galley

Regarding training there are different approaches, both in regard to existing standards, to vessel type and number of crewmembers. All participants know the training standards, but they all stress that some procedures make sense, for example to have coordinated training and simulations with different intervals, while others are perceived more idealistic not grasping the reality of being seamen. For instance it does not seem to be common practice that new crewmembers, herein masters, work as trainees before beginning at the FRP vessel.

Rather it is revealed that training is to a higher degree embedded in the daily routines at the ship. As a master pinpoints he and his first mate continuously evaluate their work based on day-to-day operations. In this manner, training is part of a communicative practice that is less systematized than standard training, but might be more contextual and relevant.

Across training procedures, be that relative to fire prevention, firefighting or evacuation, the crew comments that all procedures are the same as on steel vessels. Hence, despite the knowledge of conditional changes regarding fire safety on FRP ships, the study shows that no one knows how to change the training standards and practices accordingly.

Pictures: Damage cases and operating guidance for masters in distress situations



4.2 The ship as organization

A ship is part of a complex organizational diagram, which also is mirrored in the different phases in the life cycle of the specific ship. The key actors are the shipyard, the owner, the ship managers and the crew, including the master. There are some rules to be fulfilled when building the ship, others concerned with the operation of the ship and others again that are to be followed when e.g. the crew changes. To understand the conditions for the enactment of fire safety on FRP ships it is therefore important to integrate overall management issues and the aspect of time specifically.

4.2.1 Split authority

"*Being on a small ship, we all play a lot of roles*". As more responsibility is put into the hands of the crew, and the master specifically, the expectations of competences increase. But as an expert stresses: "*there is a difference between having authority and having the right competences to act in the most effective way*". In this sense it might be problematic to take for granted that the conditions for meeting changed demands to fire safety and fighting are already there. This aspect is also related to split authority and leadership at sea. The master is both responsible for safety (broadly) and for conducting training exercises, but he is also responsible for the daily operations – pushed forward, understood both positively and negatively, by the ship managers, owners or his own concern as owner, if this is the case. The master is therefore both split between his internal role on board the ship, day-to-day operations versus crew and ship safety, and externally being both an employee and the one with the main responsibility.

In regards to risk reducing strategies the research revealed that the final decision, "*to go or not to go*", is based on the masters professional identity – and that the interviewed masters take pride in taking the decision not to go, since this seems the most difficult one. As such the empirical findings mirror the schism of the case study among fishermen; that safety has both to do with production goals and the skill of adaptability.

Another aspect of authority is that, as an organization, the ship is in itself highly hierarchical. Despite an everyday life based on collaboration, the duties and tasks of each crewmember are clear. And regardless age and sailing experience the master has the overall responsibility for the ship, for the passengers and for the crew. This clearly supports a sense of security among the interviewees, but as the theoretical concept of sense-making elucidates, such a hierarchy might also lead to a collapse of sense-making if the master and subsequently the first mate do not act desirable. Thus, split authority – both master to crew and master to external actors, is a precondition when enacting seamanship and a crucial aspect to understand when developing systemic fire safety.

4.2.2 Time perspectives

"*It seems like we do not even have time to put on our immersion suit!"* The crew are very much aware of the temporal aspects concerning fire on FRP ships. Especially the masters and the experienced crew know that time is a crucial parameter, whereas the young crew do not have this focus to the same degree.

A master underscores his concerns regarding FRP ships by referring to these vessels as "plastic ships", others by stressing that Umoe Ventus burned within 15 minutes and that this fact seems frightening. The study exposed, that as part of subjective and inter-subjective perceptions of accidents, the crew share stories. They all knew about the accident at Umoe Ventus and Sea Gale (which is now Fob Swath 3), but the aspect of distancing through differencing was also apparent. The focal point of the stories was that the crew got seized with panic and that they did not make the appropriate decisions relative to the situation. In this manner the stories were not presented as stories of learning but rather as stories of failure specifically related to the crew behaviour on the presented ships.

The measures taken by Umoe Mandal, the shipyard building Umoe Ventus, are primarily of technical character; with the exception of crew training before the vessel departs from the shipyard. But this measure relative to human action might clash with the crew turnover and the contractual conditions of the crew. Since it is only the first crew who are introduced to the new technical features, the learning is rather of a technical matter than a behavioural matter taken the subsequently use of the ship into account.

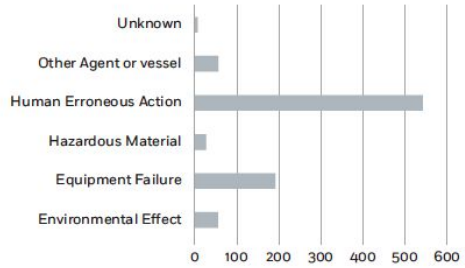
This is furthermore illustrated in the circumstance, that despite the acknowledged perspective of an extremely short time span from fire ignition to extensive fire spread, the crew in their explanation of firefighting and evacuation strategies did not present a different scenario than scenarios related to steel ships. The focus of the crew is first and foremost on the passengers and they all state that the passengers are to be saved first, before they will consider firefighting. But at the same time they are aware of the implication that the fire will then have five to ten minutes to evolve before the crew actually starts fighting it.

4.3 Behaviour on Board

In the following section, the main insights concerning conditions for behaviour on board are exposed. Especially the discussion of relevant competences and the equipment as supporting system for action were identified as key aspects.

4.3.1. Competences

"*You need to know what to do*". The crew quote underscores their focus on human competences. Human factors play a critical role in both accidents that occur, and in the handling of a given dangerous situation. This reality is illustrated in the following figure on marine accidental events in the period 2011-2015:



From a total of 880 accidental events analysed during the investigations, 62% were attributed to a Human Erroneous Action.

Source: European Maritime Safety Agency (2016)

The numbers in the figure are supported by the perceptions of the crew, since they all relate most accidents and incidents to human mistakes. Having a focus on these human factors alongside the temporal aspect regarding fire on board FRP ships, implicates that the experience of the crew seems to be more important than on other vessel types. The masters both stress that experienced crew is preferred and that unqualified crew is a stressful factor on FRP ships. There are two aspects at stake in regards to competences; the actual experience of a crew member and nationality. Despite the shared international rules, the masters emphasize that there are different competence levels – and that especially crew from Asia and Eastern Europe are not, in the outset, deemed as competent as crew from Scandinavia and Western Europe.

When asked what the main competences of the crew are in regards to safety the prompt answer is the ability to stay calm and not panic. The point that crewmembers need to "*use their head*"

elaborates this. These competences are critical for the crew, since they basically have to rely on each other. Still, there is also a shared understanding that everybody acts differently in stressful situations, making it hard to know if oneself, or ones colleagues, will actually behave in an appropriate way.

Another acknowledged competence regarding the profession is humbleness. As a first mate stresses: "*First of all, do not go against nature – go with it. You need to work the weather, but you also need to know that you can never win!".* The quote mirrors the shared perception among interviewees that a good seaman always thinks twice, acts according to the circumstances and stays calm i.e. to have surplus of mental resources.

4.3.2. Equipment issues

"One of the biggest problems regarding fire on ships like this, is that the smoke will kill you first". During the field visits a theme became equipment and to some extent the architecture of the vessel. Basically the fire equipment and the evacuation strategies are not especially designed for FRP ships and do not take neither the time perspective nor the toxic smoke into consideration.

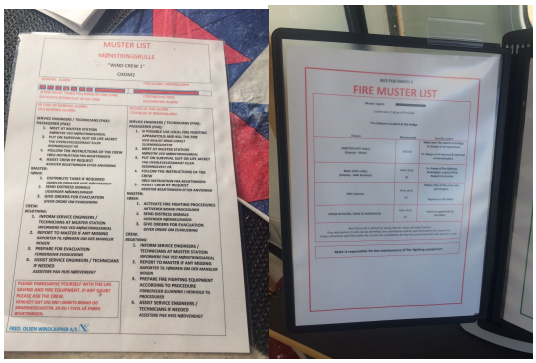
Since the crew are not trained as smoke divers and/or due to the size of the crew which does not make such equipment a legal requirement, the firefighting consists mainly of basic fire-fighting equipment such as foam extinguishers and sprinklers. In regards to time, the crew pinpoints that it actually takes some minutes to put on the immersion suit and regarding the toxic smoke there are no gas masks on board. One of the only differences compared to steel ships is that, due to the time aspect, there are always two safety rafts – one on each side of the ship.

Other exposed concerns have to do with the design of the ship. At Fob Swath 3 the crew cabins are placed behind the galley with only one entrance and hence no fire exits - since it is not possible to open the windows in the cabins. Also the emergency buttons at the bridge are positioned close to each other. A design that became critical when Sea Gale burned, since the story is that the crew panicked and pushed all the red buttons, herein the Stop Generator buttons (see picture next section).

A last focus, both at the field visits and in the expert study was the muster list. The muster list is a key document for the crew, since it defines who is going to do what and when – in case of alarm. As such the list is the most concrete tool relative to specific procedures and behaviour on board. The main problem regarding the muster list is that it is often composed based on previous muster lists and strategies that might not even be related to an FRP vessel.

4.3.3. Illustrations

Muster lists & Pick-up areas



Bridges & Panels



4.4 Existing training programmes

As part of the expert study and the pre-phase of the research at hand, a study on existing training programs was conducted. The aim was to obtain knowledge on the context of training and hence to qualify the forthcoming recommendations. In the following section, the maritime educational landscape in Denmark is presented and the perceptions of fire safety and evacuation among instructors within study programmes are identified.

4.4.1 Maritime educations in Denmark

In Denmark there are ten maritime educational institutions. The different institutions encompass two maritime schools (herein two trainings ships), a navigation school, two maritime education centres, three schools of marine engineering, a school educating commercial fishermen and one educating masters and skippers.

Danish Agency for Institutions and Educational Grants supervises the maritime education institutions to ensure that seafarers are trained in accordance with national and international regulations, including the STCW convention. STCW is an abbreviation for The International Convention for the Training of Seafarers, on Sailing and on Watch-keeping, and sets the qualification and educational requirements for masters, officers and watchmen on seagoing merchant ships.

The maritime education includes training for ship officer, shipmaster, ship engineer, ship mechanic, skipper, ship assistant, ship cook and commercial fishermen. To understand the crew's different roles in general and in regard to safety specifically, a list of their functions on the ship is hereby included:

Senior/Dual officer (Skibsofficer)	Responsible for sailing planning and navigation. Furthermore responsible for the ship's technical facilities, as well as safety and rescue equipment.
Master (Skibsfører)	Responsible for operational planning and navigation and responsible for the ship's safety and rescue equipment.
Skipper (Skipper)	Works as a mate on small and medium-sized ships.
Ship assistant/mate (Skibsassistent)	Take care of the practical work on board and work both on the tire and in the machine.
Officer (Styrmand)	Is mate/first mate on smaller ships.
Ship engineer officer (maskinmester)	Responsible for the ship's technical installations and overall maintenance on board.
Ship machinist (Skibsmaskinist)	Ensures that all machines on board operate. Do typical service on smaller merchant ships.
Ship mechanic	Maintains the ship and the ship's main and auxiliary machinery as well as

(Skibsmekaniker)	technical systems.
Cook (Skibskok)	Take care of all work in the area of the galley.
Commercial fisherman (Erhvervsfisker)	Sails as a fisherman on all vessels.
Commercial skipper (Fiskeskipper)	Steering officer, master and supervisor aboard fishing vessels.

The above mentioned working roles might all be present on the ship in a potential fire situation, which is why it is relevant to look into how the personnel are trained while under study - but also as part of continuing education. The various maritime education programs have workbooks describing the education process, which serve as guidelines for the education itself so as to proceed according to the international maritime conventions. The workbooks present information about the different safety and fire procedures the students are taught in.

4.4.2. Training in fire safety

The existing study programs concerned with fire safety rely mainly on the STCW convention and relates both to the maritime education itself and to continuing education. There are different standards depending on education and final roles of the students, but as part of continuing education all seamen are obliged to get their certificates renewed every fifth year.

The training programs focuses primarily on knowledge building relative to fire safety and on training the ability to follow procedures and interpret what action is to be taken in regard to the situation at hand. The students are therefore educated in generic fire strategies and only type of vessel, cargo or passenger ships, are explicitly addressed. Despite the shared understanding among interviewees that simulation is one thing and reality another, the educations do not focus on competences such as creativity, adaptability and how to think fast while staying calm. Instead the underlying assumption revealed in the interviews is that frequent training makes fire safety a second nature.

The maritime educational institutions take a broad perspective on safety. As an interviewee stresses, safety both has to do with the work-life on ships and the students' lives in general. Therefore there is a focus on creating a perception of safety as an integrated culture that permeates the actions and the mind-set of the students. Hence, the traditional training is supplemented with experience-based fire scenarios. Based on articles, reports and field visits the instructors take different accidents as point of departure for developing these scenarios and as outset for student discussions. Another aspect regarding knowledge sharing is the unstructured knowledge sharing going on when seamen meets at the continuing education and when seamen are invited to the educational programs as instructors. In this manner knowledge sharing is happening on different levels: from instructors to seamen, from seamen to instructors, from seaman to seaman and from instructor/seaman to students.

The maritime educations do not change their programs before a change in legislation has happened. Thus, even though it is acknowledged that FRP ships have some specific conditions relative to fire safety, there are no programs and training specifically designed to handling fire at FRP ships.

To sum up, the integration of fire safety regarding FRP ships is, at the Danish maritime educations, mainly based on discussions of accidents and subjective experiences, and there is no systematic training in the ability to tackle unexpected situations and improvisation.

5 Analytical tensions

The empirical analysis revealed three main tensions, which seem crucial to recognize when developing future guidelines for fire safety behaviour aboard FRP ships. In the following each tension will shortly be elaborated.

5.1 Generic procedures vs. contextual procedures

Fire safety consists of both generic procedures when being on board a certain ship type and contextual procedures relating to the specific vessel. This is mirrored in the tools that the crew and the master apply. There are specific rules regarding training, which are generic since they apply to all vessels of a specific type –e.g. the High Speed Craft Code – and then there is the muster list, which ideally takes the specific vessel as point of departure.

As mentioned the muster list is as such a key document for the crew besides being the most concrete tool relative to specific procedures concerning behaviour on board. But in practice the muster list seemed to be stock in-between a contextual and a generic document. The muster list, and the walk through of the list by the authorities at audits, might therefore be a weak link in the process of ensuring a high level of fire safety at FRP ships. Especially if the auditors do not have an awareness on the fire properties of FRP, and hence the contextual aspects influencing firefighting and evacuation procedures.

The exercises, both on board and as part of training programs, are based on generic procedures and are primarily concerned with the ship as passenger vessel or as cargo vessel. And despite the awareness that time is a key aspect regarding fire at FRP vessels both the maritime educations and the crew seems to be without tools to address this aspect in their simulations and training practices.

From a theoretical perspective on resilience, the muster list and the exercises are illustrations of "before" tools, since the plan and the training on board makes the crew visualize a specific scenario before it takes place. But still the scenarios are somehow fixed, hence, there is no time and no practice, for variety and re-thinking of new possible situations. As earlier mentioned, the aspects of authority also influences to what degree and in what way the generic procedures are in fact followed. Thus the tension between generic procedures and contextual procedures arises as theory meets practice.

5.2 Procedural competences vs. adaptive competences

By the introduction of new building materials, the roles of the crew changes. Whereas a steel ship to some degree is characterized by inherent, structural safety, FRP ships rely heavily on conditional safety i.e. technical and human factors. To make a FRP ship *as* safe as steel ships, the legislation focuses on equivalency – increasing the role of both electronic systems and human factors. This condition makes it relevant to discuss the competences of the crew. The issue at stake is that in stressful situations humans act according to their base of experience, but in emergencies/fatal situations, the actor will not necessarily have such a base to draw upon.

On the one hand it is therefore pivotal that the crew can follow procedures, but on the other hand it might be as important that they have the ability to dispense with these procedures if it is needed in the specific situation. Thus there is a challenge regarding static training for intrinsically dynamic situations and to identify what competences are essentially the most relevant. In regards to the time dimensions of resilience the question of competences addresses the "under" perspective. As an interviewee states; "*There is an inherent paradox in resilience management concerning the balance between controlled safety and virtuosity – I mean, how to orchestrate adaptability and elasticity?".*

5.3 Traditional/normative perception of "the craft of being a seaman" vs. real-life settings for *performing* good seafaring

The master is the last man leaving the ship – this heroic image of a master that leaves no men behind is widely shared, both inside and outside the profession of seamanship. But the question is what makes a good seaman, what is in fact expected from him and which skills are needed and appreciated? Among the informants there is a specific focus on experience as key and among the masters of the FRP ships they share a wish to work with experienced crew. But newly educated seamen need to accumulate knowledge and experience over time – as an informant states: "*calm sea makes poor sailors*".

As an interviewee stresses the field of seamanship has actually not changed that much despite enhanced use of technology and the introduction of new construction materials. And as stated earlier, the paradigm shift from steel to FRP are still primarily happening at a tactical level, despite being backed up by the political agenda. Nevertheless, the main focus is on the use of new materials and not on the implications regarding a change in mind-set. The focal point in this context is that the paradigm shift is more profound – it has to do with the very conditions for enacting the profession itself. When lack of time, personnel and experience becomes a key parameter regarding firefighting, the traditional perception of being a good seaman is challenged.

The accident at Umoe Ventus revealed that the real-life setting for performing seafaring was drastically different from that on steel ships. The crew was highly experienced, yet it seems that the experience from Umoe Ventus has not turned into organizational learning at an operational level (among seafarers and instructors), which might have to do with the process of distancing through differentiation and with a clash in sense-making relative to a normative perception of the good seaman. This tension is related to the "after" aspect of resilience, and hence to the barriers and opportunities of learning - to prevent a likely situation happening again.

6 Recommendations

Based on the empirical findings and the analytical categories, this section gives recommendations to fire safety on FRP ships and training programs respectively. The recommendations are to be read as input and inspiration and not as strict guidelines. The field of FRP ships is still underdeveloped knowledge-wise, which is why this study is a sort of first attempt to gain in-depth insights deeply anchored in practice. Another important note is that the recommendations address different levels, some relates to the strategic level (Danish Maritime Authority, International Conventions), some to the tactical level (ship management, ship yards, maritime educations) and others to the operational level (crew, students).

6.1 Input: general fire safety on FRP ships

- When building ships in new materials the concept and application of equivalency needs to be discussed more thoroughly. Since human factors are the most widespread reason for accidents, it calls to attention that more responsibility is put in the hands of the crew. When designing fire safety on FRP ships it is especially critical to approach maritime fire safety as comprised of interrelated factors such as human behaviour, technology, operations, building material etc. and not approach these as single components.

- At a strategic and tactical level it is imperative that there is an awareness of the contextual aspects, which influence the degree of fire safety on FRP ships. Therefore it would be rewarding, if the strategic level to a higher degree supported updated procedures, which are based in practice – leaving room for existing practices and the reality of being a seafarer.

- In a field build on experience it is key that organizational learning occurs - the process of distancing from differentiation underscores that the window for learning needs to be augmented by a more systematic approach to inter-organizational learning, that is not only based on storytelling. The authorities alongside the training schools play a key role in making conditions for this systematic approach available.

- There is a communication challenge in regards to responsibility; at a strategic level the perceptions is that rules and legislation is developed backwards, but at an operational level the perception is that the Danish Maritime Authority somehow legitimizes the procedures on board, making the Danish Maritime Authority an important player regarding *perceived* safety among the crew. An aspect, which might not be grounded in reality, since the Danish Maritime Authority do not guarantee that the contextual procedures are updated.

- The reduced time for fire spreading at FRP ships should be taken into account in ship design. This has to do with architecture, equipment and procedures. Firstly to make sure that the crew is not trapped behind a fire and that e.g. the galley not only needs to be approved as a "normal" kitchen. Secondly it might be fruitful to rethink the fire safety equipment on board on FRP ships, and lastly the muster list should be developed taking the fire properties of FRP ships and contextual matters into account.

- When designing fire safety procedures the aspect of authority and leadership should be considered. Since, as Weick stresses, role systems and respectful interaction is a pivotal factor in increasing resilience during fatal situations an enhanced focus on these matters at the strategic, the tactical and the operational levels seems decisive.

6.2 Input: training programs

- In training for fire safety on FRP ships, it would be rewarding to work more consciously with the before, under and after perspectives of the concept of resilience, especially the following sources of resilience as suggestions to counteract vulnerability: improvisation and bricolage alongside the aspect of creativity in life-threatening situations. To explicitly integrate these aspects is to acknowledge that creativity and improvisation needs to become a natural and normal way of managing critical situations.

- Based on the above-mentioned it is crucial to discuss what competences, as master and crew aboard FRP ship, are in fact the most relevant: could it be adaptability, flexibility, thinking fast, finding new solutions? For inspiration relative to training in adaptive competences the maritime educations can for example look into similar training programs within e.g. the military and the field of innovation studies.

- It is recommended to support a systematization of the experiences shared among seamen. One suggestion could be to develop a tool to collect all the day-to-day evaluations of the crew. Such a tool could support a simultaneous change in practices and operations and also become part of a contextual introduction to new crewmembers at the specific vessel.

- Since there is a lack of structured knowledge building within the field, the educational institutions could prospectively play a more active role in not only applying existing knowledge, but also producing new knowledge. Since the institutions have an extraordinary entrance to real-life insight from seafarers, the platform for knowledge building seems to be already there.

- It would be rewarding to develop training sessions/seminars, which takes not only type of vessels into account, but also the building material of the vessel. Since the development is pointed towards more vessels being made from new materials and using new technology, it could future proof the education in regard to increased awareness on the implications regarding behaviour and in regards to increased knowledge of different material's/technologies fire behaviour.

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