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## **Deliverable D07.2**

### **Field Study Report of Alarm Panel Insufficiencies and Improvement Identification**

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## Abstract

The LASH FIRE Digital Fire Central prototype has been developed over several iterations to arrive at its current state – an interactive, screen-based interface with functionality to match a large set of common fire management activities, including fire detection and assessment, deck and cargo information, control of fire dampers, fire doors and the drencher system. In addition, it also allows its users to follow events on a fire response timeline. Up until the time of this study, however, prototype development has mainly rested on needs and feedback reported by informants and test persons, and there was a perceived needs amongst the researchers to better understand the practical actions and interactions that would occur in an actual onboard fire scenario.

Two approaches were chosen to produce data for the present study. The primary ambition was to reach a deeper understanding of operational fire management under realistic circumstances. The secondary ambition was to gather experiences and perceptions from an international community of seafarers involved in onboard fire management and the use of fire safety systems.

Due to Covid-19, the possibilities to visit ships and carry out any classical ethnographic studies were out of reach. To still be able to collect data, a remote, video-based method was developed. The method consisted of two activities onboard ships – first, a system ‘thinking aloud’ walkthrough and later a fire drill, both of which were thoroughly documented on video. The questionnaire issued to seafarers focused on firefighting in ro-ro spaces and covered the phases 1. Detection 2. Confirmation 3. Assessment 4. Decision-making and 5. Suppression (excluding manual suppression).

The study clearly indicates that information needs should not only be considered for the Fire Commander and other bridge personnel, but also for personnel in the ECR, in the drencher room and at the fire scene. Distribution of fire safety systems controls should be done according to a concept for work distribution, paying respect to workload and crew inclusion, supporting shared situation awareness.

Several design implications for the Digital Fire Central were identified. Keeping track of events (e.g. written logs) was observed but there were no instances where it could be positively confirmed that notes were used to inform planning and decision-making. In addition, several observations were made where the information load around both ongoing and future activities on bridge personnel was high. Supporting such management processes is an important objective of LASH FIRE development, and one that is also included in ongoing work. Continuing, there may be a need to support assessment of the effects of drencher activation, information that could be used to determine when manual intervention is necessary, timely or even safe. Concerning manual intervention, there could be benefits to letting the bridge give more contextual information to the fire team around possible routes of entry or obstructions in the path. Digital technologies create many new opportunities for communicating and sharing information, but existing systems such as VHF/UHF has several benefits that should be retained. Results also indicate that benefits from new technologies may be undermined by organizational dynamics such as workplace culture and power hierarchies, obstructing the flow of information.



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# 1 Executive summary

## 1.1 Problem definition

The LASH FIRE Digital Fire Central prototype has been developed over several iterations to arrive at its current state – an interactive, screen-based interface with functionality to match a large set of common fire management activities, including fire detection and assessment, deck and cargo information, control of fire dampers, fire doors and the drencher system. In addition, it also allows its users to follow events and make annotations on a fire response timeline. Up until the time of this study, however, prototype development has mainly rested on needs and feedback reported by informants and test persons, and there was a perceived needs amongst the researchers to better understand the practical actions and interactions that would occur in an actual onboard fire scenario. Another aspect needing attention was the fact that, so far, feedback about fire management and systems functionality had only been obtained from a limited amount of crewmembers, all of which have represented Scandinavian ship operators. For this reason, there was a need to investigate seafarer experiences and perceptions in an international context.

## 1.2 Method

Two approaches were chosen to produce data for the present study. The primary ambition was to reach a deeper understanding of operational fire management under realistic circumstances. The secondary ambition was to gather experiences and perceptions from an international community of seafarers involved in onboard fire management and the use of fire safety systems. Due to Covid-19, the possibilities to visit ships and carry out any classical ethnographic studies were out of reach. In order to fulfil the first objective, a video-based ethnographic method was developed. The method consisted of two activities onboard ships – first, a system ‘thinking aloud’ walkthrough and later a fire drill, both of which were thoroughly documented on video. The second objective was fulfilled using a questionnaire. The questionnaire issued to seafarers focused on firefighting in ro-ro spaces and covered the phases 1. Detection 2. Confirmation 3. Assessment 4. Decision-making and 5. Suppression (excluding manual suppression).

This deliverable serves to guide future iterations of the Digital Fire Central developed within LASH FIRE, pointing to central needs and challenges in operative work that need to be met by design.

## 1.3 Results and achievements

The study shows that information is created and communicated in a network of actors onboard the ship, each with their own needs and contributions to understanding the situation. This information must provide a good base for Fire Commander planning and decisions, but it should also cater for crewmembers at work in the ECR, the drencher room and at the location of the fire. Moreover, results have shown that all of these actors engage in frequent communications and that many tasks are collaborative, placing yet higher demands on supporting systems.

In the recorded drills, the Fire Commander rarely engaged in any prolonged information retrieval and analysis, but rather worked to uphold continuity in the fire management process, supporting the activities of crewmembers on the bridge, in the ECR and at the scene of the fire, while systems interaction was delegated to other crewmembers present. A large component of the Fire Commander’s work appeared to be the function of a communications hub, making sure that activities across the ship were performed in a synchronized, timely and correct manner. Designing for fire command is clearly something different than designing for detailed monitoring of fire development. This is reflected by the LASH FIRE division between the digital fire central (focusing on digital interfaces) and the overarching Firefighting Resource Management Center (focusing on the



overall system of people and technology in the safety organization), but it still warrants further studies of collaboration around information relevant to a fire scenario.

Integrating functionality for document retrieval and management into a digital interface seems warranted. One functionality that did not seem to be present during the drills was the ability to judge the effects of drencher activation, information that could be used to determine when manual intervention is necessary, timely or even safe.

On the theme of fire response follow-up and support, it could be discussed whether the bridge should be able to give more contextual information to the fire team around possible routes of entry or obstructions in the path. The drills showed instances where the Fire Commander on the bridge seemed to have little insight in the actual state and progress of the Fire Team. This is a subject that, so far, has not been explored at any depth in the LASH FIRE project, although related research such as positioning or Fire Team members is ongoing, a functionality that was also requested by respondents to the questionnaire.

Observations were made suggesting that social dynamics and culture may play a role in operational performance, factors that may negate the benefits of technological development. On the topic of power hierarchies, for example, when very few people are inside the command loop, should something happen to the commander, it may be difficult for other officers to maintain the fire management process, and it could also make other crewmembers less prone to question or stop erroneous decisions. Secondly, the extent to which other crewmembers have insight into the fire management decision-making process might also affect their understanding of orders and the logic behind the fire management approach, making it more difficult for them to anticipate future developments and adapt their own actions to an overall strategy.

On the topic of implementation, a result from the questionnaire was that users of existing digital fire panels reported only moderate user satisfaction, both for fire alarm panels and drencher panels. Comments reflected a fear of information overload, and there were also requests for physical controls instead of only touch-based controls. This suggests that digital, screen-based solutions are no magic bullet, granting a positive user experience, but that systems need to be tailored and adapted to end-user needs in order to fulfil their potential.

The results obtained in this study will be used to inform the next iteration of the Digital Fire Central, in particular with regard to logging, prognosis, information sharing and document management.

#### 1.4 Contribution to LASH FIRE objectives

Work to support the development of the Digital Fire Central prototype covers the overall WP07 objective “Reduced potential for human error, accelerating time sensitive tasks and providing more comprehensive and effective decision support, by increased uptake of human centred design and improved design of tools, environments, methods and processes for critical operations in case of fire.” and in particular the Action 7A objective to “Re-design and develop guidelines for improved fire detection system interface design, promoting intuitive operations and quick decision-making.”

#### 1.5 Exploitation

The results obtained in this study will be used to inform the next iteration of the Digital Fire Central, in particular with regard to logging, prognosis, information sharing and document management. Further work with this prototype will be reported in D07.6. Results could also fuel discussions around systems development among shipping companies and design firms, but more concrete input to those stakeholders will be provided in D07.3.

## 2 List of symbols and abbreviations

CCTV	Closed-Circuit Television
ECR	Engine Control Room
FRMC	Fire Management Resource Center
GA	General Arrangement
IMO	International Maritime Organization
OOW	Officer On Watch
Roro	Roll on – Roll off
UHF	Ultra-high Frequency (radio)
VHF	Very high Frequency (radio)

### 3 Introduction

Main author of the chapter: Staffan Bram, RISE

The LASH FIRE Digital Fire Central prototype has been developed over several iterations to arrive at its current state – an interactive, screen-based interface with functionality to match a large set of common fire management activities, including fire detection and assessment, deck and cargo information, control of fire dampers, fire doors and the drencher system. In addition, it also allows its users to follow events and make annotations on a fire response timeline. Up until the time of this study, however, prototype development has mainly rested on needs and feedback reported by informants and test persons, and there was a perceived needs amongst the researchers to better understand the practical actions and interactions that would occur in an actual onboard fire scenario. Another aspect needing attention was the fact that, so far, feedback about fire management and systems functionality had only been obtained from a limited amount of crewmembers, all of which have represented Scandinavian ship operators. For this reason, there was a need to investigate seafarer experiences and perceptions in an international context.

This document reports the findings from two studies meant to provide further insights in fire management operations. Chapter 6 presents qualitative results from three drills arranged for the purposes of LASH FIRE and the video-based ethnography that were conducted in connection with those, as well as findings from an international survey issued to seafarers, probing their experiences and perceptions of fire management and its associated systems. In Chapter 7, these results are discussed and implications are drawn for the continued development of the LASH FIRE Digital Fire Central.

## 4 Background

Main author of the chapter: Staffan Bram, RISE

The research presented in this report consisted of two main activities – a video-based ethnographical study of three fire drills arranged for the purposes of LASH FIRE, and a seafarer survey, probing their experiences of fire and perceptions of onboard fire safety systems.

The first iterations of the Digital Fire Central were mainly based on end user interviews and design feedback sessions, complemented with general field studies onboard ships to familiarize researchers with environments, systems and activities connected to fire safety. In the present study, the ambition was to gain a better understanding of fire management as it plays out in a realistic (but simulated) fire scenario, reaching beyond crewmembers' general perceptions and accounts of operational fire safety.

All LASH FIRE development of fire management support sets out from a socio-technical understanding of work, meaning how people and technology function together, in a social context, to achieve common goals (Hollnagel 2014). To this end, an approach based on ethnographic research methods was chosen. Ethnographic methods have been described as an important aspect of systems design (Button, Crabtree, Rouncefield & Tolmie, 2015). Within ethnomethodology and its application to design, it is acknowledged that people might often find it hard to articulate tacit knowledge, and that professional practice may differ from work as prescribed in routines and procedures. In addition, ethnomethodology stresses that social aspects, such as structures, processes, perspectives, procedures and experiences, are important in order to understand situated action (Ten Have, 2004). In applying ethnomethodology to design, more common methods of requirements elicitation and interviews are complemented with observations of social interactions and work in practice – how people act and interact in professional settings, demonstrating their “lived experience”. While the study of human-system<sup>1</sup> interaction was a key objective in the present study, observations were also made that shed light on the social setting of fire management activities. In this case however, due to restrictions due to the COVID-19 pandemic, video recordings were used as a substitute for close interaction between researchers and drill participants.

Button et al (2015) stress the importance of “vulgar competence” over theoretical interpretation in ethnography, meaning that the observer, in order to recognize actions and interactions, must try for a certain level of immersion in the study environment, rather than trying to force observed action into a theoretical template. In accordance with common applications of ethnomethodology (Ten Have, 2004), the theoretical framework for this study was held loose – there was a preunderstanding within the research group about common activities, practices and interactions involved in fire management, and of the way such a response is usually organized. Continuing, the drills built on the conception that some level of surprise in the fire scenario would produce a more natural response within the crews, as opposed to strictly scripted and predictable setups. Apart from this, both data retrieval and analyses were largely open, keeping descriptions of events simple and non-theoretical.

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<sup>1</sup> The term 'system' in this context is meant to denote any objects, artefacts, processes and procedures in use during firefighting activities.

## 5 Method

Main author of the chapter: Julia Burgén, RISE

Two approaches were chosen to produce data for the present study. The primary ambition was, as mentioned earlier, to reach a deeper understanding of operational fire management under realistic circumstances. The secondary ambition was to gather experiences and perceptions from the wider community of seafarers involved in onboard fire management and the use of fire safety systems. Previous studies had exclusively focused on ship operators and crews in a Scandinavian context, and in partner discussions, comments had been made that fire management conditions vary widely in an international perspective. Since LASH FIRE aims to affect maritime fire safety regulation and that such regulation has a global impact, it was deemed necessary to better understand these varying conditions.

### 5.1 Video-based ethnography

Due to Covid-19, the possibilities to visit ships and carry out any classical ethnographic studies were out of reach. To still be able to collect the data, a remote, video-based method was developed. The method consisted of two activities onboard ships – first, a system ‘thinking aloud’ walkthrough and later a fire drill, both of which were thoroughly documented on video. To reduce the possibility of participants adjusting their normal practices in one activity based on their participation in the other, the activities were not carried out at the same time and the involved crewmembers were not the same.

The walkthrough videos were recorded independently by crewmembers on the involved ships. In these videos, the crewmembers demonstrated the functionality of fire safety systems by walking through normal operational procedures, while describing their actions vocally.

The scenario of each fire drill was developed either in collaboration with, or entirely by, officers on the ships in question, involving as few others as possible. The approach of minimizing information to the crew while maximizing realism was chosen to provoke natural responses to the fire scenario, in an effort to increase ecological validity of the results. A smoke machine was used to trigger the detectors and adding realism to the drill and a warning beacon was used to indicate the location of the fire. Unfortunately, it was not possible to carry out the drill with a fully stowed ro-ro space and it was not possible to trigger heat detectors (where applicable).

Both the system walkthrough and the fire drill were planned to be run by a facilitator from the respective ship operator, and they were provided with guides instructing them on what to do before, during and after the activity, in addition to a welcome letter and consent form for the participants (see system demonstration guide in appendix A). It was then up to the facilitator to collect the footage and deliver it to the researchers.

Chest-mounted action cameras were selected as the recording method. This way, the footage would provide a first-person view of actions while the participant could move and work freely. During the system walkthroughs both the participating crewmember and the facilitator wore a camera. During the fire drills, 2-3 selected crewmembers, in addition to the facilitator, wore cameras. The facilitator could then focus on capturing an overview of the bridge or following the fire team. That way, simultaneous actions were captured from different perspectives time. Figure 1 shows an illustration of how the cameras were worn and what they captured.

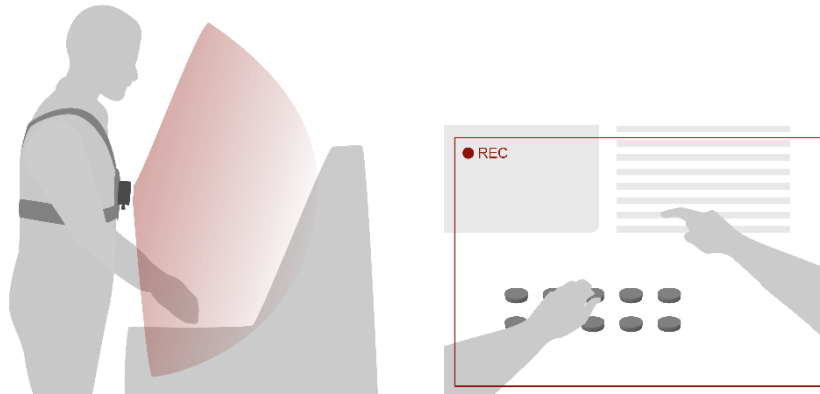


Figure 1. Action camera mounting on participant

After the drill, all footage was edited to create a video for analysis. For the walkthrough video, the clips providing the best view at the moment were collected. The fire drill videos were synchronized and combined, see figure 2. Audio streams were also edited so that not all were active at the same time, and a speaker symbol is visible on the clip(s) that the audio is currently coming from. Combining the different video sources allowed the researchers to follow and assess simultaneous action. Individual videos were also available for analysis when a more detailed view was needed.



Figure 2. Screenshot from finished video material, completed with descriptions on who is wearing each camera.

Three ships participated in the study and a summary of the difference between the settings is provided in Table 1.

Table 1. Summary of settings on participating ships

	Ship A	Ship B	Ship C
<b>Type</b>	Ro-pax	Ro-pax	Ro-ro
<b>Fire commander</b>	Chief Engineer	Captain	Chief Engineer
<b>Drill planned by</b>	Participating C.E. + non-participating C.E.	Captain + LASH FIRE team	Captain

<b>Drill set-up</b>	A smoke machine + light was placed in the ro-ro space. Detectors were deactivated to allow smoke to build up.	A smoke machine + light was placed on the ro-ro space. Detectors not possible to deactivate. The crew was not informed about the starting time of the drill. With respect to rest hours, only the fire organization participated (no evacuation teams etc.).	No special preparations known to the LASH FIRE team
<b>Ship status</b>	In port	In port	In port
<b>Drill starting point</b>	OOW alone on bridge with facilitator, FC working in his office, ECR manned by three people.	Captain, three officers and watchman on bridge with two LASH FIRE team members. Third LASH FIRE team member on ro-ro space. The rest of the crew unaware of the starting time of the drill.	Captain, Chief Officer and Chief Engineer on bridge with facilitator. Captain sounds the fire alarm and makes a PA call to inform that 'This is a drill for the crew only'.
<b>Camera locations and viewpoints</b>	<b>Bridge:</b> Officer on watch, Chief Engineer and facilitator. <b>ECR:</b> Engine Control room operator,	<b>Bridge:</b> Captain and Safety Officer <b>Ro-ro space:</b> LASH FIRE team member 1 <sup>2</sup> <b>Moving:</b> LASH FIRE team member 2 (on bridge then transitioned to following the fire team).	<b>On bridge:</b> Facilitator <b>Drencher room:</b> 1 <sup>st</sup> Engineer <b>Moving:</b> Chief Engineer Officer <sup>3</sup>
<b>Debriefing</b>	Two digital sessions, first with the two chief engineers planning the drill and then with two of the ECR crewmembers.	Group discussion directly after the drill with all involved crewmembers.	No.
<b>Important unexpected events</b>		The detection panel was faulty and it was not possible to shut off the first alarm, causing the fire alarm to sound. The smoke	None detected by the LASH FIRE team.

<sup>2</sup> The lights were shut off, which made this footage unusable.

<sup>3</sup> Recording was not successfully started

		still had to build up, so the drill was not actually started until 15 minutes after the fire alarm.	
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#### 5.1.1 Analysis

LASH FIRE researchers first reviewed the drill recordings individually, making notes on events and interactions in a shared document. This material was then used as data for a series of analysis meetings where each observation was discussed, attempting to determine how the design of environments, technical systems, organizational structures, procedures and practices affected firefighting performance and outcomes. This analysis covered a wide array of topics ranging from micro-level instances of systems interaction, up to macro-level interactions (both social and technical) between individuals and groups onboard. The next step involved a process of iterative categorization of findings. In this categorization, researchers attempted to keep descriptions simple and close to observed uses of language, activities and actions. Under each category, findings were sorted and processed in order to produce a coherent narrative.

### 5.2 Fire safety systems questionnaire

A joint questionnaire was developed for LASH FIRE work tasks 7A, 7C and 6B. While the desired respondents differed between the tasks, the channels of distribution for a questionnaire would be the same. The focus of the questionnaire was firefighting in ro-ro spaces and the questionnaire covered the phases:

- Detection
- Confirmation
- Assessment
- Decision-making
- Suppression (excluding manual suppression)

The target group for the questionnaire was any seafarer who would be involved in handling fires in the ro-ro space (excluding members of firefighting team, who manually suppresses the fire). The ambition with the questionnaire was to gain a better understanding of the diversity among ships and national contexts, both in terms of organisational, operational and technical aspects, regarding firefighting in ro-ro space.

#### 5.2.1 Questionnaire development

Representatives from the different work tasks were put together into a working group. Each member had knowledge about firefighting in ro-ro space from interviews and field studies carried out within the project or in previous projects. The work with developing the questionnaire was an iterative process where questions and questionnaire paths were constantly adjusted as the work progressed.

Firstly, there was a brainstorming session for question development. It was decided that the questions would be divided into different paths, each corresponding to a possible location and/or role for firefighting. The questions were then entered into a web-based questionnaire format using Office Forms. There was no obligation (and no functionality) for respondents to enter personal data.

Finally, a draft of the questionnaire was sent to a group of selected seafarers and maritime academics as a pilot. The selection of seafarers was made to ensure that all paths of the questionnaire was covered. Additionally, it was sent for review to a group of selected project members of LASH FIRE. The questionnaire was updated based on the results from the pilot.



### 5.2.2 Design of the questionnaire

Since open questions are time consuming both regarding answering and analysing (Gillham, 2008), closed questions were used as much as reasonable. When the question was a “branching question” the reply option had to be radio buttons to be able to direct the respondent depending on his/her answer. For every closed question there was also an alternative where the respondent could choose “not applicable”, “I don’t know” or “Other: \_\_\_\_\_”.

General images were used as examples for illustrating different level of user interfaces for fire detection panel and fire suppression panel. The respondents were asked to choose image(s) which best correlated to the user interface design for their specific ship.

#### Layout of the questionnaire

In the first section of the questionnaire the respondents were asked questions about their experiences and role/roles and about their specific ship. The questionnaire was then divided into four different paths, and respondents were directed to a specific path or to the end of the questionnaire depending on their previous answers. The different paths are described in Table 2.

*Table 2. Disposition of paths in the questionnaire*

Path	Target group for path	Questions mainly regarding
Bridge	Firefighting management located on bridge	<ul style="list-style-type: none"> <li>- Detection and suppression panels.</li> <li>- Fire alarms messages and sounds</li> <li>- Decision making</li> <li>- Assessment</li> </ul>
Engine control room (ECR)	Persons involved in firefighting, located in engine control room	<ul style="list-style-type: none"> <li>- Detection and suppression panels</li> <li>- Fire alarms messages and sounds</li> <li>- Decision making</li> <li>- Assessment</li> </ul>
Fixed installation rooms	Persons involved in firefighting located in fixed installation room (e.g. drencher station)	<ul style="list-style-type: none"> <li>- Activation of fire system in fixed installation room</li> <li>- Decision-making</li> <li>- Assessment</li> </ul>
Confirmation	Persons confirming the fire at site (e.g. AB)	<ul style="list-style-type: none"> <li>- Confirmation of fire</li> </ul>

#### Estimated response time

The response time should be kept short to increase the chance of persons responding to the questionnaire. In previous research it is stated that good target time is around 10-15 min (Revilla & Höhne, 2020; Galesic & Bosnjak, 2009). Due to this, the maximum response time of the questionnaire, regardless of path, was decided to be 15 min and the estimated response time for the longest path was within this limit.

### 5.2.3 Channels for distribution

The questionnaire was distributed within the LASH FIRE network and through a Maritime University, where the MOAG generated the largest part of all answers. Several seafarer unions outside Europe were also contacted and asked to help distributing the questionnaire to their members.

### 5.3 Research ethics

All answers to the survey were made anonymously, and no results have been presented that could be traced to individual respondents.

The video-based ethnography carried with it larger ethical considerations. Consent was gathered for all participating crewmembers, using a form that was distributed together with other information and instructions around each session. Video data obtained during the studies was stored on a server with access limited to the involved researchers. At a later stage, one operator expressed the interest to include segments from these recordings in a promotional project video. For this purpose, additional consent was obtained from crewmembers appearing in the material.

## 6 Results

Main author of the chapter: Staffan Bram, RISE

### 6.1 Observations from fire drills

This chapter presents results from three fire drills on three different ships. Drills were recorded with wearable cameras, and in two cases, they were complemented with interviews or group discussions where observations were explored further.

#### 6.1.1 Fire Management Leadership

While firefighting operations onboard can be viewed as a series of separate activities with direct bearing on fire development (e.g. detection, ventilation management and extinguishment), data obtained during the drills suggests that an equally important function of the safety organization is to keep track of the state of events, plans, actions and their outcomes. To this end, even though officers and crewmembers on the different ships had slightly different approaches to the task, all engaged in handling and sharing of several types of information that served to build awareness of the developing situation.

Central observations were made around the activities and work patterns of the Fire Commander, a role held by either the Chief Engineer or the Captain on the observed ships. This role had previously been regarded as a potential prime user of the Digital Fire Central, but on all three ships, the Fire Commanders were less concerned with the use of information systems and fire safety systems controls, and instead spent most of their time directing action and managing communications between the bridge, the ECR and the fire teams. In one instance, for example, a Fire Commander was observed querying the ECR for information that he already had at his disposal, given his position in front of a modern fire safety control panel in the bridge safety center. In a subsequent interview, his stated reason for this was to make sure that the ECR personnel was aware of the situation and status of the fire safety systems.

#### 6.1.2 Communication patterns

Drill observations revealed that fire management on a ship is a highly communicative and collaborative activity, with crewmembers working constantly to collect, assess and share information. This was mainly done through closed-loop communication (where the communicating parties repeat each other's messages) and callouts on the bridge. Items for communication between or within different groups have been summarized in Figure 3.

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#### Bridge internal

Activated detectors  
Location of fire  
Development of fire

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	Fire damper status
<b>Bridge – Runner</b>	Signs of fire Location of fire
<b>Bridge – Fire Team</b>	Fire location (general position (aft port etc) and frame number Status of fire pump Position of dampers Mustering of fire team Position of fire team (at entry) Smoke diver deployment time Smoke diver air bottle levels
<b>Bridge - ECR</b>	Status of fire / spread Pump activation / status Drencher activation / status Electrical interventions (breaking) Shutting of dampers
<b>Bridge – drencher room</b>	Fire location Pump status Drencher status
<b>ECR – Fire Team</b>	Drencher status Pump status Drencher activation
<b>ECR – Technician</b>	Technical interventions Drencher status

Figure 3 - Items for communication

On an operational level, there were a few instances where the bridge never received feedback on requests made or orders given (e.g. closing of fire dampers or activation of drenchers), seemingly leading them to forget about initiated actions. It was also evident that all parties were not included in communication around initiated actions. In some cases this was caused by the use of telephone rather than radio, e.g. in telephone communication between the bridge and drencher room, excluding the ECR. This observation could be related to the fact that on two ships, the ECR had much more of a background role. On the other hand, on the ship where the ECR was actively engaged, telephone communication about drencher activation was not hearable for the Fire Team Commander. In a follow-up interview, chiefs stressed the importance of e.g. working with separate radio channels in order to steer communication and avoid overwhelming the crew with information. On their ship, there seemed to be a conscious communication strategy, but this was not apparent on the other two ships.

Some issues concerning communication were observed during the drills. Firstly, there were several instances of VHF signal disturbance or loss, which sometimes prompted the crew to relay messages through intermediaries. Secondly, there were examples where radio messages seemed to go unnoticed, e.g. due to noise and many competing signals in the ECR.

Another bridge activity that stood out during the observed drills was note-taking. Notes covered a wide variety of data, focusing on occurred states or events such as activated detectors, activation of drenchers, closing of dampers, crew headcount, Fire Team positions and times for smoke diver deployment, and very rarely on planned actions or future events, which only seemed to rely on memory. On two ships, notes were taken on a simple notepad by the II/III officer manning the bridge safety station. On the third ship, notes were taken on a whiteboard by crewmembers managing evacuation planning and the Fire Commander briefly visited this station on a few occasions, but there was no notetaking on matters directly related to fire response. Note-taking appeared to take some time and effort, and sometimes appeared as a distraction, interrupting or delaying other actions. The use of these notes was not immediately apparent, and there was no observation where the contents were shared or referenced in communication between bridge personnel.

### 6.1.3 Information resources and system controls

Fire management during the drills involved the use of numerous information artefacts and system controls, often spread out over different locations on the bridge, ECR and drencher room. There were also several examples of crew-made artefacts meant to facilitate work and, as it would appear, compensate for unclarities or other issues in systems design, such as written reminders and laminated information sheets. Printed documentation appeared to play a large role both for the Fire Commander and for the II/III Officer manning the safety station, to the extent where documents came to clutter the workspace. A summary of observed information resources and system controls has been made in Figure 4.

Medium	Information / control
Printed documents	Safety procedures Detector numbers and placement Drencher zones Dangerous Goods manifest CCTV positions PA announcements
Written notes	Time for GA activation Activated detectors Time for activation of drenchers Time for closing of dampers Crew headcount Fire Team positions Time for smoke diver deployment
Analogue control panels	Fire detector status Drencher control & status Fire pump control & status Fire dampers control & status Fire doors control & status
Digital control panels	Fire detector status & controls Fire alarm Drencher zones Fire doors status
Pulldown schematics	GA plan

Fire safety plan	
Whiteboards	GA plan Activated detectors Headcount

Figure 4 - Information resources and system controls

A number of situations occurred during the drills that hinted to issues related to information and fire safety system controls. Firstly, the placement of interfaces and controls seemed to have a relevance for fire management performance. On one ship, for example, a written note had been put on the safety panel reminding the user about the use of fire dampers, also pointing out the location of damper controls which were situated in another part of the bridge. Secondly, there were some types of information that appeared to be of high relevance, but where the crew could only rely on memory or written notes in order to keep track of them, e.g. the status and duration of drencher activation, the state of fire dampers, hose pressure and smoke diver duration or deployment and the required hose length between the connection point and the location of the fire.

On the whole, there were few examples of artefacts to support information sharing or collaborative work around information relevant to the drill scenario, and equally few examples of any such collaboration on the bridge. Whiteboards were commonly available, and although these were mainly used for taking notes on mustering and evacuation planning, in one instance it was also used to note activated detectors. On all ships, the Fire Commander moved frequently across the bridge, partly to check up on the progress of crewmembers, but most often to access different systems or simply to get better reception, or to be able to use the radio without being disturbed or disturbing others. Lastly, there were examples of password-protected systems used in the process of fire management, adding to workflow complexity in the safety center.

The drencher system is a vital part of fire suppression in the roro space, and in all three drills it was used as a first response after confirming the fire. Only small differences were observed in the time elapsed between the order to activate the drencher and the time when the system was active, with water on deck. These times can be found in Figure 5. In all three cases, the person activating the drencher was already in or near the location of drencher activation when he or she received the order.

Ship	Time elapsed
1	3 min 25 s (1 min 52 s after order)
2	2 min 12 s (22 s after order)
3	2 min 34 s (1 min 17 s after order)

Figure 5 - Time from fire confirmation to activation of drencher

While drencher activation seemed to be carried out as fast as possible, in two out of three drills there seemed to be no apparent rule for when the drencher should be stopped and replaced with manual firefighting. Instead, manual interventions commenced when the smoke divers were ready. On one ship, temperatures given by detectors were used as a basis for this decision, but on the other two ships, there were no examples of any information being used explicitly to judge whether the drencher had had its desired effect. Of course, had the information available during the drill been taken at face value, given that the detection pattern only indicated a small fire, then it would probably have indicated that there was no need for a prolonged manual intervention.

Availability of controls for the drencher system varied between the ships. On the first ship, remote control existed both on the bridge and in the ECR. On two other ships, only manual control in the drencher room was available. There were also differences in operational procedures for the drenchers. For example, in the first case the OOW ordered activation of the drencher before the Fire Commander had even arrived, on the second ship all such orders were given by the Fire Commander on the bridge, while on the third ship, the Fire Commander ordered the person manning the Drencher Room to communicate directly with the Fire Team around starting and stopping of the drencher.

#### 6.1.4 Role allocation and crew involvement

Even though all Fire Commanders engaged in frequent communication, the Fire Commander's decisions around firefighting strategy were difficult to tie to any discussions or information present on the bridge. In some instances, the Fire Commander made his plans known to bridge personnel working close by, but often without any pronounced motivation. This could be due to the fact that the crew was following protocols that were widely known or that decision grounds were apparent in the light of previous communication, but it could also constitute a risk, should something happen to the Fire Commander that prevents him or her from upholding command.

The three different ships displayed quite different patterns regarding the involvement of the ECR and its personnel. On two ships, the role of the ECR was less pronounced and ECR personnel was less involved in frequent communication. The explanation for this could be that the ships employed different safety organizations with different role allocations, while also having slightly different designs in terms of fire safety systems interfaces and controls. One of these ships was just in the process of an re-organizing with the purpose to improve the safety organization. One person in this crew pointed out that the Chief Engineer did not have any responsibilities in the old fire organization, which was considered a waste of crewmember skills. For comparison, the Chief Engineer had the role of Fire Commander on the two other ships. On the third ship, the Fire Commander and ECR engaged in frequent communication and recordings from the ECR also revealed an active process of information gathering and decision-making, suggesting that this environment is highly relevant for information systems development. One interesting observation here was that the ECR was assigned several activities that could also have been carried out remotely from the bridge, such as drencher (and pump) activation, closing of fire doors and ventilation management. This practice naturally offloaded the Fire Commander, but it could also be discussed how such active participation together with bridge-ECR communication served to reinforce ECR situation awareness. It should also be noted that on this ship, the role of Fire Commander was held by the Chief Engineer, and his normal role and working relations could be thought to influence bridge-ECR communications.

It was also observed that communication between the bridge and Fire Team(s) differed between the three different ships. In some instances, close communications were upheld between the Fire Commander and Team Commanders, while in other, little information about the team's status and activities were relayed to the bridge. This seemed to create situations where operative conditions were unknown to command on the bridge, something that seemed surprising given that direct observations from the scene of the fire constituted the primary source of information to gauge its development. This could possibly be explained by the fact that the drill was pre-planned in collaboration with the Fire Commanders, i.e. meaning that they had few unknowns that might prime them to seek out more information. Nevertheless, first-hand information about the status of firefighting operations ought to be important for fire Command strategic decisions.

### 6.1.5 Orientation and communication of positions

Comments from crewmembers participating in the drills suggested that understanding the correct location of the fire and translating this information to effective drencher activation was seen as a key priority. In accordance with observations from previous studies, wayfinding and orienting around the position of the fire demanded some effort during drills.

On one ship, both the bridge and ECR had graphical interfaces for the fire alarm system, which gave direct information about the location of an activated detector, something that seemed to speed up the process of localization considerably. On the two ships where no graphical interface existed for the fire alarm system, the crew employed the fire alarm code, documentation showing the exact placement of each detector, GA plans (with frame numbers) and CCTV (with accompanying documentation to determine what area a specific camera covered) to find the position of the fire. The bridge also supported Fire Team Command in choosing the point of entry and approach to the fire, a task that often seemed to rely more on the Fire Commander's knowledge of the ship than on maps or documentation. For example, one Fire Commander noted that a certain frame number should be conveyed to the Fire Team for reference, because he knew that the number/signage of this frame would be visible to them on the roro space wall as they approached the fire. Several observations were also made where there was an apparent risk of confusion, for example around decks, frames, drencher zones, detectors and cabins with very similar names or numbers. This presented a particular challenge in VHF communication, sometimes demanding messages to be corrected and repeated.

### 6.1.6 Limitations

Even though this study was directed towards naturalistic behavior in fire management, there were still instances during the drills where some crewmembers (and officers in particular) appeared to act out a scenario that was well prepared for. This can partly be explained by the fact that some chiefs/masters acting during the drills were also involved in the construction of scenarios, but it is also likely that rumors might have spread among other parts of the crew. One suspected effect from this is that the actions of the Fire Commander might not have reflected all the crew interactions, variability in behavior and on-the-spot decision-making that an actual fire might provoke. Another aspect contributing to this were limitations to fire scenario complexity. In all three cases, the time available both for onboard preparation and execution of the drill was constrained, limiting the amount of complications that could be included. Finally, the fact that actions performed during a drill will normally not have any real negative consequences could also cause decisions to be taken more lightly and with less negotiation.

## 6.2 Results from the fire safety systems survey

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The questionnaire resulted in 78 responses, where 3 of the responses were for ships that were out of the scope of the survey (and the respondent had no previous experience of ro-ro/ro-pax or vehicle carriers). Therefore, only 75 answers were considered in this analysis. For some questions, the groups resulting in less than five answers are not included, for instance when answers are grouped based on the type of detection panels. Additional graphs and tables of the results are available in Appendix B.

### 6.2.1 Participant profiles

The respondents mainly work on ships with European shipowners. See figure 6. The most common flag states were Denmark, Greece and Sweden.

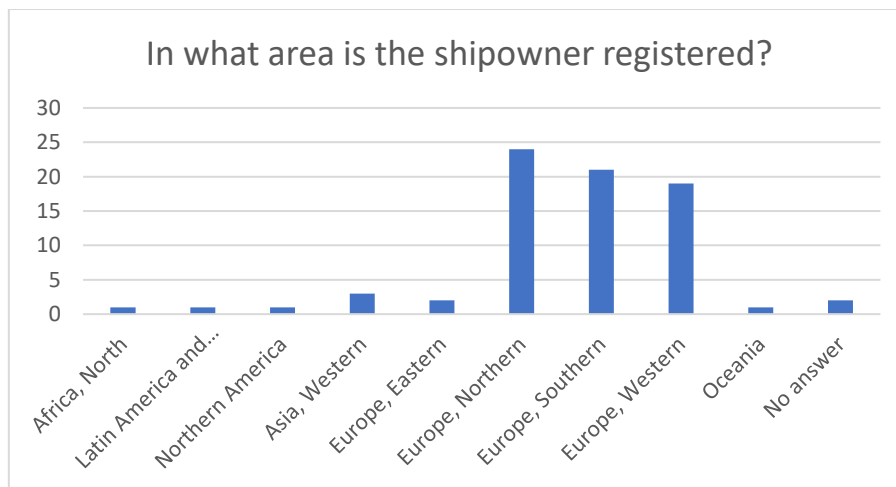


Figure 6. Answers regarding shipowner registration area

The majority (67) of the respondents were working on (or had previous experience of) Ro-Pax ships. Ro-ro and vehicle carriers were 6 and 2 respectively. About half of the respondents (33) worked on a ship with gross tonnage of 25 000 – 50 000 GT.

The grouping of answers are for many questions based on the respondent's main work location on the ship. The locations/roles 'fixed installation room' and 'confirming/identifying the fires' together with some free text descriptions of locations/roles did not generate groups large enough to be presented. See list of roles for each location below.

Table 3. Participants' locations and roles

Location	Bridge or safety centre	Engine control room	The fire location
Total responses	48	9	15
Role(s)	Responsible for fire management (26)	Responsible for fire management (2) Engine control room operator (7)	Responsible for fire management (9) Supporting fire management (4) Member of firefighting team (2)



	Responsible for navigation <sup>4</sup> (14) Supporting fire management (4) Other (4)		
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For crew members located on the bridge, about three quarters had more than three years of experience in their current assignment. For crew members who worked as engine control room operators, six out of seven had more than three years of experience in their role. Respondents choosing 'Responsible for navigation' also had to answer a follow-up question if he or she also operates the fire detection panels, with the purpose to filter away those who may not be fully familiar with the systems.

The majority of the respondents (58) did not have any experience of a large fire incident<sup>5</sup>. However, eight persons had experience from a large fire in ro-ro space and nine persons had experience of a fire somewhere else onboard. The respondents who had experienced a fire in ro-ro space were asked to further describe how they experienced the support of the ship's built-in systems. In summary, their experiences were as follows:

*Table 4. Free-text answers from respondents with experiences from real fire incidents.*

Detection (Fire panel and alarm)	<ul style="list-style-type: none"> <li>• Successful detection by detection system</li> <li>• Fire panel gave correct information about smoke in garage</li> <li>• Alarm was quickly raised</li> <li>• Fire confirmed by runner</li> </ul>
Fire extinguishment (drencher system)	<ul style="list-style-type: none"> <li>• Drencher system activated immediately</li> <li>• Some difficulty using drencher system due to uncertainty of numbering of ro-ro space area in closed deck</li> <li>• Extinguished by drencher system</li> <li>• Drencher system activated and fire controlled quickly.</li> <li>• Fire hoses were a first response, but due to hard access to the centre of fire the drencher system was used for extinguishment</li> </ul>


### 6.2.2 Fire detection panels

To find out which type of fire detection panel that was installed on the respondents' ship, the respondent was asked to choose one (or several images) that best represented the detection panel used onboard. The different images are shown in Figure 7. This question was asked to both crewmembers located on the bridge and in the engine control room.

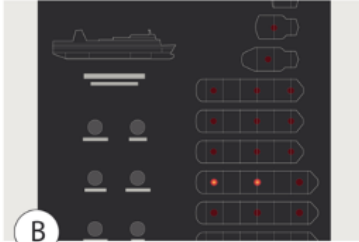
<sup>4</sup> including free text answers such as captain, master and overall responsibility

<sup>5</sup> Defined in the questionnaire as: *Example of a larger incident is when extensive repairs are needed.*

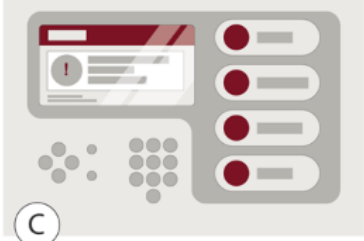
Which image represents the fire detection panel(s) you use?  
It is possible to choose more than one




A



B



C



D

☐ A: Text based system with no display. Can possibly print a history note.  
☐ B: Analogue mimic panel with LED indicators.  
☐ C: Text based system with small display. Controlled with buttons.  
☐ D: Digital mimic panel. Touch or mouse controlled.  
☐ Annat

Figure 7. Images given as examples of different types of detection panels.

According to the answers to this question, it is most common to have a text-based system with small display controlled with buttons (C) or a digital mimic panel controlled with touch or mouse (D). On some ships the detection panel was best described as a combination of several images, especially panel D in combination with other(s). This could indicate that more than one detection panel are used, which corresponds well to previous findings in the project SEBRA [5].

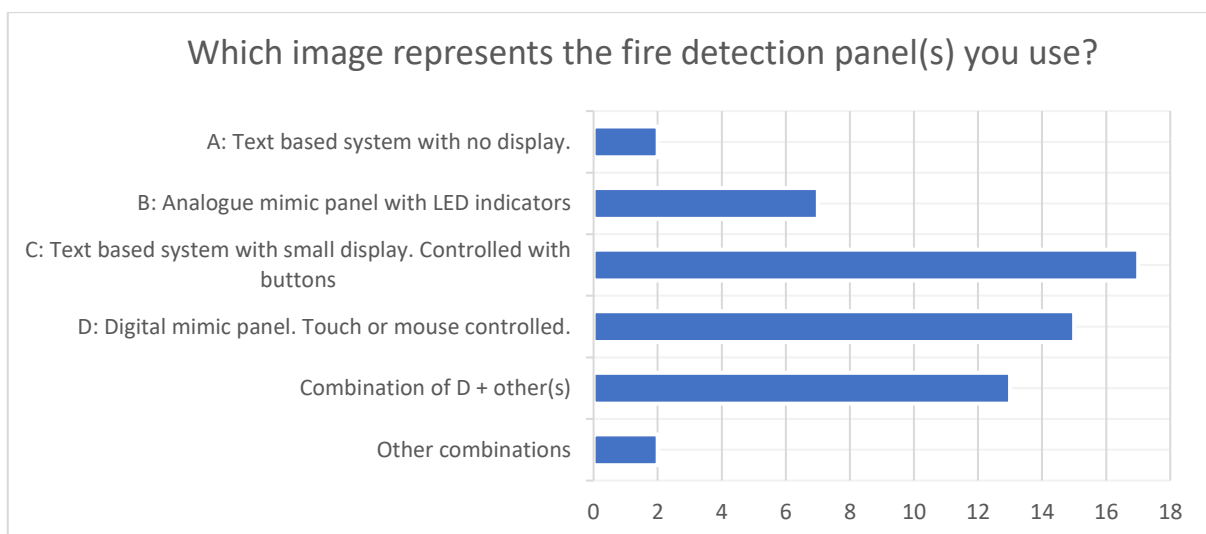


Figure 8. Types of detection panels, answers from bridge and ECR.

Based on the answers from bridge-located respondents, it is possible to notice differences between the different systems listed below (full result available in appendix B). The questions for ECR were not identical and each panel-type generated less than five answers, which is why corresponding answers are not reported from the ECR.

- A digital mimic panel or a digital mimic panel together with one of the other systems, is rated to be better designed with regards to:
  - understanding how the fire is developing
  - which alarms needs immediate attention
  - presenting the correct information at the right moment
- The consistency between different information systems (e.g. similarity regarding symbols and labelling etc.) was judged better designed in the digital mimic panel.
- A combination of the digital mimic panel and another system generated higher score on the questions if the system was well designed with regards to:
  - Understanding which alarms that are not urgent.
  - Finding the functions or information needed.

The overall satisfaction with the digital mimic panel is higher than for the other types of system, see Figure 9.

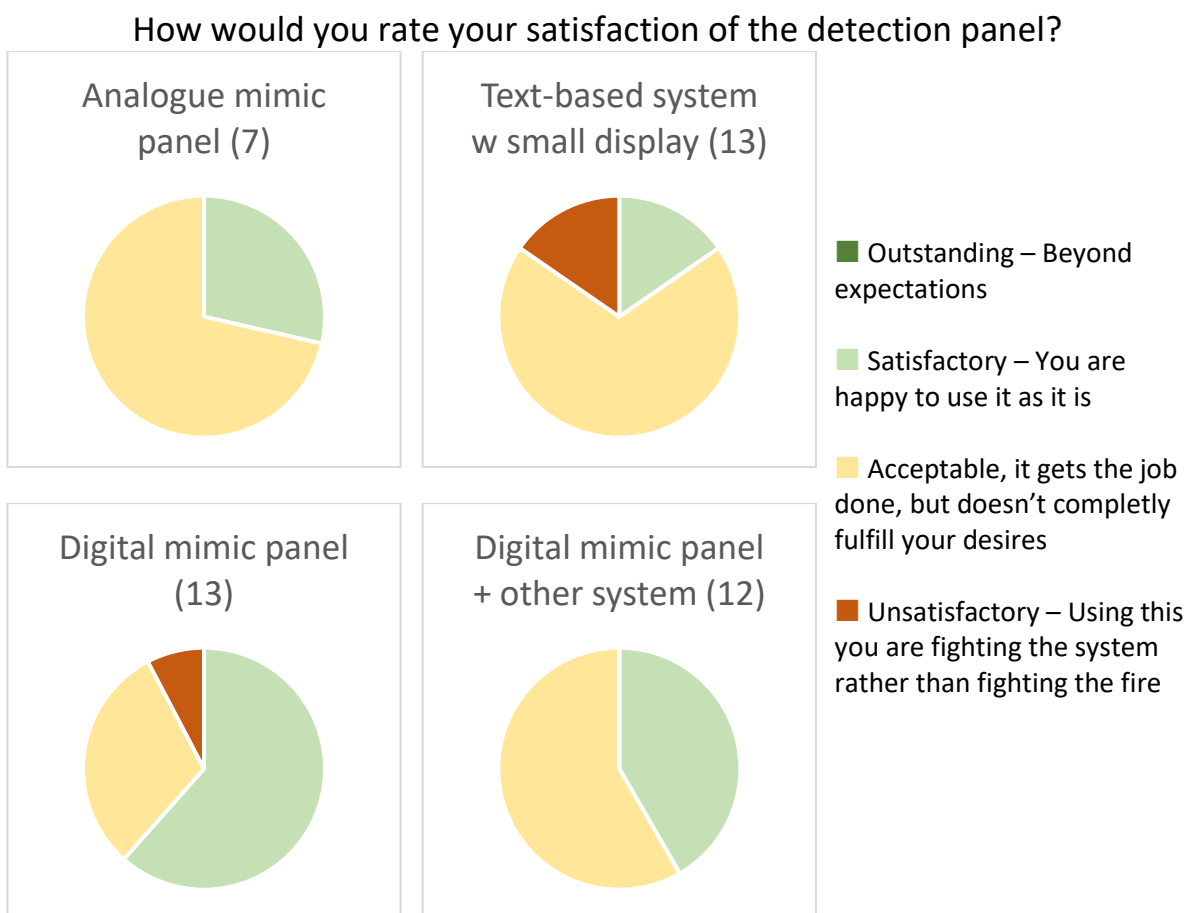


Figure 9. Overall satisfaction per system type.

At the end of this section, there was a free-text question for comments or improvement suggestions. Some of the answers (with some rephrasing) are listed below, sorted based on the type of system the respondent had chosen.

Table 5 - Free-text answers with comments or improvement suggestions related to the detection panel.

Text-based system with no display	<ul style="list-style-type: none"> <li>• Clear information about the status of the activated detector - without codes</li> <li>• The English of the messages is bad</li> </ul>
Analogue mimic panel	<ul style="list-style-type: none"> <li>• Need for more detailed information and be replicated in Drencher Room for integration of systems.</li> </ul>
Text-based system with small display	<ul style="list-style-type: none"> <li>• Independence of the thermal and optical sensors in the garage</li> <li>• Systems that include a monitor and then the ship's plan and the arrangement of the detectors are significantly better. From a direct comparison within the fleet</li> <li>• Visual, general arrangement-based displays are more informative and allow faster evaluation of the situation</li> </ul>
Digital mimic panel	<ul style="list-style-type: none"> <li>• Fire panels should be designed on a fire plan mimic with ability for memos or remarks.</li> <li>• Have physical buttons, LEDs and less data</li> <li>• The alarm sounds disturb the fire management when the fire is increasing. That requires someone being close to the panel to stop the sound</li> </ul>
Text-based system with small display & digital mimic panel	<ul style="list-style-type: none"> <li>• The most recent alarm should be highlighted.</li> <li>• Get rid of sub-menu's and create a visual and intuitive UI that clearly display the activated sensors. If multiple systems are activated, they have to be merged together at first sight in one place. Perhaps with integrated CCTV, covering the area of possible fire</li> </ul>
Digital mimic panel, analogue mimic panel & text-based system with small display).	<ul style="list-style-type: none"> <li>• Combine fire detection and fire extinguishing systems in one panel. At least indication and manual openings of drencher system on ro-ro decks</li> </ul>

### 6.2.3 Alarms

Overall, the digital mimic panel shows better results related to the alarm messages (see appendix B). By comparing the answers from bridge and ECR, it is possible to conclude that there are more issues related to alarm sounds in ECR. For instance, among the ECR respondents it was fewer who selected "The sounds are easy to distinguish from other alarm sounds" (50%) and "The sounds are easy to hear (volume)" (25%) and more who selected "The alarm sounds are too similar to other alarms" (25%), compared to bridge answers. Note, however, that there are only 8 answers in total from ECR on alarm questions.

The answers from the respondents with experience of real incidents are likely the most interesting to look at. These are included in

Table 66.

When it comes to false alarms, "steam in cabin" and "exhaust in fumes in ro-ro space" are the most common reasons, followed by "faulty sensors".

Table 6. Answers from respondents who claim to have experience of real incidents (both bridge and ECR)

How distinct are the fire detection system alerts?

*This question refers to the sounds on the bridge and 'other alarms' could be any type of alarms.*

**(Multiple choice question)**

Total answers	The sounds are easy to distinguish from other alarm sounds	The sounds are easy to hear (volume)	The alarm sounds are too similar to other alarms	The alarm sounds are overpowered by other alarms	The alarm sounds disturb the fire management unnecessarily much	Other
14	64%	71%	14%	7%	7%	

#### 6.2.4 Fire suppression panels

Regarding activating the drencher (or other fixed installation) in the ro-ro space, 60% of the respondents located on the bridge says that it is possible to activate it from there (Figure 8). Out of the yes-answers (28, Figure 9), 86% says that it is not only possible, but also *normally* activated from there. Out of the no-answers (19), 84% says that it is activated from a drencher room (or similar).

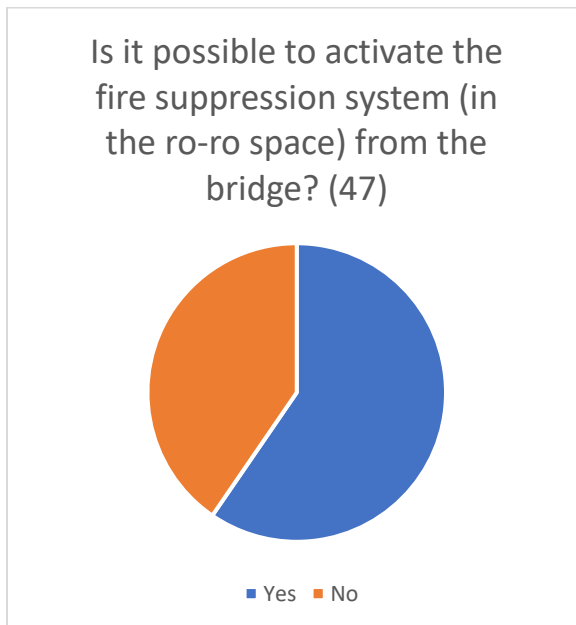


Figure 10. Remote drencher activation

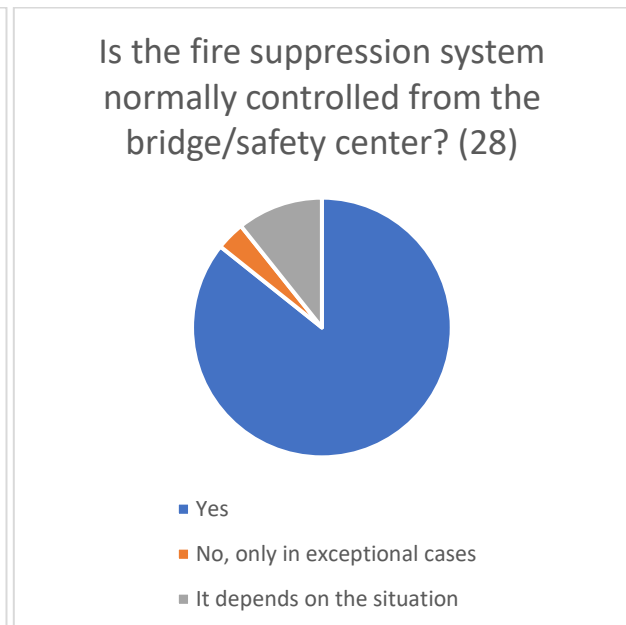
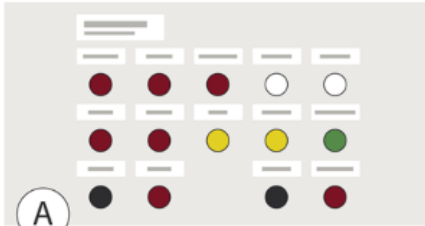


Figure 11. Bridge drencher activation

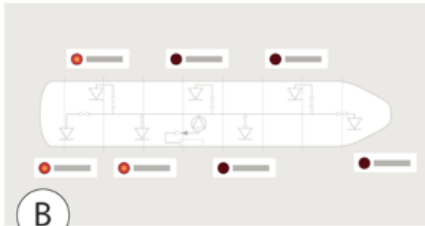
From the ECR, 44% says that it is possible to activate it from there, but this is based on a total of only 9 answers.

As with the detection panel, the respondents were asked to choose what image (or combination) that best represented their systems onboard. The images and answers are shown in Figure 12 and Figure 13.

Which image represents of the fire suppression panel(s) you use?  
It's possible to choose more than one alternative



A



B

☐ A: Buttons which controls pumps and valves. Either physical or screen based.

☐ B: Ship and/or process mimic. Either physical or screen based.

☐ Annat

Figure 12. Images given as examples of different types of detection panels.

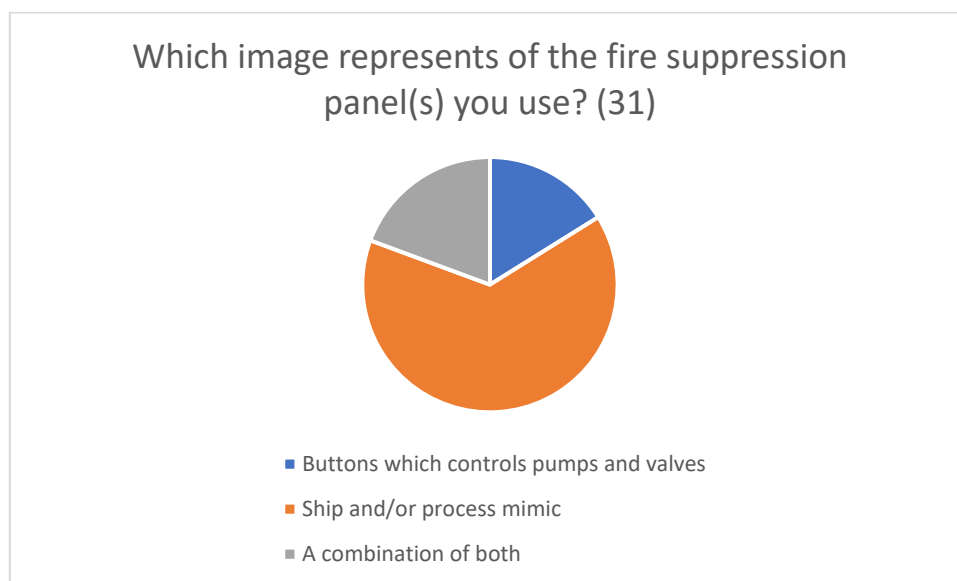


Figure 13. Responses from bridge and ECR located respondents

The difference in score on various design aspects are rather low between the different types of systems (see more in appendix B). This is also reflected in the results from the overall satisfaction (see Figure 14).

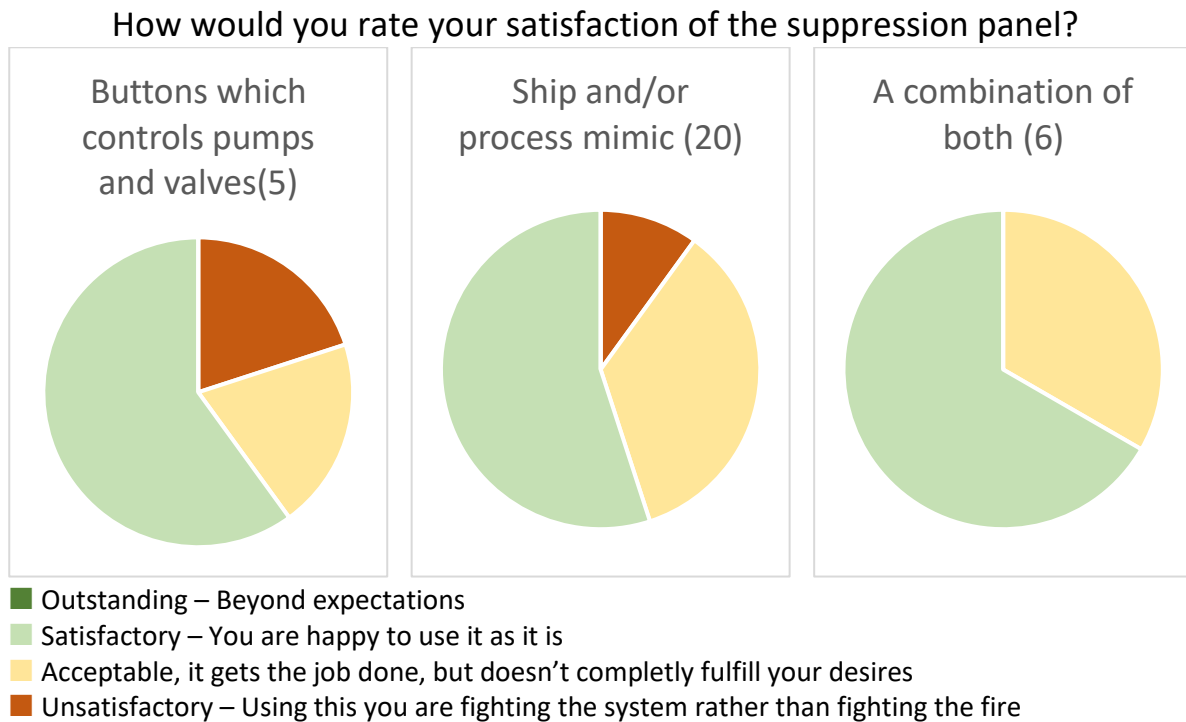


Figure 14. Drencher activation panel satisfaction (ECR and bridge).

#### 6.2.5 Information and communication

Among respondents located on the bridge, 85% report that they use CCTV (among other things) to confirm/dismiss a fire in the ro-ro space, while only 47% report that they have/use heat detectors.

In the questionnaire, respondents were asked what types of information are essential for quick decisions regarding firefighting. For bridge respondents, all alternatives were deemed important, but the ones scoring highest were presence of passengers in ro-ro space, location of fire team members, location and types of dangerous goods.

Although the form of the question is a little different, the respondents located at the fire scene has similar top picks: location of fire team members in the top, followed by ventilation status, location and types of dangerous goods. Location of passengers is however one of the rarely selected options.

#### 6.2.6 Other

The bridge respondents were asked what aspects they believe cause delays in the decision-making process. "Ship maneuvering" and "Using manual call buttons" got the most positive (no delays at all) answers. "Finding the origin of the fire" and "confirming that there is a fire" appears to cause the biggest delays. Interestingly, "Ship maneuvering" also stands out as one of the bigger causes for delays when extreme, large and moderate delays are all compiled.

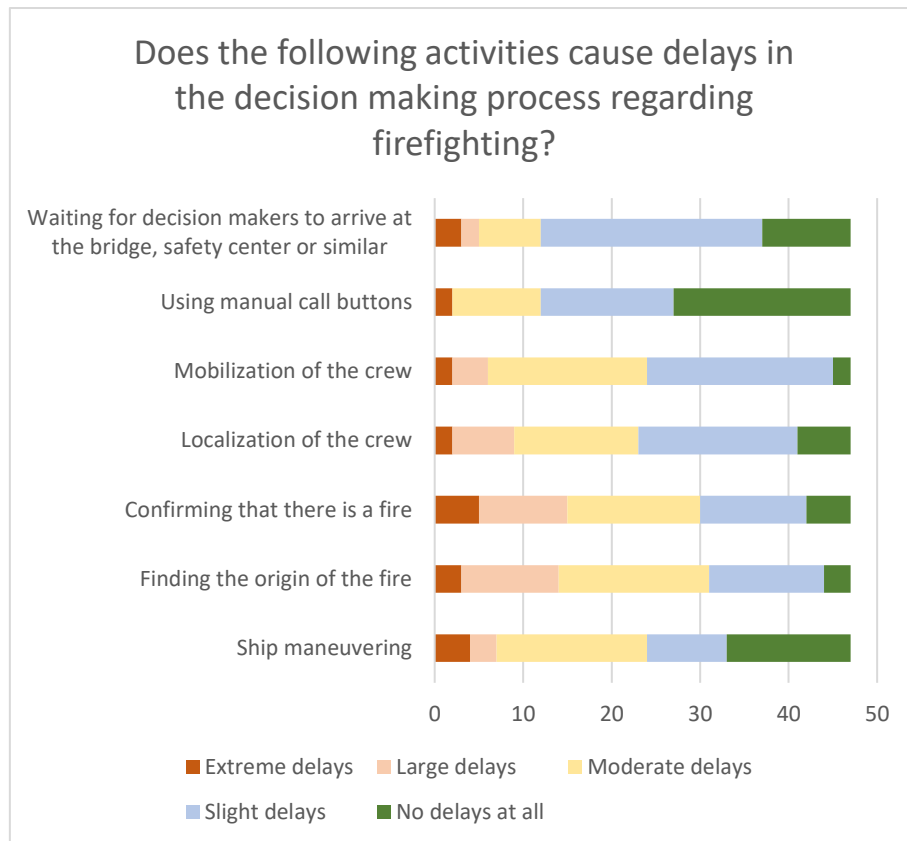


Figure 15. Reasons for delays in the decision-making process.

As the last question, the respondents was asked if they feel safe or unsafe on bridge/ECR. Rather few selected that they feel insecure and unsafe. It was almost as many choosing “Neither positive nor negative” as “I feel confident and safe”.

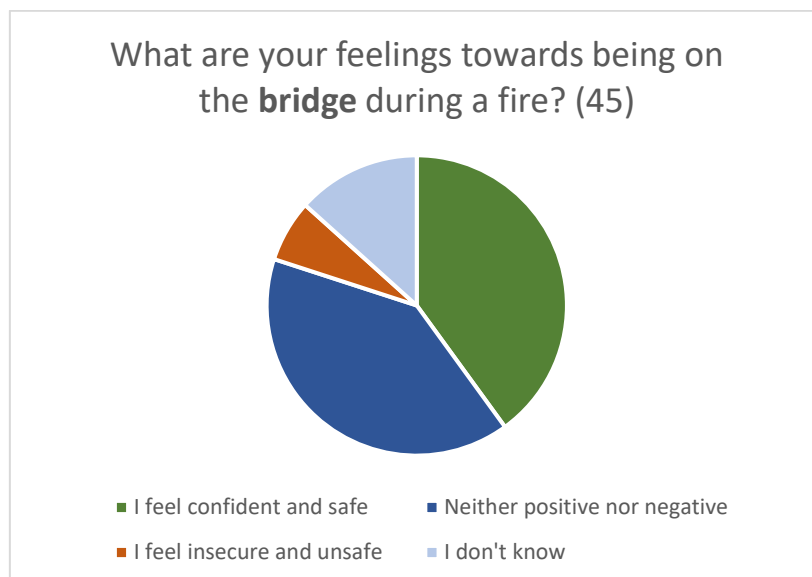


Figure 16. Bridge-located respondents

As a follow-up for those feeling either safe or unsafe, it was asked what the main reason for this feeling was. There were only two responses on reasons for feeling insecure and unsafe. This was due to bad quality of the CCTV and lack of information from the fire scene, while the other answer was



due to lack of experience of real fires and because he or she is still new on the ship. The positive follow-up answers covers reasons such as:

- The crew is experienced
- The safety standard onboard is high
- I have all the information I need, I know the ship, the systems and the crew's capabilities
- I have a good overview of the situation in a safe place

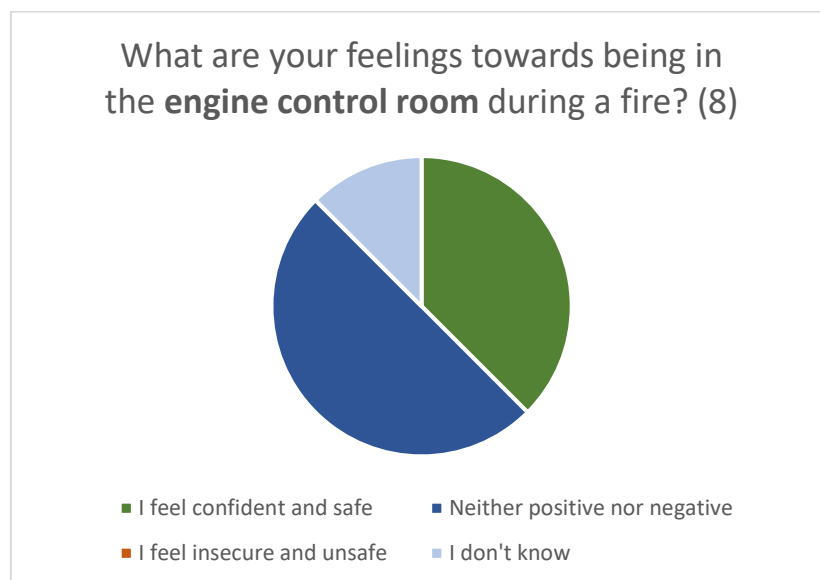


Figure 17. ECR-located respondents

## 7 Discussion & conclusions

Main author of the chapter: Staffan Bram, RISE

The drills arranged to provide data for this study showed that information management during a fire is neither an isolated activity, nor relevant for the bridge command function only. Instead, information is created and communicated in a network of actors onboard the ship, each with their own needs and contributions to understanding the situation. This information must provide a good base for Fire Commander planning and decisions, but it should also cater for crewmembers at work in the ECR, the drencher room and at the location of the fire. Moreover, results have shown that all of these actors engage in frequent communications and that many tasks are collaborative, placing yet higher demands on supporting systems. In this chapter, central findings from drill observations are compared to survey results, and implications for further digital fire central design iterations are discussed.

### 7.1 Collaboration and command

The ambition behind development of the LASH FIRE digital fire central prototype is to provide better support for fire management decision-making, where less time is lost due to confusion or cumbersome systems interaction. In the observed drills, however, the Fire Commander rarely engaged in any prolonged information retrieval and analysis, but rather worked to uphold continuity in the fire management process, supporting the activities of crewmembers on the bridge, in the ECR and at the scene of the fire, while systems interaction was delegated to other crewmembers present. A large component of the Fire Commander's work appeared to be the function of a communications hub, making sure that activities across the ship were performed in a synchronized, timely and correct manner. In the questionnaire, only 26 out of 48 respondents that reported as users of safety center panels were Fire Commanders. However, it is interesting to note that the Fire Commander on the ship that had the most advanced fire management system on the bridge was also the one to engage the most in communication, using information provided in the safety center to probe and direct the work of fire management operations across the ship. In particular, this ship demonstrated a close collaboration between the bridge and the ECR (where a similar digital interface was available), with frequent communication and activities in the decision-making loop. For example, even though the drencher could have been activated from the bridge, this task was delegated to the ECR, suggesting that even though it is beneficial to have sets of drencher controls distributed over several locations, responsibility for activation should be assigned based on a conscious operational concept, paying respect to distribution of workload and total crew engagement. Designing for fire command is clearly something different than designing for detailed monitoring of fire development. This is reflected by the LASH FIRE division between the digital fire central (focusing on digital interfaces) and the overarching Firefighting Resource Management Center (focusing on the overall system of people and technology in the safety organization), but it still warrants further studies of collaboration around information relevant to a fire scenario.

### 7.2 Fire Commander decision-making

On all ships, the observed drills contained few examples of collaborative information management, e.g. where the Fire Commander worked together with other members of the bridge crew in order to make sense of situational data and create grounds for fire management decisions. There could be several different explanations for this observation. Firstly, the fact that the Fire Commanders on all three ships had been involved in the development of drill scenarios naturally diminished the element of surprise, and as a consequence, the situations where the commander needed external input for his or her decisions. Even though this approach may be functional for an experienced commander, it

could still be viewed as an operational weakness. Firstly, when very few people are inside the command loop, should something happen to the commander, it may be difficult for other officers to maintain the fire management process, and it could also make other crewmembers less prone to question or stop erroneous decisions. Secondly, the extent to which other crewmembers have insight into the fire management decision-making process might also affect their understanding of orders and the logic behind the fire management approach, making it more difficult for them to anticipate future developments and adapt their own actions to an overall strategy. It is entirely possible that a more complex, real-life fire would spur more dialogue and collaboration in the decision-making process, creating more needs for collaborative artefacts. That kind of setup would probably also be more likely to provoke a realistic emotional response to events – the stress and adrenaline resulting from trying to protect lives and assets.

### 7.3 Communication and effects of digitalization

Given the fact that communication appeared to be such a central function in fire safety performance, it may be important to assess the effects more advanced information systems may have on collaboration within the ship's safety organization. During the three drills, communications were mainly carried out verbally, face-to-face, over radio or telephone. New information systems could provide much of this information in a clearer way, without being as affected by common issues such as noise or poor coverage, something that was pointed out as a problem in the questionnaire. It is also true that radio communication during an incident can be very intense, and that the crew has to manage radio channels very deliberately in order to minimize disturbance. On the other hand, verbal communication offers certain advantages over digital presentation, such as the ability to quickly clarify and contextualize information, to assess whether the other part understands, or perhaps the most important, to judge the physical/emotional state of crewmembers. Another benefit of voice communication is that it leaves the hands and eyes free, allowing the person to monitor events and control systems simultaneously. Finally, one person in the questionnaire commented that a poor use of English in fire safety systems may lead to lower usability. This presents an interesting design case for the FRMC – making full use of digital information sharing while still preserving the benefits of current practices, making sure that new ways of presenting information do not introduce new risks.

Findings indicate that if more information is made available to the bridge, this could facilitate a more engaged and anticipatory form of leadership, allowing more people to assess operational data and contribute to the decision-making process, while at the same time reducing the workload of the Fire Commander. Effective collaboration can be supported by design artefacts that provide shared references. However, it should also be noted that work forms differ widely between ships, affected (for example) by the local work culture and degree of power hierarchy between officers and crew. On the ship where the Chief Engineer acted as Fire Commander, and where the ECR played a central role in fire monitoring, it appeared that the normal working relations between the chief and his crew made it easier for him to maintain communications and to gauge the status of the ECR crew based on their feedback. This shows that while providing a well-functioning information system to support fire management is of great importance, work must also be organized in a way that makes full use of its capabilities. In a similar vein, the strengths of current practices (e.g. benefits of verbal communication) must also be understood so that they can be retained, compensated for, or even amplified, when new technologies are introduced.

According to respondents to the questionnaire, mobilizing the crew may cause serious delays in the fire management process. It may be warranted to study ways of reaching and engaging the crew earlier when a potential fire is discovered. For example, on some ships certain crewmembers carry smartphones that give them direct information on fire alarms that occur. On the other hand, some

ships are plagued with false alarms that might induce a lot of stress if a system was designed to give earlier notification (e.g. at the point of first detection). For instance, feedback from crewmembers suggests that such a practice might violate the crew's right to rest.

#### 7.4 Keeping track of events and plans

In two cases, note-taking on fire-related events and fire management progress appeared to be a prioritized task on the bridge, although the exact purpose of these notes remained somewhat obscured. What could be observed, however, was that Fire Command often had to juggle a large amount of temporal information, monitoring the fire's development, keeping track of given orders and making plans for future actions. Even under the controlled circumstances of these drills, there were examples of information being lost in the flow of events, the Fire Commander requesting information or feedback that was never given and seemingly forgotten. One of the Officers taking notes carried them around and showed no signs of wanting to share them with anyone. When later asked by researchers if it was possible to photograph the notes, they had to be rewritten to be readable. In the questionnaire, one respondent explicitly asking for system functions to make memos and remarks. Based on observations, information that could be represented in the digital fire central is notes on fire safety system events (e.g. detection, closing of fire doors, closing of fire dampers, activation of drencher), operational events (e.g. mustering, time of smoke diver deployment), orders awaiting feedback, and plans for future action.

For all tasks related to logging and planning, however, it should be evaluated whether manipulating this kind of information in a digital interface might add to the workload of the person manning the safety station, for example if the method of input does not match the speed of making simple written notes. Also, it should be assessed whether automated logging of fire safety system events might inhibit the user's situation awareness, given that the information would no longer be reviewed as consciously.

#### 7.5 Systems and information integration

In terms of bridge design, work with the LASH FIRE Digital Fire Central has set out from the ambition to integrate information and controls that may often be scattered over the bridge and other compartments of the ship. This ambition was strengthened by observations from the drills. For example, the written reminder on one safety panel to remember closing the fire dampers (the panel being mounted in another part of the bridge) demonstrates that when relevant information and controls are not placed logically, they may be overlooked. On another note, the frequent use of written information often appeared to be cumbersome and impractical. Based on this observation, integrating functionality for document retrieval and management into a digital interface seems warranted. One functionality that did not seem to be present during the drills was the ability to judge the effects of drencher activation, information that could be used to determine when manual intervention is necessary, timely or even safe. One respondent to the questionnaire gave an example where in one instance, manual firefighting had to be aborted when it appeared that the fire was too hard to reach because of the stowed cargo. Again, on the theme of fire response follow-up and support, it could be discussed whether the bridge should be able to give more contextual information to the fire team around possible routes of entry or obstructions in the path, e.g. based on information around cargo placement. LASH FIRE includes the development of a Cargo Stowage Tool which is a step in this direction, although explicit use for the purposes of Fire Team direction is beyond the scope of the project.

In terms of design integration across the ship, it became clear that design artefacts in cargo and passenger areas may also affect the intuitiveness and usability of bridge fire safety systems. For

examples, names or numbers given to things such as detectors, drencher sections, frames or cabins could invite confusion and mix-ups if they are not consciously assigned to prevent this, a finding that occurred both in observations and in survey replies. Remarks in the questionnaire seemed to confirm this, e.g. criticizing the use of codes for detection in fire alarm displays. On a similar note, there were several examples where the Fire Commander provided the Fire Team with cues or references in the roro space to be used for wayfinding when approaching the fire. This indicates both that such references should be easy to make sense of, that they should be salient in the Digital Fire Central, and that they must be clearly available in the vicinity of the fire.

On the subject of manual fire intervention, the drills showed instances where the Fire Commander on the bridge seemed to have little insight in the actual state and progress of the Fire Team. This is a subject that, so far, has not been explored at any depth in the LASH FIRE project, although related research such as positioning of Fire Team members is ongoing, a functionality that was also requested by respondents to the questionnaire. Here, respondents from the bridge asked for information about firefighter positions. This was also a request from Fire Team members, adding requests for information around ventilation and dangerous goods. To complement the CCTV system which will often become blocked by smoke, another prospect could be video streams from worn cameras, which may provide increased visibility if most of the smoke gathers at the ceiling, and possibly other means than VHF for the Fire Team Commander to provide fire scene information to the bridge. A side finding that is not directly related to systems usability but that nevertheless seemed to introduce some delay in one of the drills is password protected systems. Cyber-terrorism and manipulation of onboard systems is a subject that is gaining attention. For example, bridge systems are mentioned in the IMO guideline on maritime cyber risk management, in connection to both attacks and system failures that are caused without malicious intent (MSC-FAL.1/Circ.3 5 July 2017). Here, a conflict might emerge with fire safety systems availability, should this not be taken into account when installing fire safety control and information systems onboard.

Digital mimic panels scored the highest for functionality in the questionnaire, especially for judging the fire's development, and answers also indicated that digital panels promote consistency in presentation of information. Interestingly, however, user satisfaction was far from complete, both for fire alarm panels and drencher panels. Comments reflected a fear of information overload, and there were also requests for physical controls instead of only touch-based controls. This suggests that digital, screen-based solutions are no magic bullet, granting a positive user experience, but that systems need to be tailored and adapted to end-user needs in order to fulfil their potential.

## 7.6 Implications for training

Even though the ambition in creating the drills was to maximize realism and provoke a naturalistic response to events, there were several indications that officers and crewmembers had prepared in advance, e.g. being on standby at or close to their work stations. Also, as previously mentioned, the persons acting as Fire Commander on the three ships had all been involved in drill planning and rarely seemed surprised by how the drill evolved. To a large extent they followed the safety procedures, while actual problem-solving and decision-making was limited. Previous research (Bram et al, 2019) has shown that officers may often be reluctant to introduce surprises in drills, something that could explain outcomes in this instance. However, the lack of realistic training for officers, honing their ability to act on incomplete or surprising information, also points to a shortcoming in the drill regime. It should also be pointed out, however, that creating realistic feedback in bridge fire safety systems was a challenge. A smoke machine on deck was used for this purpose, but activating heat sensors was never achieved. Even though this is not included in LASH FIRE development

activities, future iterations of the Digital Fire Central could be envisioned to offer such a functionality, for example, a training mode with fire scenarios and corresponding activation patterns.

## 7.7 Method discussion

### 7.7.1 Video-based ethnography

The ambition with the three drills was to recreate as realistic circumstances as possible, allowing the researchers to get more insight into operational fire management. Even though it could not be avoided, it was clearly suboptimal to involve participating officers in planning, something that would probably hold true for any drill. In a future application of a similar method, another crew than the participating one should probably be approached for planning and preparations. That said, making any kind of preparations onboard without alerting the crew to what was to happen also proved very difficult. In the end, ecological validity of the studies benefited from the natural variations and disturbances that will always occur in a joint, large-scale exercise, with researchers still being able to obtain usable results.

It also proved difficult to construct scenarios that were sufficiently complex to provoke any dynamic or intense decision-making on behalf of the officers present. At the planning stage it was assessed that the time factor was important for this purpose, and that scenarios should cover enough developments and complications to produce many examples of interaction, both between crewmembers and with their fire safety systems. All ships included in the study were in operation, and in another situation it would probably have been rewarding to perform this kind of study in conjunction with an already scheduled large-scale drill, given that these occur regularly (but seldomly) in the operator organizations.

At the first ship, a round of post-drill interviews were arranged where the researchers could ask follow-up questions about observations from the drill recordings. For various reasons, this was not possible on the other ships. Doing this would probably have shed some light on events (and in particular, fire management decisions) that could not be penetrated based on recordings alone. Furthermore, it might have served to calibrate the weight of perceived observations. This kind of calibration is still possible within the project and efforts will be made to seek participant input on the contents of the present report.

The method of using video recordings as the foundation of an ethnographic study is perhaps uncommon. Although this choice of method was primarily spurred by the limited access to crews and ships caused by the COVID-19 pandemic, it also provided some benefits. Of course, having participants wear cameras could be thought to affect their behavior, although there was little hinting to such effects during drills. Instead it could be noted that using action cameras allowed the researchers to take more of a background position, with minimal engagement and interaction with crewmembers, perhaps making them slightly more relaxed and free to act naturally.

### 7.7.2 Questionnaire

Distribution proved to be the largest challenge throughout work with the seafarer survey. Due to the limited amount of responses, certain questions or categories of questions obtained too few answers to allow any real quantitative analysis. The purpose of the survey was however primarily to gather qualitative data and this was still possible.

Several seafarer unions all over the world were contacted with the request to add the questionnaire to, for instance, newsletters or Facebook posts, but no union chose to do this. The lack of interest from the unions came a little bit as a surprise, because it had been assumed that the main issue would be more related to motivating people to complete the questionnaire rather than to get the

word out. More time could have been spent on finding other channels for distribution, but the main lesson here is probably that personal contacts in relevant is a prerequisite for response. In addition, given the nationalities of respondents, it can be noted that the aim to gather a global perspective on fire management failed. This perhaps reflects the fact that maritime safety development is a highly regionalized phenomenon, and that the playing field (and corresponding engagement) for onboard safety differs widely across the globe. Thus, including other regional and socioeconomical perspectives on safety development remains a large but very important challenge to address.

## 7.8 Summary - Design implications for the Digital Fire Central

### Supporting collaboration

- Fire management is collaborative – it is not sufficient to consider the information base for Fire Commander planning and decisions, the same should also be done for crewmembers at work in the ECR, the drencher room and at the location of the fire.
- Facilitating communication and sharing of information is a vital aspect of fire management support and its support through digital systems could be explored further. At the same time, the benefits of face-to-face or verbal communication should be preserved.
- Social and work relations among crewmembers and officers seem to affect their interaction. Such relations may affect the actual benefits of new information systems, meaning that the organization and technical support for fire safety should be developed in conjunction. Organizational features such as the form of operational hierarchy (e.g. singular, autonomous command) seems to affect the operational engagement and awareness of the crew. Digital, screen-based solutions are no magic bullet granting a positive user experience; such systems need to be tailored and adapted to end-user needs in order to fulfil their potential.

### Supply and integration of information

- Distribution of fire safety systems controls should be done according to a concept for work distribution, paying respect to workload and crew inclusion (maintaining shared situation awareness)
- Managing documentation often appeared to be impractical during the drills. Incorporating this in a digital interface should be explored.
- There may be a need to support assessment of the effects of drencher activation, information that could be used to determine when manual intervention is necessary, timely or even safe.
- There could be benefits to letting the bridge give more contextual information to the fire team around possible routes of entry or obstructions in the path, e.g. based on information from a cargo monitoring function.
- References used for orientation (e.g. names and numbers) should be easy to make sense of, should be salient in the Digital Fire Central, and must be clearly available in the vicinity of the fire. This is addressed in LASH FIRE WP06 solutions.
- Respondents from the bridge asked for information about firefighter positions.
- Fire Team members also asked for information about firefighter positions, and in addition, for information around ventilation and dangerous goods
- The sound environment (i.e. noise or parallel activities) differs greatly between different onboard environments and must be taken into account in fire safety systems interface development.
- The issue of false alarms demands serious consideration. For example, false alarms have proven to affect the possibility of issuing earlier notices to crewmembers (e.g. at first



detection), because the frequent triggering of false alarms would threaten the crew's right to rest.

- Conflicts may emerge between cybersecurity and fire safety systems availability, should this not be taken into account when installing fire safety control and information systems onboard.

### **Supporting awareness and planning**

- Keeping track of events (e.g. written logs) was observed but there were no instances where it could be positively confirmed that notes were used to inform planning and decision-making. In addition, several observations were made where the information load around both ongoing and future activities on bridge personnel was high. Supporting such management processes is an important objective of LASH FIRE development, and one that is also included in ongoing work. Information that could be represented in the digital fire central is notes on fire safety system events (e.g. detection, closing of fire doors, closing of fire dampers, activation of drencher), operational events (e.g. mustering, time of smoke diver deployment), orders awaiting feedback, and plans for future action. It should however be evaluated whether manipulating this kind of information in a digital interface might add to the workload of the person manning the safety station, and whether automated logging of certain items may be negative for situation awareness.

### **Implications for training**

- Officers seem to be disfavored when it comes to realistic training of their fire management duties, e.g. planning and decision-making.



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## 10 ANNEXES

### 10.1 ANNEX A



**Fire safety systems demonstration**  
Facilitator's guide

## Fire safety systems

### System demonstration



**Your research folder contains:**



#### **Before**

All you need to know about the preparations



#### **During**

A guide to follow during the session



#### **After**

What to do after the session



#### **Welcome letter**

An introduction letter to the participant



#### **Consent form**

To be filled in by the participant

**Any questions?**

Erik Styhr Petersen  
erik.s.petersen@ntnu.no



**Fire safety systems demonstration**  
Facilitator's guide

## BEFORE

This LASH FIRE system demonstration is meant to provide information about the use of the fire safety systems. The session will take place on the command bridge on the ship and the participant is the fire officer onboard. The participant should not be intended to participate in the LASH FIRE (WP06 and WP07) drills during the spring 2021.

During the session, the participant will be asked to explain the fire management system as if he or she was introducing a new crewmember. The session will be recorded with the enclosed GoPro camera. It is expected to take about one hour to complete.

When contacting the participant, emphasize that the researchers of LASH FIRE only want to gain a better understanding of the systems at hand, and that the session in no way is a critical review of knowledge or work practices. Before the session, make sure that all equipment is in order.

### Check

- ☐ Battery
- ☐ Memory card

### Bring

- ☐ Research folder
- ☐ Pen
- ☐ Camera
- ☐ Chest-mount harness

### Recording capability

Full battery: 1-1,5 hours

The camera and spare battery is fully charged at delivery.

### Any questions?

Erik Styhr Petersen  
erik.s.petersen@ntnu.no



## Fire safety systems demonstration

### Facilitator's guide

## DURING

Start by going through the Welcome letter with the participant. This letter contains the purpose and contents of the session. Then go through the grounds for consent, according to the form.

### Set-up

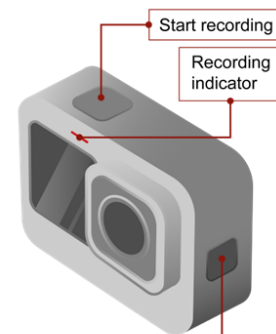
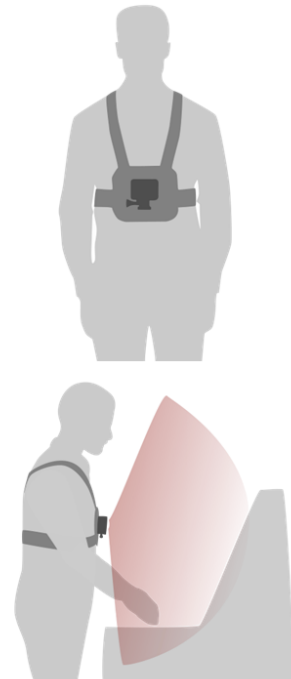
- ☐ Provide participant with Welcome letter
- ☐ Collect the participant's consent
- ☐ Rig camera equipment
- ☐ Start recording (and let it roll the entire session)

### The session

On the next page, you will find a list of what to ask the participant to demonstrate. Remember that the participant should demonstrate the system as if he or she was introducing a new colleague. See guidance in the bottom corner.

### Wrap-up

- ☐ Stop recording
- ☐ Leave the Welcome letter with the participant and encourage them to get in contact if they want to add anything



**Press and hold:** ON/OFF  
**Press:** Change the capture mode to video

### Helpful tips:

You can say simple things 'Keep on speaking', or 'Is there more to say about this function', to help the participant back on track. It is however very important that you do not ask leading questions, inject opinion, offer advice or even corrections.

### Any questions?

Erik Styhr Petersen  
 erik.s.petersen@ntnu.no



**Fire safety systems demonstration**  
Facilitator's guide

## System walkthrough guide

Ask the participant to demonstrate and explain the following:

### Bridge Systems

- Show from which location(s) a fire can be managed and what panels or equipment are relevant.

### The Equipment

- Show me the **fire detection system**
  - What messages may occur in the alarm panel? What do they mean?
  - How do you tell where the detector is placed?
  - How do you see the status of a detector? (e.g. disabled)
  - What controls does the fire detection system have? (e.g. for acknowledgement or silencing of alarms)?
- [if applicable] Show me the **remote fixed fire suppression system** (drencher/CO<sub>2</sub>) for the ro-ro spaces.
  - Show me how the suppression system is controlled.
  - How do you see the status of functions?
  - How do you find out what drencher zone or CO<sub>2</sub> compartment to activate?
- Show me the **fire and safety plan** and how is it used.
- Show me the **fire door panel**.
  - What controls does the panel have?
- Show the **communication devices** used during a fire incident.
  - What uses do different devices have during an incident?
- Show me an example of a **stowage plan**.
  - How is the plan taken into account during a fire?
- Show the **ventilation control panel(s)**
  - Show its functions and what you need to know in order to use them.
  - What are the 'standing orders' in case of a fire?
  - How are areas in the ship) described? Is this consistent with the fire detection system and suppression systems?

### Other locations

- [if applicable] Show me the **drencher room**
  - Show any slave screens (alarm panels)
  - Show any GA and drencher zone drawings/writing
  - If applicable, show the switch for the pumps feeding the drencher system, and the switch for selecting water source (freshwater/seawater)

### Any questions?

Erik Styhr Petersen  
erik.s.petersen@ntnu.no



Fire safety systems demonstration  
Facilitator's guide

## AFTER

The recordings made during the session may not be copied from the camera. This is important in order to respect participant consent and GDPR regulations.

Notify NTNU that the equipment is ready to collect and return it as it was delivered, including:

- ☐ Camera and harness
- ☐ Charger
- ☐ Consent form

### Any questions?

Erik Styhr Petersen  
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## Fire safety systems demonstration

### Participant's information

## Welcome!

The LASH FIRE project looks for ways of strengthening fire prevention and management on roro/ropax ships. One part of this work is to suggest improvements to systems, equipment and environments used by the crew during a fire incident. In order to do that, we need to develop a sound understanding of how fire management is supported today.

This activity is meant to give us a better understanding of the systems and environments used during a fire incident. A session leader will ask you to talk about the different systems, describing how they work, as if you were introducing them to a new crewmember. Also describe what you think about working with the device, including both things that work well and things that could be improved.

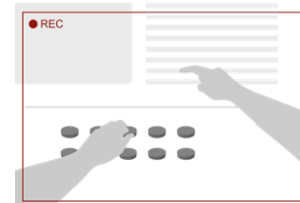
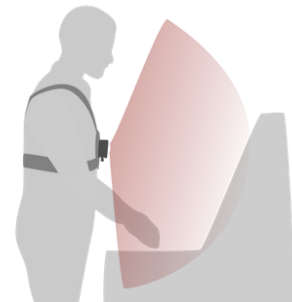
Data collected during this session will primarily only be used for analyses within the project, but we also ask for your consent to use video clips in other ways. Recordings or transcripts will never be used in a way where you as an individual can be identified.

**We want to clarify that this is not a test of your skills or knowledge of the system.**

Thank you for taking the time to participate in this session. If you have any further questions afterwards, please do not hesitate to contact us.

Erik Styhr Petersen

[erik.s.petersen@ntnu.no](mailto:erik.s.petersen@ntnu.no)



The LASH FIRE project is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 814975. This particular study is organized by RISE (Research Institutes of Sweden), NTNU (Norwegian University of Science and Technology) and NTNU Samfunnsforskning.



**Fire safety systems demonstration**

Consent form

**Informed consent of system demonstration**

The LASH FIRE project investigates fire safety on RoRo and RoPax ships. The project is funded by the European Union's Horizon 2020 research and innovation programme, grant agreement 814975.

The fire management system demonstration where you will participate is meant to examine the functions of the fire management system.

You will participate as an expert user of fire safety systems.

**Consent**

- I have been fully informed about the purpose of this system demonstration, how information is gathered and treated.
- I have been given opportunity to ask questions about the system demonstration before it begins and know who to contact with further questions.
- I have been informed that my participation is voluntary and anonymous and that I, whenever I feel the need, may cancel my participation without stating a reason.
- Regarding the usage of video-recorded material, I agree that this material can be used as indicated below:
  - Internal in the LASH FIRE project ☐ Yes ☐ No
  - External, for LASH FIRE related purposes ☐ Yes ☐ No
  - Within the company, for information purposes ☐ Yes ☐ No
- I hereby consent to participating in this system demonstration which is part of the LASH FIRE project.

Place/Date/Year

---

Signature of the participant

---

Printed name

---

## 10.2 ANNEX B

### 10.2.1 Participant profile

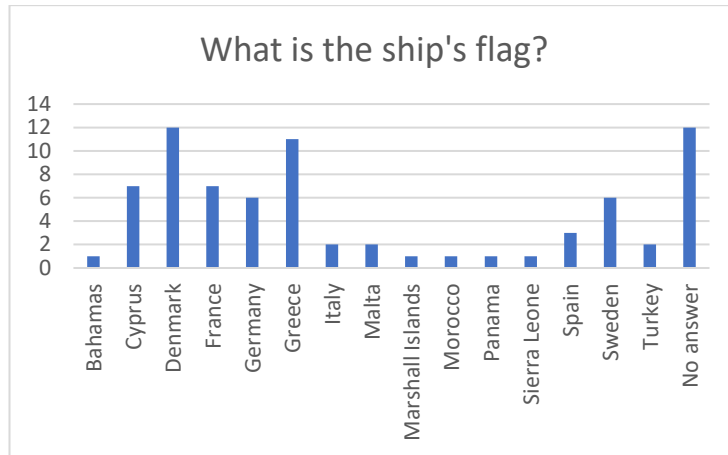


Figure 18. Answers regarding ship's flag

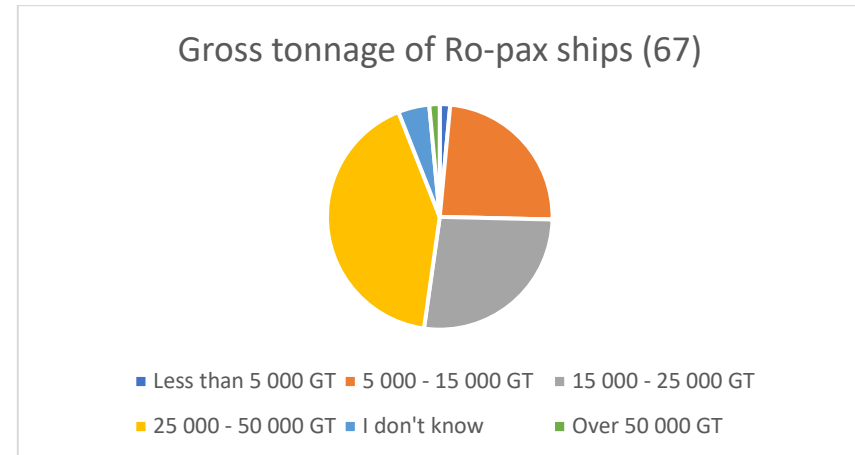
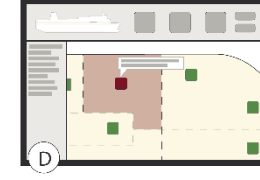
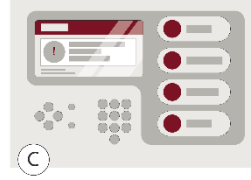
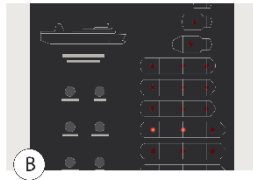


Figure 19. Answers regarding gross tonnage for Ro-Pax ships

## 10.2.2 Fire detection

Table 7. Bridge answers per system type

I think the fire detection system is well designed with regards to...



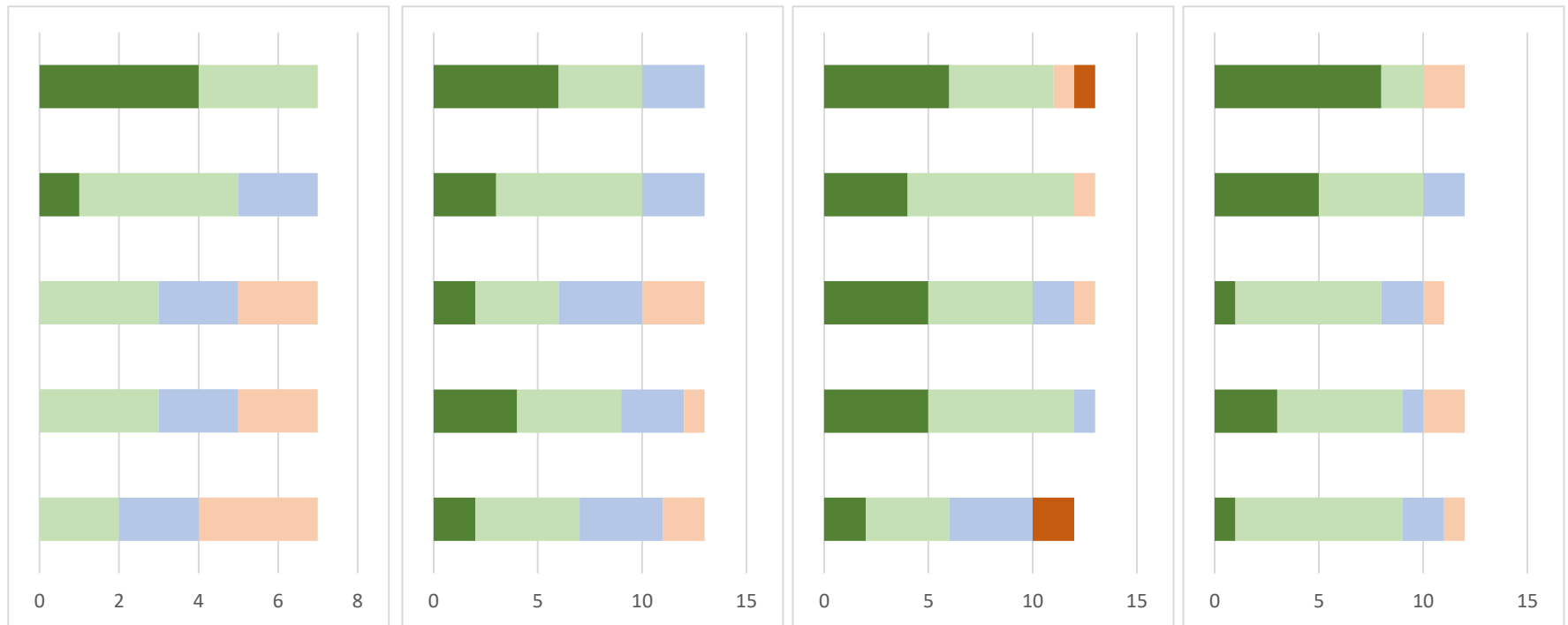
...quickly make me aware that there's a fire incident.

...understanding which detector first activated the alarm.

...understanding how the fire is developing.

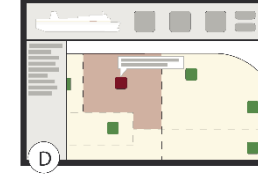
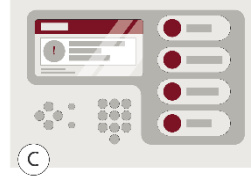
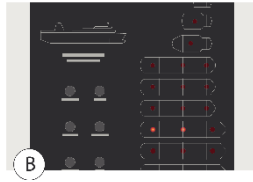
...understanding which alarms need my immediate attention.

...understanding which alarms that are not as urgent.



■ I strongly agree ■ I agree ■ Neutral ■ I disagree ■ I strongly disagree

I think the fire detection system is well designed with regards to...



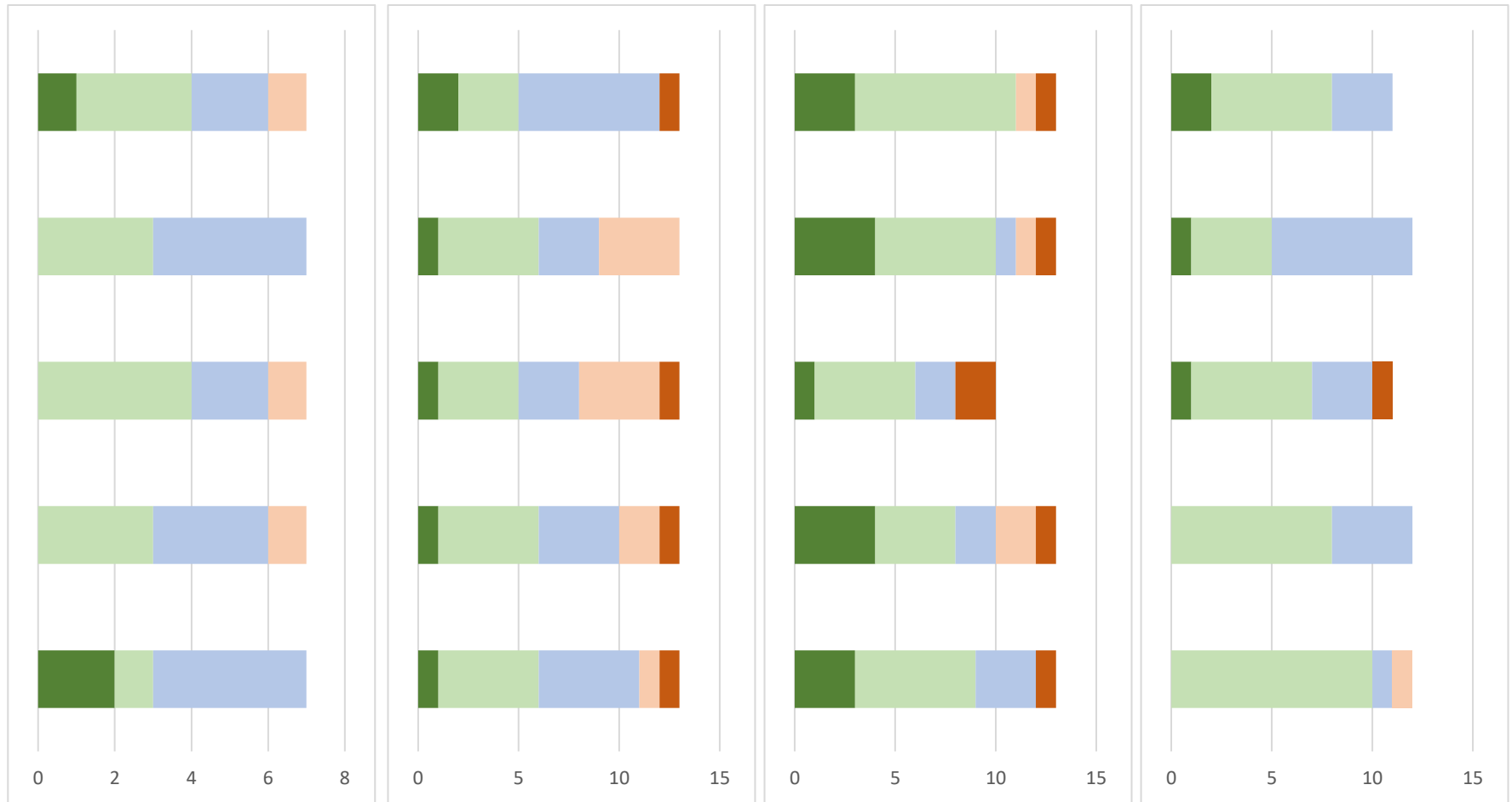
...presenting the correct information at the right moment.

...the consistency between different information systems (e.g. similarity regarding symbols and labeling etc.).

...following interactions with the system on other locations (e.g. if an alarm is acknowledged from other location).

...having all the functionality needed.

...finding the functions or information needed.



■ I strongly agree ■ I agree ■ Neutral ■ I disagree ■ I strongly disagree

### 10.2.3 Alarms

Table 8. Alarm messages on bridge panels (groups with less than five answers excluded)

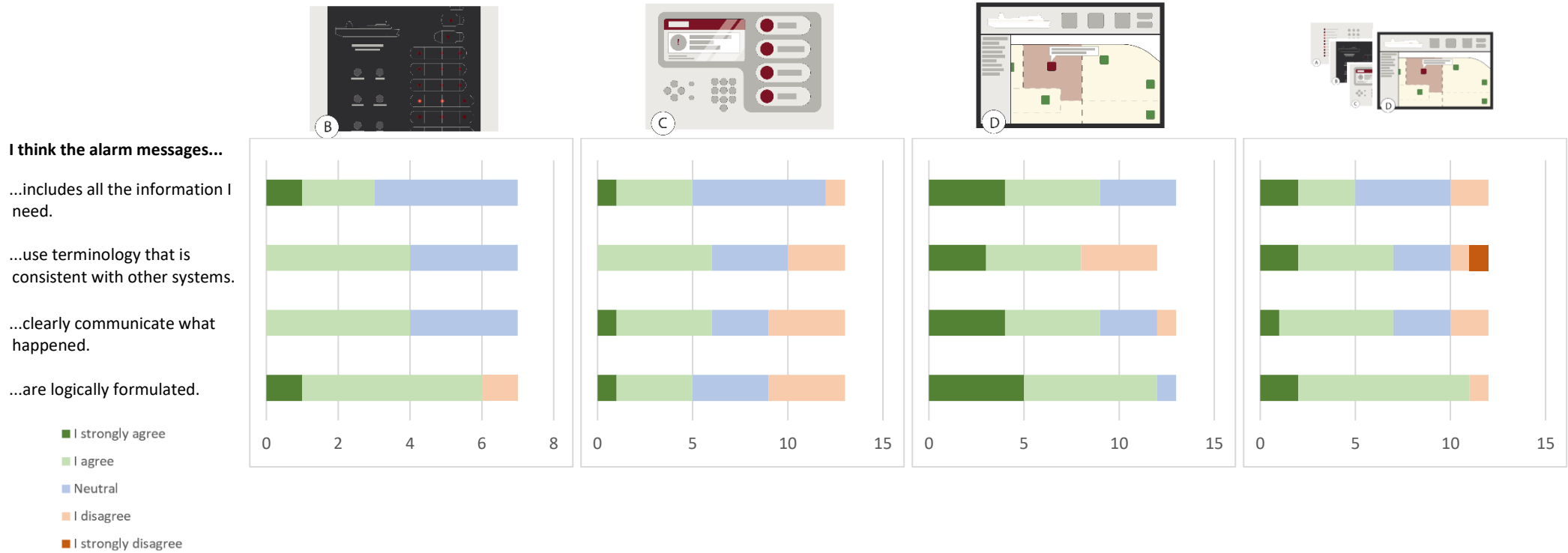


Table 9. Alarm sounds (multiple choice question)

How distinct are the fire detection system alerts? <i>This question refers to the sounds on the bridge and 'other alarms' could be any type of alarms.</i> <b>(Multiple choice question)</b>							
	Total answers	The sounds are easy to distinguish from other alarm sounds	The sounds are easy to hear (volume)	The alarm sounds are too similar to other alarms	The alarm sounds are overpowered by other alarms	The alarm sounds disturb the fire management unnecessarily much	Other
Panel B, bridge	7	100%	43%				
Panel C, bridge	13	69%	69%		8%		
Panel D, bridge	13	69%	69%	15%	8%	15%	8%
Panel D + other(s), bridge	12	67%	67%	25%			8%
Any panels, ECR	8	50%	25%	25%		13%	
<i>Participants with real experience<sup>6</sup></i>	14	64%	71%	14%	7%	7%	

<sup>6</sup> These answers are both from the bridge and from ECR, and the answers are also included under the corresponding panel.

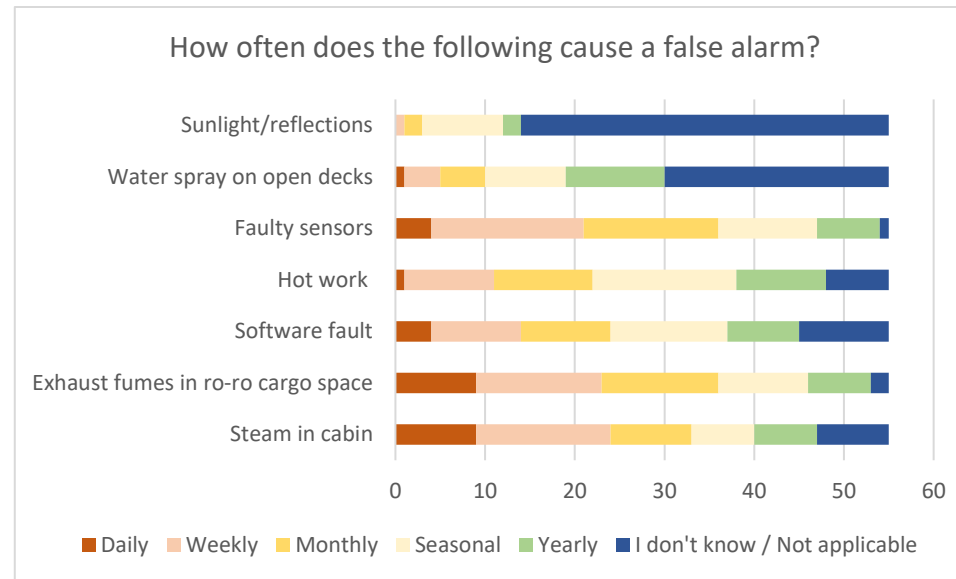


Figure 20. False alarms, including answers from bridge and ECR

#### 10.2.4 Fire suppression

Is it possible to activate the fire suppression system (in the ro-ro space) from the bridge? (47)

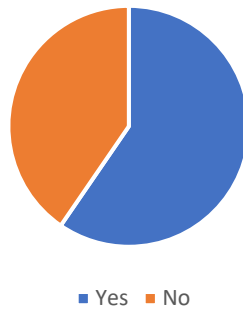


Figure 21. Responses from bridge-located respondents

Is the fire suppression system normally controlled from the bridge/safety center? (28)

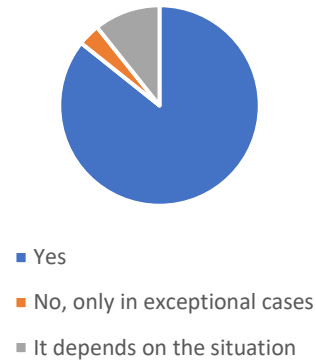


Figure 22. Follow-up question on "yes" responses

From where is the suppression system activated? (19)

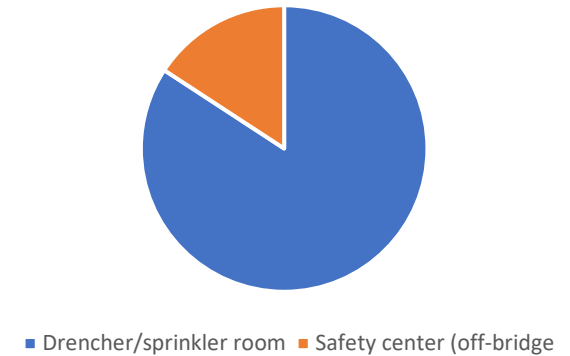


Figure 23. Follow-up questions on "no" responses

Is it possible to activate the fire suppression system (in the ro-ro space) from the engine control room? (9)

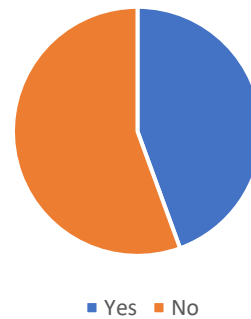


Figure 24. Responses from ECR



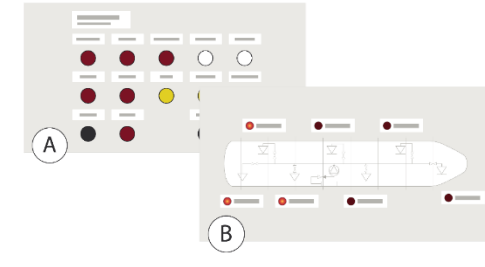
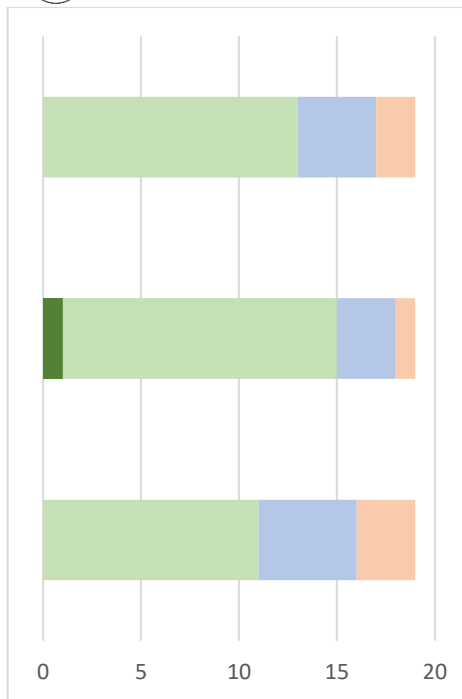
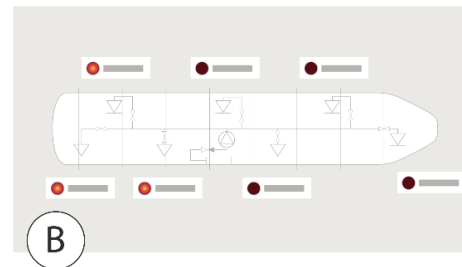
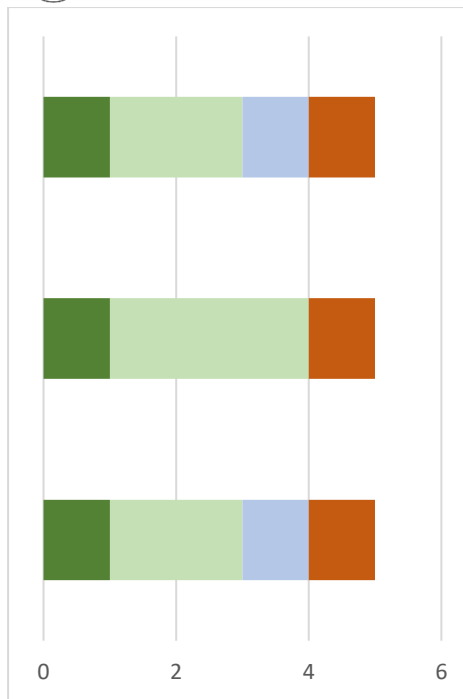
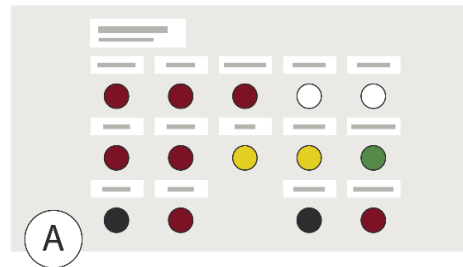
Table 10. Results from both bridge and ECR

I think that the suppression panel is well designed with regards to...

... the clarity of what action to take

... the feedback from the system, meaning if the function(s) is activated or not.

... the consistency between different information systems (eg. consistency regarding symbols and labeling etc.)



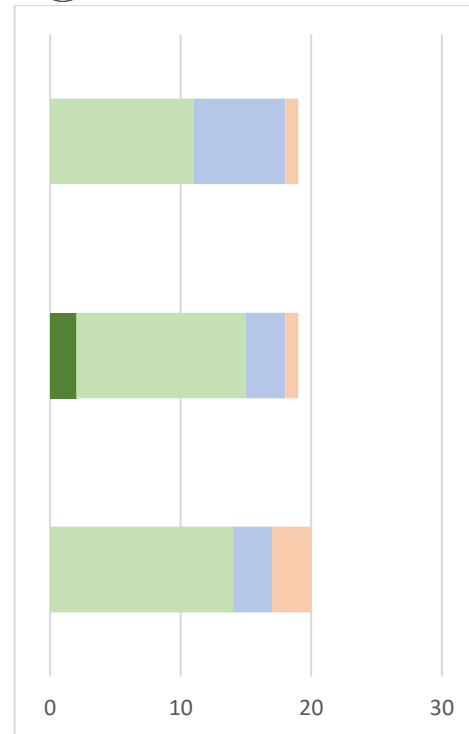
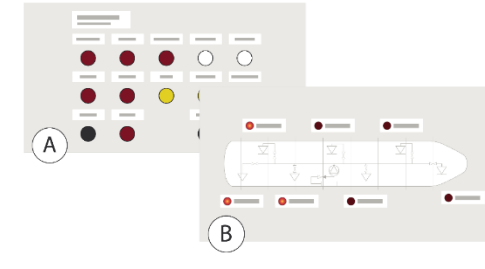
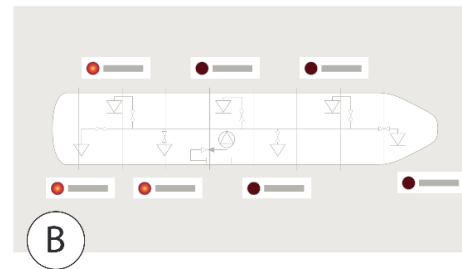
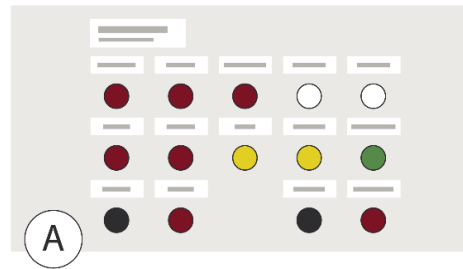
■ I strongly agree ■ I agree ■ Neutral ■ I disagree ■ I strongly disagree

I think that the suppression panel is well designed with regards to...

...following interactions with the system on other locations (e.g. if suppression is activated from the engine control room).

... having all the functionality needed.

... finding the functions/information needed.



■ I strongly agree ■ I agree ■ Neutral ■ I disagree ■ I strongly disagree

## 10.2.5 Information and communication

Table 11 Information sources (multiple choice)

Which technology is used in the confirmation/dismissing of fire in ro-ro space?						
Radio	Phone	CCTV of the cargo spaces	Visual confirmation or dismissing from crewmember	Heat sensors	Other	Total responses
77%	36%	85%	9%	47%	2%	47

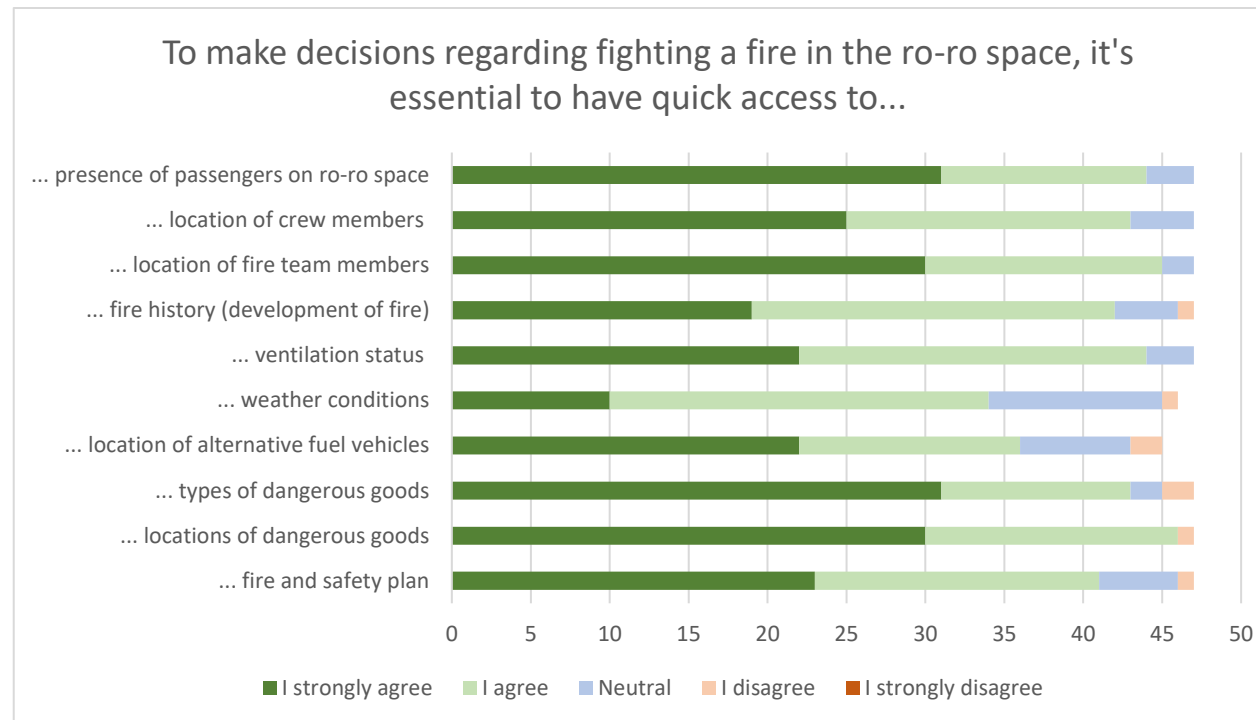


Figure 25. Information needs (bridge)

Table 12. Information needs, fire scene (multiple choice).

Which information would be most valuable to have direct access to when fighting a fire in the ro-ro space? Choose up to three options <sup>7</sup>										
Total responses	Location of fire team members	Status of pumps	Status of fire doors	Location of passengers	Ventilation status	Location of other crew members	Location of dangerous goods	Types of dangerous goods	Location of alternative fueled vehicles	Other
15	73%	13%	27%	27%	53%	20%	47%	40%	20%	7%

<sup>7</sup> This limitation was not possible to make and a lot of the respondents chose more than three options.