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LASH FIRE

Deliverable D07.10

Deployment and Validation of Firefighting Resource Management Simulator Prototype

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Abstract

The Firefighting Resource Management Centre (FRMC) has been operationalized through a set of tools (Work System Analysis, Drill Designer, Condition Cards, and Debriefing Guide) intending to improve many aspects of the firefighting resource management on a ro-ro ship. This report presents the human-centered design of the tools and the validation performed through a simulated fire drills performed at SAS training facilities in Jovellanos, Spain. Learning outcomes from current fire drills on ro-ro ships are uncertain, and drills are often utilized only as a means to adhere to legislation. The FRMC tools have been developed to improve learning outcomes from fire drills. Results of the demonstration show that the tools to a large degree had the intended impact of broadening perspectives, increased reflection, and facilitate discussion. Thus, the face-validity of the tools were acceptable, and crew members were positive about the usability of the tools. The tools could feasibly be utilized to improve learning outcomes for crew members on ro-ro ships.

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Content

1 Executive summary

1.1 Problem definition

The LASH FIRE firefighting resource management centre (FRMC) is a concept that encompasses the technical, organisational, and human resources needed for safe and efficient fire response. The FRMC was defined in D07.4 Development of firefighting resource management centre design (Skogstad et al., 2022), and includes the interaction of ship crew and their training needs, communication, and equipment use.

IMO regulations include rules on the frequency and content of fire-drills, and as such fire drills are an important avenue for the crew to consider and practice fire-emergencies. However, the learning outcomes of drills can be enhanced through simple means. In the LASH FIRE project, a set of tools has been developed to improve parts of the FRMC through improved learning outcomes from fire drills (see D07.8 Vicario et al., 2022). The final FRMC tools presented in this report are:

- **Work system analysis**, which is a functional model and graphical representation of the system of firefighting capabilities. The tool can be used to systematically identify factors that can affect fire safety on a specific vessel.
- **A Drill design template**, which is a tool to make use of insights derived from the other tools (work system analysis, debriefing guide) in the planning of drills.
- **Condition cards**, which can be used to facilitate the introduction of variability and the unexpected into safety discussions and drills.
- **Debriefing guide**, which support the learning from drills and the ability to gain feedback that can be systematically used in improvement work.

This report will present the development of the tools from a human-centered design perspective, and the results of an effort to validate the tools through a simulated exercise.

1.2 Method

The FRMC tools were developed following human-centered design principles. Each tool was developed with consideration of their rationale, design goals (i.e., how they intend to support a problem), and criteria for evaluation.

The tools were developed by analysing data from interviews, video ethnography, and virtual walkthroughs in an iterative approach. Demonstration and validation of the tools were performed at SAS training facility in Jovellanos, Spain. Workshops, table-top exercises and simulated drill scenarios were performed. The results from this simulation in the form of feedback from participants were used to assess the face validity of the tools, and a human-centered design evaluation.

This report has received input from LASH-FIRE deliverables D07.4 (Skogstad et al., 2022) and D07.8 (Vicario et al.,2022).

1.3 Results and achievements

The results in the report are from the successful simulation of the FRMC tools at SAS training facilities in Jovellanos, Spain. In short:

- Working with the **work system analysis**, participants experienced greater awareness of others' perspectives, and gained a more detailed understanding of the functions required in fire-emergency management. However, the tool was described as comprehensive and time-

consuming, and may be more feasible to use for officers and land-organization, than sharp-end ship crews.
- The **condition cards** could be used to increase creativity and help introduce variance to the fire-drills in order to anticipate and train for unexpected events.
- **Debriefing guide** promoted more discussion among participants than regular debriefs, and could be useful to share experiences and making implicit knowledge explicit. However, participants emphasized that such a tool would not be used if it was too complex or making documentation too time consuming.

Overall, the human-centered design evaluation of the simulation demonstrated that the face-validity of the tools were acceptable, and that the tools could improve learning outcomes prior to, during, and after drills for crew members on ro-ro vessels.

1.4 Contribution to LASH FIRE objectives

This report is contributing to the following LASH FIRE objectives:

- Strengthen the independent fire protection of ro-ro ships by developing and validating effective operative and design solutions addressing current and future challenges in all stages of a fire (LASH FIRE Objective 1).
- Reduce the potential for human error, accelerate time sensitive tasks and provide 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 (LASH FIRE WP07 Objective).
- Develop and validate a firefighting resources management centre (FRMC) with improved design for critical operations in case of fire, reducing the potential for human error, accelerating time sensitive tasks, and providing more comprehensive and effective decision support (LASH FIRE Action 7-C Objective).

1.5 Exploitation

The results from this report demonstrated that the FRMC tools developed in LASH FIRE can feasibly be utilized by ship operators – e.g. senior management on board or by shore management – to improve individual and organizational learning outcomes from fire drills. This will subsequently improve safety by reducing the potential for fire-emergencies, and by reducing the consequences if a fire-emergency should occur.

2 List of symbols and abbreviations

CCTV	Closed-circuit television
DFC	Digital Fire Central
DPA	Designated person ashore
ECDIS	Electronic Chart Display and Information System
FRAM	Functional Resonance Analysis Method
FRMC	Firefighting Resource Management Centre
IMDG Code	The International Maritime Dangerous Goods Code
ISM Code	The International Safety Management Code
LASH FIRE	Legislative Assessment for Safety Hazard of Fire and Innovations in Ro-Ro Ship Environment
Ro-ro	Ship type with cargo, type roll-on roll-off
SMS	Safety Management System
VTS	Vessel Traffic Service
WAI	Work-as-imagined
WAD	Work-as-done
WSA	Work System Analysis

3 Introduction

Main author of the chapter: Martin Rasmussen Skogstad, NSR

To achieve the primary ambition with the FRMC – to create the best possible environment for the crew to handle fire situations – the FRMC has a broad scope. The FRMC concept is developed to support firefighting resource management in different (temporal) phases before, during and after a fire, through both material/technological and immaterial/organizational measures. In the LASH FIRE deliverable D07.4 Development of Firefighting Resource Management Centre Design (Skogstad et al., 2022), the FRMC is defined and scoped as follows:

> *The Firefighting Resource Management Centre (FRMC) encompasses the entire management of resources involved in a fire scenario, including training, fire-drills, the people involved in fighting the fire, how they are organised, their communication, their equipment and how they use it. The word "centre" in FRMC does not refer to a physical room or place, as it does in a safety centre; rather it is the metaphorical collection of all things central in firefighting resource management.*

This report (alongside D07.11 Firefighting resource management simulator prototype (Skogstad et al., 2023) ; which focuses only on the demonstration performed at Centro Jovellanos in January 2023) represent the final steps in completing the objective in Action 7-C:

> *Develop and validate a firefighting resource management centre (FRMC) with improved design for critical operations in case of fire, reducing the potential for human error, accelerating time sensitive tasks and providing more comprehensive and effective decision support.*

The academic background supporting the FRMC including work-as-imagined (WAI) versus work-as-done (WAD) and resilience is presented in D07.8 Design Definition and Development of Firefighting Resource Management Simulator Prototype (Vicario et al., 2022).

3.1 Operationalizing the FRMC as tools

During the development of the FRMC it was operationalized as a set of tools. At the start of the LASH FIRE project the FRMC focused on both a physical workstation – making the "centre" aspect of the name more literal – and everything revolving around that station. The physical workstation was an area of focus for both this action, Action 7-C, and another action in the same work package, Action 7-A. As there was a large overlap in personnel in the two actions it was decided that this focus should be included in only one of the actions. This led to "The Digital Fire Central" being part of 7-A (Kaland, 2020; Steinke et al., 2022).

Our initial plan to cover "everything revolving around that station" was through a guideline or best practice on using the technology and equipment, organizational aspects, roles and responsibilities, and training and drills. However, as creating one guideline or best practice to suit all ro-ro ships is near impossible our goal was to create a guideline that would improve current firefighting resource management, rather than providing prescriptive solutions. To improve the chances of our results having an impact we've operationalized our guideline as a set of tools.

The four tools are:

- Work System Analysis (WSA; see section 4.1)
- Drill Design Template(see section Drill Design 4.2)
- Condition Cards (see section 4.3)

- Debriefing Guide (see section 4.4)

The tools are interconnected and designed to support proactive safety work and to strengthen a feedback loop with the organization by increasing understanding of “work as done”, supporting adaptivity and developing resilience strategies both in the blunt and sharp ends of the organization.

Findings from the WSA can for example feed into both Condition cards and the Drill Designer to help develop training and drill scenarios, e.g. for a new fire drill with a specific learning objective. Results obtained through the Debriefing Guide in previous exercises should in a similar manner feed back into the Drill Designer or new Condition Cards to make sure results and lessons learned are not lost.

4 Human-Centered Design

Main author of the chapter: Hedvig Aminoff, NTNU

A proactive approach to fire safety means to not only react to past incidents, but to proactively identify sources of hazard and disturbances. It is important to establish a loop of feedback and control for safety management: measuring/observing the current level of safety and setting targets for how to improve safety. The suggested tools are intended to support a loop of learning as well as shaping important fire safety activities.

This section provides background and rationale for the design of the tools, design goals and the human-centered evaluation that is part of the demonstration.

4.1 Work System Analysis

Main author of the chapter: Hedvig Aminoff, NTNU

WSA is centered on a generic functional model of firefighting activities, and a set of guiding questions intended to support systematic and detailed analysis of firefighting capabilities. There are generally gaps between how work is described in procedures and how work is conducted in realistic conditions, and workers have many strategies to make work run smoothly despite variable conditions and situations. For safety reasons, it is important to decrease the distance between how the higher levels of an organisation understand “work as imagined” and how officers and crew aboard ships perform “work as done” (Hollnagel et al., 2017). In this process it is important to gain insight to the conditions and situations that shape work, as well as the strategies workers use to make things go right, despite variable circumstances.

The WSA combines elements of two well-established Human Factors/Ergonomics methods: Work Domain Analysis (Rasmussen et al., 1990; Vicente, 1999) and FRAM analysis (Hollnagel, 2012). WSA is designed to be used by senior management on board or by shore management and should be seen as a complement to other types of safety analyses, for example Human Reliability Analysis (HRA) as described in the IMO guidelines for Formal Safety Analysis (IMO, 2018).

4.1.1 Design goals WSA

WSA is intended for systematic analysis of the work system engaged in firefighting, to investigate how different scenarios may develop, how firefighting activities can vary under different conditions and circumstances, and how responders might deal with this variability.

The tool supports proactive safety management as it can help identify and anticipate different types of hazards, potential gaps or vulnerabilities in the work system, as part of improvement work. The method highlights the importance of also paying attention to the many ways in which practitioners make daily work run smoothly by applying their skills and experience, hence it is also a way to gain knowledge about successful work strategies.

The results from using WSA can feed into the Drill Designer in several ways, as it helps identify variability that can be included in training scenarios, as well as identified gaps in knowledge and practices that can be defined as training objectives. WSA can help provide insight into variability, which can be input for generating interesting training scenarios. This is described in more detail in the section about the Condition Cards.

4.1.2 Description WSA

WSA consists of

1. A generic work system model
2. Instructions for detailing a model for a specific ship
3. A template for documenting results

4.1.2.1 The generic work system model

The FSA guidelines (IMO, 2018) recommend that safety analyses be supplemented by a generic model which provides a comprehensive view of the problem in question. This generic model should have an integrated systems view (see Figure 1), that not only includes a ship's technical and engineering system, but also humans and the organizational and management infrastructure.

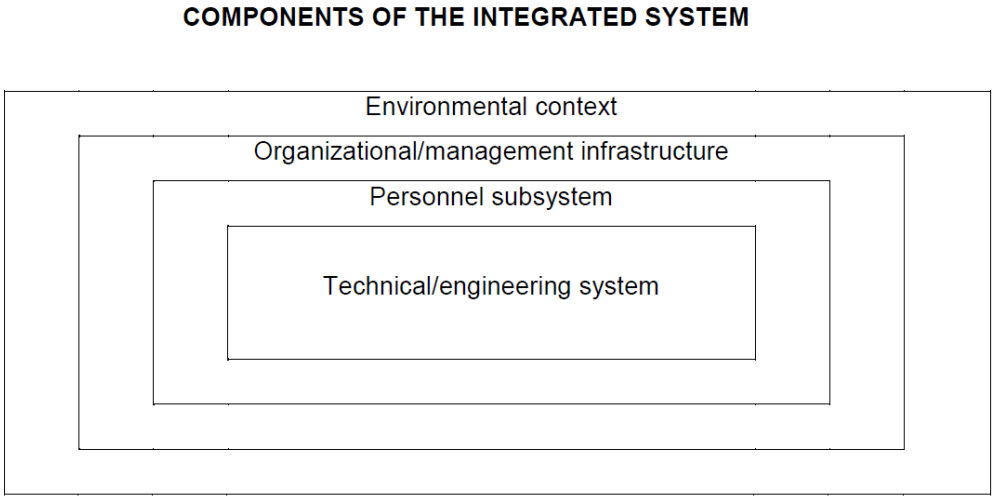


Figure 1 Components of the integrated system, from (IMO, 2018, p.17).

A generic work system model was developed through iterative steps. The first iterations built on observations on board, literature studies and interviews with ship crews, and were associated with particular ships. Later iterations were made more generic, with terminology that is harmonised with regulations and guidelines, with the goal of providing a template on which future end users could build their own, ship-specific analyses.

The work system model describes functions and features of firefighting in a way which corresponds to the generic model proposed by to IMO guidelines for safety assessment (IMO, 2018). It is a comprehensive visualisation which includes higher level organizational aspects, as well as human, electronic and hardware aspects. The generic model of firefighting on Roro-ships focuses on central functions such as prevention, detection, alarm, containment, suppression etc., and the reasons and resources that determine how these functions can be carried out. The structure of the model is the type of means-ends matrix which is used in Work Domain Analysis (Naikar, 2013). The means-ends relation shows resources on one level that are used to satisfy the function or purpose at the level

above. An abstraction hierarchy structures the elements of a work system in increasing levels of abstraction: from physical elements, such as equipment, to functions/activities, and finally abstract "elements" of the system, such as social and organizational values and priorities that affect decision-making. The inclusion of such a wide range of factors makes the model useful for systematic reasoning about a very wide range of situations (Naikar, 2013). The level of detail of the generic model can be increased and detailed so it represents a specific ship.

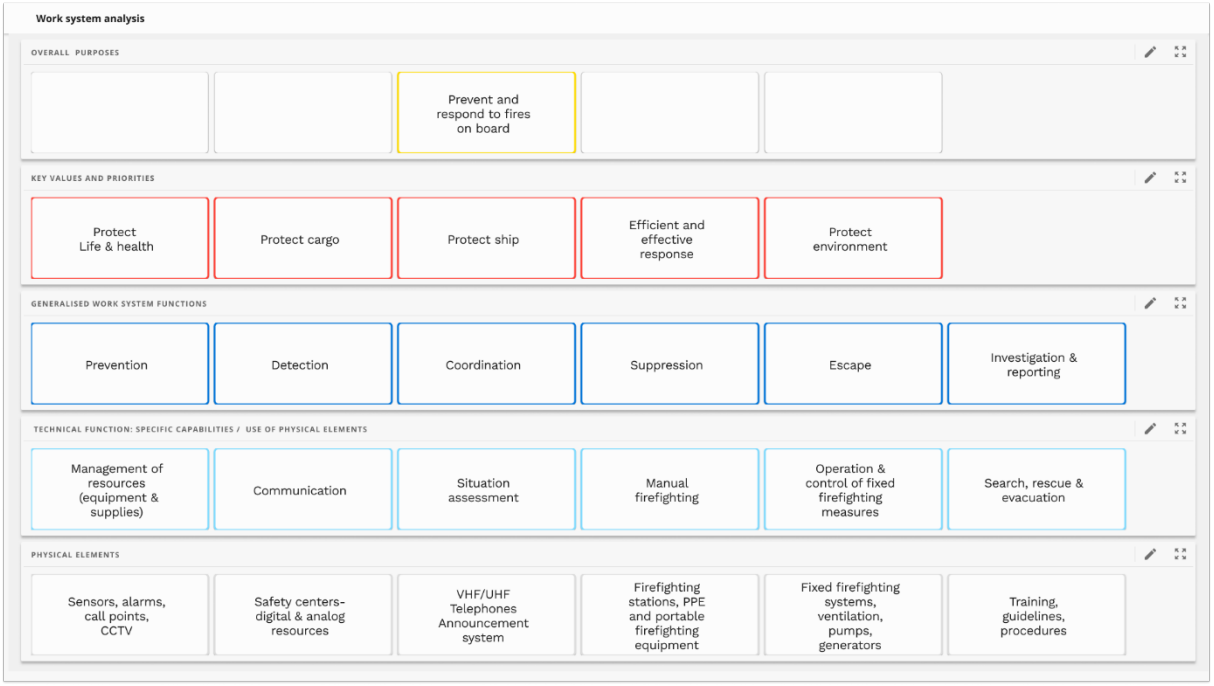


Figure 2 The generic work system model

The picture above shows the generic work system model, here in a mock-up of a software system where a user would be able to modify or elaborate the model. Each horizontal level shows aspects of the system on different levels of abstraction. The top-level shows purposes of why the work system exists. The second level shows goals and priorities that for example can affect decision-making. The third level shows the functions and tasks that are performed. The fourth level shows the use or capabilities of the physical elements, and the fifth, lowest level shows physical elements that are required for performing the system functions.

1. **Overall Purpose**: the high level purpose/objectives of the work system
2. **Values and Priorities**: human, organisational and social values that constrain what actions are acceptable, eg, safety, efficiency, working conditions. This level can capture conflicting priorities which create trade-offs in practical work situations.
3. **Work System Functions**; the generalised purpose of the technical functions
4. **Technical functions**: the capabilities/affordances of the physical elements of the work system
5. **Physical elements**: tools, equipment, and facilities that are needed to achieve the systems purposes.

Figure 3 Levels in the means-ends matrix of the firefighting work system

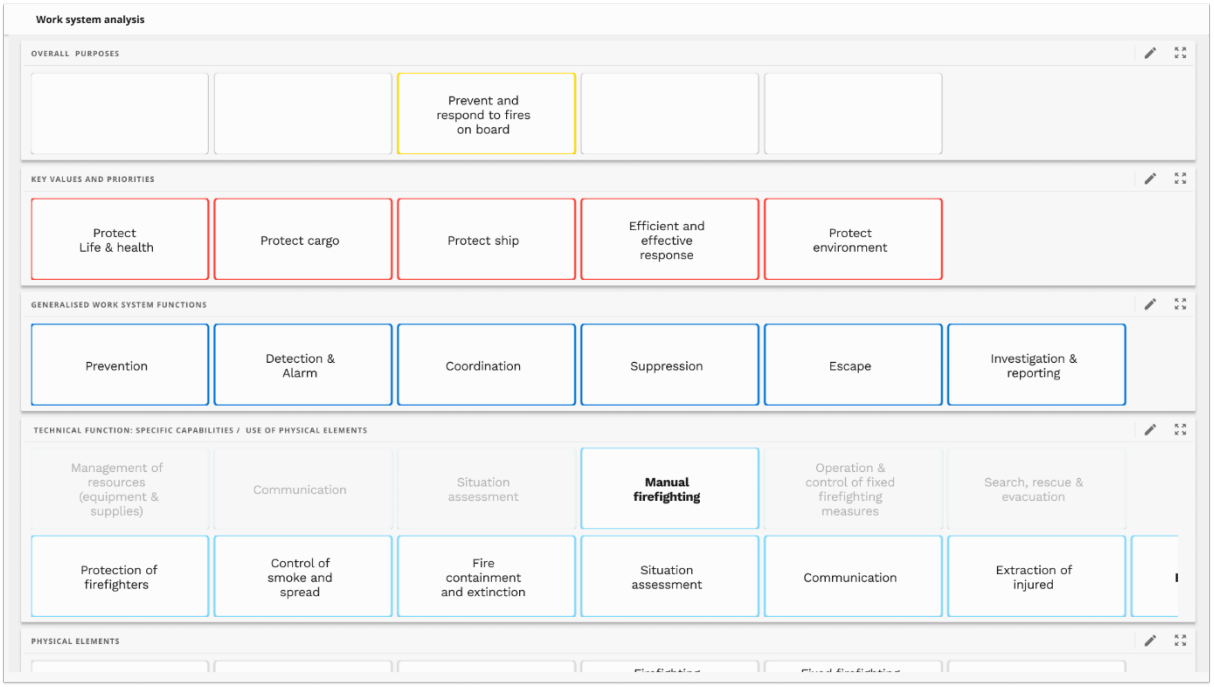


Figure 4 The generic work system model showing generic functions of manual firefighting.

Figure 5 shows how specific functions can be modelled in increasing detail, for example to focus on fire teams (manual firefighting) or on functions for incident command such as situation assessment, managing resources and coordination.

One of the strengths of modelling work in this way, rather than for example describing sequences of activities, is that this makes it possible to represent many system elements and to investigate how they interact, e.g. dependencies between actors, equipment, and organization. The model also provides a very compact and efficient format that can illustrate interactions and patterns of behavior in large, work systems, even if they are dynamic - constantly adapting and evolving.

4.1.2.2 Instructions for detailing firefighting on a specific ship

The generic model provides a structure for further analysis e.g., to model functions in fine detail, or to identify hazards by reflecting upon factors and conditions which can influence scenarios or performance. This is also analogous to the detailed task analysis and the identification of human-related hazards described in IMO guidelines for FSA (IMO, 2018).

In this way the tool can help raise awareness of how different conditions and circumstances can affect operations, and help identify vulnerabilities and improvement needs. These might range from practical measures that can be addressed locally e.g. placement of signage or equipment, to strengthening practices through training, or issues that need to be addressed through organisational measures, regarding design, technology, or resources.

The instructions provide a simple guidance for creating a task description, identifying functions and reflecting about task features, personal and organisational factors, as well as working conditions and environmental factors.

Work system analysis

Instructions

1

The main steps in a work system analysis

1. Select an event
2. Describe it in a short text
3. Define the functions – what is done?
4. Investigate how functions are linked
5. Investigate how the functions can vary in different conditions
   - Typical conditions
   - Try to think of likely but unusual conditions
   - Try to think of unlikely or extreme conditions

2

Start a work system analysis by describing, how an activity usually takes place

Example: the first steps after a fire alarm

"The OOW will send a runner to confirm if there is a fire, and if there is, the OOW will summon an alarm for the crew and the firefighting team will muster. "

3

Identify the functions – what is done?

What is done?

The OOW will send a runner to confirm if that there is a fire, the OOW will summon an alarm for the crew and the firefighting team will muster.

4

Define functions. The action words are clues!

What is done?

The OOW will send a runner to confirm if there is a fire, and if there is, the OOW will summon an alarm for the crew and the firefighting team will muster.

Confirm fire | Summon alarm for crew | Muster

5

Analyse the event by asking questions about each function

Confirm fire

Ask questions about each function :

Who does it? (a runner)

What has to be done or what conditions are needed before the function can be carried out? (need to know location)

What resources are necessary during the function? (radio communication)

Are there any rules or expectations for how the function should be carried out? (they have to know the ship)

Does the function have to be carried out before, during or after another activity?

(it has to be done before you determine it's a false alarm; containment measures may be taken at the same time)

6

Questions to ask about a function

- Who does it?
- What conditions need to be met before you can start the activity?
- Does the activity have to be done before or after any other activity?

- What are the procedures/ guidelines/ instructions for this activity like?
- Is there a correct or optimal way of carrying out the activity?
- Is there a wrong or risky way of carrying out this activity?

7

Think about conditions that can affect performance and how events develop

Organisational factors	Human-machine interaction	Operational support	Human physical / psychological limits	Team work
• Availability of personnel and equipment, • Training, preparation, competence, experience • Work shift issues	• Buttons • Switches • Screens • Sounds • Manuals and instructions	• Availability of procedures • Work conditions, • Available time	• Stress • Fatigue • Fear • Many different goals, goal conflicts	• Language issues • Crew turnover • Communication issues: VHF/UHF disturbances, language issues

8

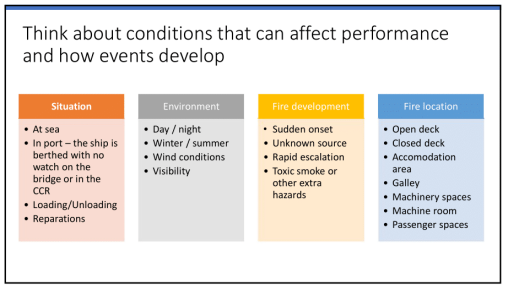


Figure 5 PowerPoint presentation slides of the WSA

4.2 Drill Design Template

Main author of the chapter: Hedvig Aminoff, NTNU

A simple template to support drill design was developed as a way of showing how insights derived from the WSA or from debriefings can be brought into the planning of drills. The Drill Design Template also illustrates how training objectives can be included when drills are planned.

4.2.1 Background

Regulations demand that each ship have a drill and exercise program, which specifies the frequency and content of drills and exercises. The ISM Code specifies that lessons learned from drills and exercises shall be addressed in the safety management system (SMS), along with records of musters, exercises and drills, and onboard training.

Drills generally focus on practicing routines and procedures, in order to develop practical experience and skills required for responding to emergency situations. Drills also fill the function of raising risk-awareness. For crew members, drills provide practical experience with firefighting equipment, but also familiarity with procedures, and the knowledge and skills required to comply with their assigned duties and responsibilities. For the Head of Safety on the ship (The Chief Officer; sometimes also referred to as the First Officer Chief Mate or First Mate), drills are a means for verifying that necessary procedures are implemented and that participants in the drill are aware of the procedures and trained to perform their duties. Drills are also a way to prove the feasibility of the ship's safety management system (firefighting procedures as well as the rescue plan) under different situations, including difficult or unusual circumstances. From a practical perspective, drills also support processes to ensure that firefighting equipment is operational. For this reason, drills are planned in a way which ensures that a ships' firefighting systems are regularly tested, thus complying to regulatory demands.

While drills are required by regulations and fill several important functions, there are some weakness issues with current training practices. Officers responsible for planning and conducting drills reported that it is challenging to design interesting new drills, and while they attempt to involve as many as possible of the ship's crew, certain groups, such as bridge command and engine rooms are sometimes inadvertently left on the side-line.

Another identified area of improvement is regarding learning goals or objectives. Drills are often described only in terms of the activities that are to be conducted.

Defining training objectives is an important step in training design. While they can guide what an exercise should contain, e.g., the type of drill scenario, they are also important elements for assessment of performance, and/or keeping track of learning over time. Defined learning objectives can also be an important element of pre-briefings, to support self-monitoring.

Results from WSA or debriefings can provide input for training objectives. Similarly, learning new procedures or equipment can be defined as a training objective.

4.2.2 Design goals Drill Design Template

The tool is intended to help define and detail central components of training activities. Defining training objectives is important for assessing training value and the quality of individual exercises and keeping track of learning over time. Creating scenarios which incorporate variability is a way of generating interesting exercises and raising the ability to anticipate likely as well as more unusual developments in unexpected conditions. The tool is intended to support those responsible for defining and conducting drills to:

- Specify training objectives from identified training needs.
- Define scenarios which contribute to engagement and interest.
- Facilitate assessment and feedback which contribute to learning.

For the tool to be accepted, it is important that it is seen as useful and that it does not create additional administrative burden.

4.2.3 Description Drill Design Template

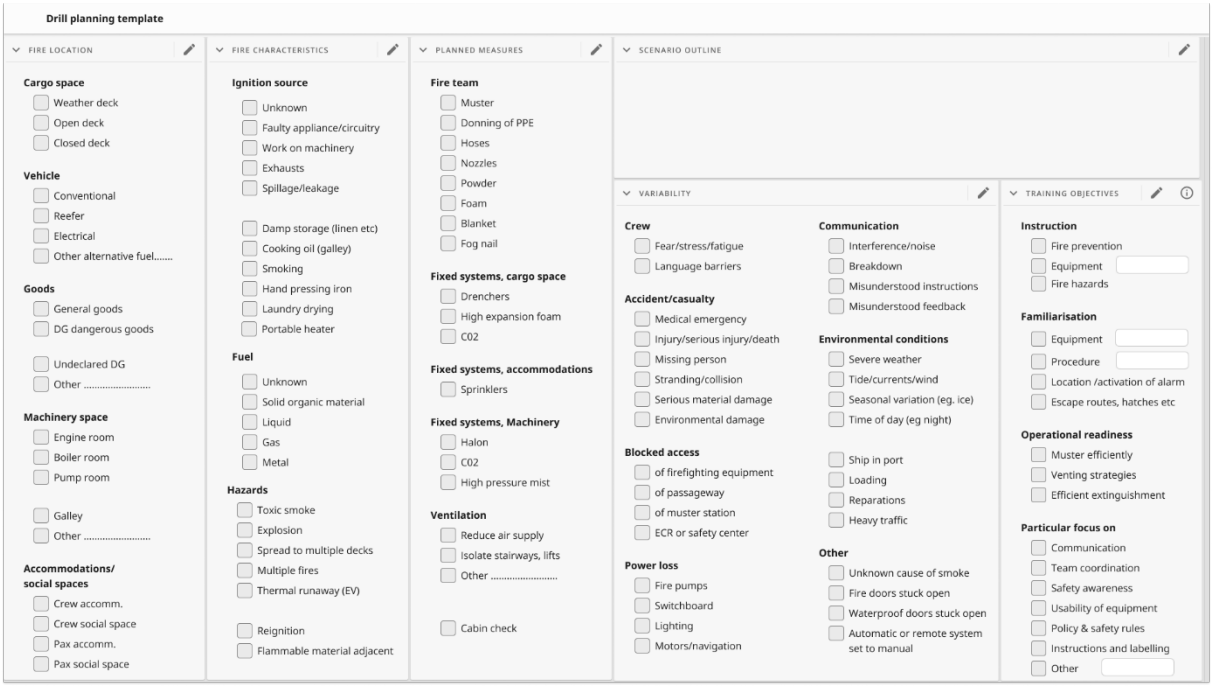


Figure 6 Conceptual design of a simple template to help vary drills and to define training objectives.

The Drill Design Template is a simple artefact that lists different elements of typical drills, such as the locations and types of fire, types of equipment that might be used etc. It also lists common sources of variability that can be included in a scenario to add complexity. In addition, there are suggestions of learning objectives.

Many of these elements may seem obvious as they are usually considered and included in drill planning today. However, the template is intended to contribute by making it easier to vary drills scenarios when planning. Listing common sources of variability is a way to raise awareness of these factors, and the importance considering variability in training contexts. The suggestions for training objectives similarly serve to make typically implicit objectives explicit, and well-defined. Training objectives can enhance interest and learning: for example, by sharing them in a pre-brief, participants can focus on certain aspects (self-reflection). The learning objectives also provide a natural point for discussion during debriefing.

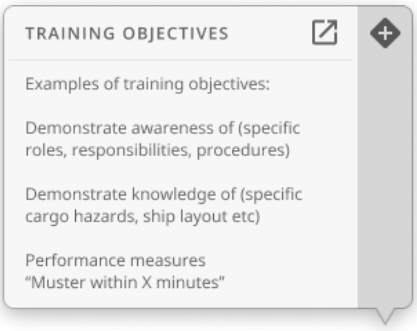


Figure 7 Pop-over with examples of how to define learning objectives

The template is intended to be used in a way where findings from WSA exercises, debriefings, or use of the Condition Cards can be added, and in this way kept "top of mind" when drills are being planned. Advice and suggestions for formulating training objectives can be provided in an instruction or in the example of a software system, an information pop-over could provide brief advice, and link to more comprehensive instructions. The template complements the Condition Cards which are described in the next section.

The image below shows an example of how learning objectives can be integrating with artefacts which are currently in common use, such as a drill check list. The example shows how improvements can be implemented in a way which does not add significant practical or administrative burden.

LASH FIRE

Fire drill plan		
Date: Week:	Reference no:	Officer in charge:
Place of fire:	Planned activities:	
Fire group meet:		
Limitation grp. meet:		
First aid grp. meet:		
Fire exercise:		
Training objectives:	Plan of action:	
Smoke generator (area):	Closing of fire doors ☐ Yes ☐ No	Closing of waterproof doors ☐ Yes ☐ No
Evacuation exercise:		
Training objectives:	Plan of action:	
Evacuation to (area):		
Rescue exercise:		
Training objectives:	Plan of action:	
Launched lifeboat no.:	With crew from:	
Safety Instruction ☐ Yes ☐ No	Team:	
Subject:	Cabin inspection:	
Various announcements/information:		
Persons exempt:	Persons not shown:	

Figure 8 Fire drill plan template

4.3 Condition Cards

Main author of the chapter: Martin Rasmussen Skogstad, NRS

The Condition Cards are a deck of cards. By choosing a tangible format, rather than app or guideline, we hope to increase the likelihood of use.

The deck of card includes both premade cards based on previous fire investigations and input from relevant Ro-ro ship crews. The deck of cards also includes many blank cards (only containing the LASH FIRE logo and EU Horizon logo and text), so that the deck can modified to match both local conditions and include aspects found during drill debriefings.

The cards were made in Adobe Photoshop. The LASH FIRE logo and acknowledgment of EU funding was provided by the LASH FIRE project. Symbols of dangerous cargo are from the IMO International Maritime Dangerous Goods (IMDG) Code. Most of the images are created by the AI-tool Midjourney (www.midjourney.com). The current list of cards is included in ANNEX C List of Premade Condition Cards.

Figure 9 Condition cards prototype used in Jovellanos demonstration.

4.3.1 Condition cards use cases

4.3.1.1 Tabletop exercise

All cards can be used to facilitate discussion. For example, imagine that an alarm has gone off and there is a fire on board. The cards facilitate "what if?"-scenarios to accompany the situation. A card is drawn from the deck revealing an additional condition, prompting questions such as:

- How would this change the situation?
- Would it require a work-around?
- How would the current firefighting management system handle the situation?
- How could we be better prepared?
- Are there other similar situations that could occur?

By using the cards as an external discussion cue, the idea is that systematic and creative discussion around fire safety and firefighting resource management can take place.

4.3.2 Planning and designing a drill

The deck of cards does not represent a card game with strict rules in terms of shuffling and random drawing. The cards can be used as prompts when planning and designing the scenario for the drill. Cards made in previous drills or through other exercises represent local aspects and conditions that the ship's crew finds important. When a real fire incident occurs, it is rarely caused by single faults, and it is rarely looks like a standard scenario. Many of the cards can be combined to make complex and difficult scenarios, leading to a better prepared crew if an accident were to occur.

4.3.3 Creating new cards

To enable the creation of new cards the deck includes many blank ones (only containing the LASH FIRE logo and EU Horizon logo and text). The other FRMC tools can be used to create new cards. The WSA represents a thorough analysis of elements related to fires. It is likely that the analysis will reveal areas that should be included in future drills. The same is true for the Debriefing Guide which can capture elements that could be included in future drills. Making new Condition Cards can be a practical way of including those elements.

Figure 10. Three of the prototype Condition Cards.

Figure 11 Reverse side of a Condition Card

4.4 Debriefing Guide

Main author of the chapter: Hedvig Aminoff, NTNU

The Debriefing Guide consists of facilitation guidance for conducting debriefing after drills, and a template for collecting experiences and learning from exercises. The guide emphasises learning through reflection on practice and feedback, and can generate insights for both level 1 (sharp end) and level 2 (blunt end) improvement.

4.4.1 Background

Regulations demand that debriefings be held after drills, however, debrief/report is often seen as necessary administrative evidence rather than learning (Hermansson & Papamatthaiou, 2021). The practical learning experience of drills can be enhanced when they are followed by discussion and reflection on practice [2]. Indirectly, debriefings can support group dynamics, when participant's share details about their tasks and information needs. Debriefings also contribute to shared situation awareness during subsequent exercises or real incidents, since the questions asked and the feedback provided highlight what is important to pay attention to (Morrison & Meliza, 1999). There is often pressure to keep debriefings short, and it can be challenging to lead an effective debriefing session, for example it may be difficult to get a good picture of events and performance, and then to pinpoint what should be included in the debrief. Another thing which can be difficult is how to formulate questions that inspire group discussions (ibid.). Hence the Debriefing Tool is designed to provide practical guidance to the person facilitating debriefing sessions.

4.4.2 Design goals Debriefing Guide

The goal of the debriefing guide is to support the learning from drills and to gain feedback that can be used in improvement work. The guide is intended to be easy to use and exemplifies a tool which can be integrated into existing practices, thus enabling improvement without adding the burden of new tasks or equipment.

4.4.3 Description Debriefing Guide

The tool consists of:

1. Instructions for the facilitator.
2. A guide with questions that can be chosen to facilitate the analysis.
3. A template for notes from the debriefing and for recording take-home points.

4.4.3.1 Instructions for the facilitator

In debriefings, the openness in discussing safety issues is affected by the overall work situation and the working conditions on board. The facilitator can help create conditions that support learning through self-feedback and open discussion. Another part of the facilitator role is setting goals and providing feedback. However, feedback might be disregarded when there is disagreement on what happened. Hence a facilitator can start a debriefing by leading the process towards a shared understanding of events.

The instructions provided in the debriefing tool focus on: supporting the facilitator to set goals; organizing the debriefing session; providing feedback; creating conditions that support reflection and discussion, and encouraging self-feedback.

LASH FIRE

Debriefing Guide

Part 1 Facilitator tips

Set goals	Setting specific goals for an exercise shows what is important during an exercise. Goals • help structure learning and knowledge • motivate learners to respond to feedback • inspire self-monitoring and self-feedback • provide focus for observing and assessing performance
Practical instructions	Select **3-5 focus areas** for a debrief, rather than trying to cover too much. Let discussions stray from a topic, if the discussion appears relevant for improvement efforts. Avoid talking too much! Wait a little during silence: particpants start talking after a while. Move on to another topic when participation and group discussion slows down. Showing pictures or video capture helps focus a discussion.
Provide feedback	Feedback should be specific and actionable. Feedback towards the group highlights the importance of team cohesiveness. Give one-on-one feedback for specific, performance-related issues.
Create conditions that support reflection and discussion	Communicate that the debriefing is important, and that what the participants share will be listened and attended to. Focus on "what happened and why"; avoid focus on "who did what". Experienced can crew contribute with knowledge to those who are less experienced. When team members understand each other's roles, they can give each other the right type of information and support. This helps group dynamics, and makes it easier to assume each others duties and responsibilities in the case of eg injury Contribute with their your own knowledge, e.g. with example from your own experience to clarify a point.
Ask questions that encourage self-feedback	Help participants reflect through: - open-ended questions addressed to the group - specific follow-on questions addressed to individuals Strive to let participants "own" the issues as well as the improvement suggestions

Figure 12 Instructions for the person leading a debriefing

4.4.3.2 Sample questions

LASH FIRE

Part 2 Sample questions

How did we do?

- What happened today?
- What did we do well?
- Was there anything unexpected?
- Was anything challenging, difficult?

Variations and adaptations

- Mention one thing that could have been done differently
- Can you give me one example of conditions that could have affected the fire, how we handled it or our performance?
- What would a worst-case scenario be for this type of fire?

What should we do for the team

- to help each other get a clear idea of the situation?
- to make sure shared information is understood?
- to understand and support each others' tasks?
- to learn from one another?

Improvement potential

- Can anyone give me one example of how we could improve
  - equipment?
  - instructions or procedures?
  - communication?

Figure 13 Examples of questions to ask during the debriefing

4.4.3.3 A template for notes from the debriefing

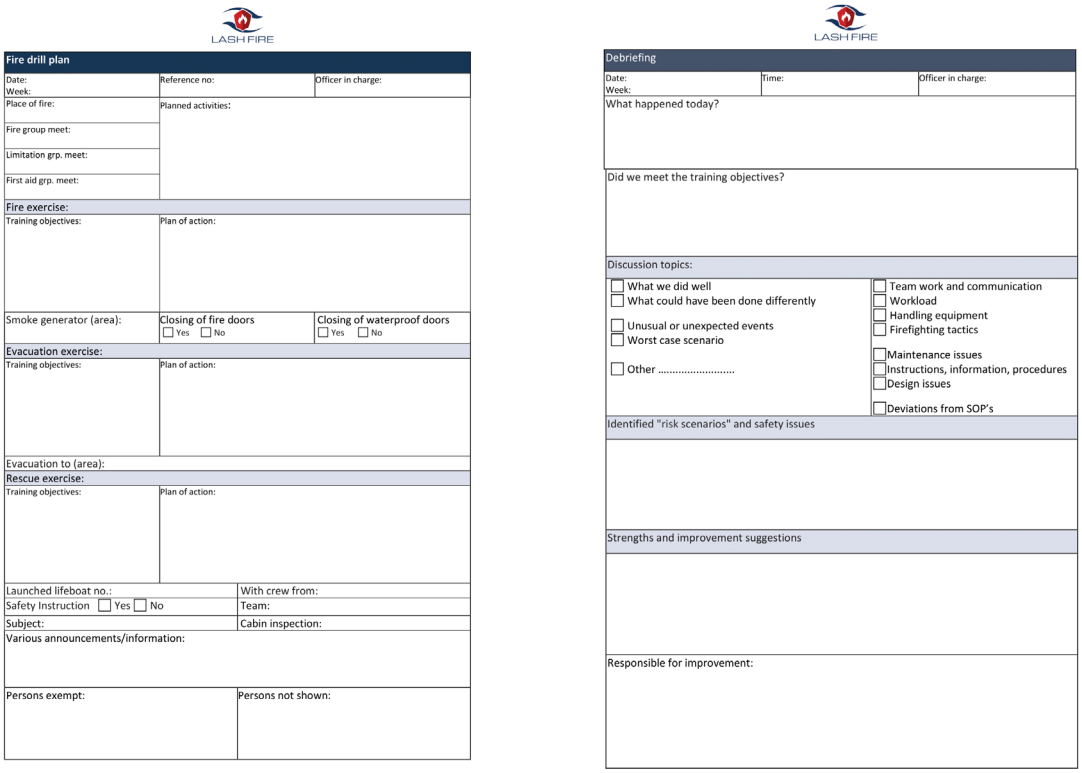
The template for notes from the debriefing is a simple form which is designed to focus the debriefing on certain key elements: a shared understanding of events; reflection on training objectives; picking up improvement needs, and engagement in improvement.

LASH FIRE

Debriefing		
Date: Week:	Time:	Officer in charge:
What happened today?		
Did we meet the training objectives?		
Discussion topics:		
☐ What we did well ☐ What could have been done differently ☐ Unusual or unexpected events ☐ Worst case scenario ☐ Other		☐ Team work and communication ☐ Workload ☐ Handling equipment ☐ Firefighting tactics ☐ Maintenance issues ☐ Instructions, information, procedures ☐ Design issues ☐ Deviations from SOP's
Identified "risk scenarios" and safety issues		
Strengths and improvement suggestions		
Responsible for improvement:		

Figure 14 Debriefing template

The format of the template makes it easy to append to for example a drill checklist, see the image below:



Fire drill plan

Date: Week:	Reference no:	Officer in charge:
Place of fire: Fire group meet: Limitation grp. meet: First aid grp. meet:	Planned activities:	
Fire exercise:		
Training objectives:	Plan of action:	
Smoke generator (area):	Closing of fire doors ☐ Yes ☐ No	Closing of waterproof doors ☐ Yes ☐ No
Evacuation exercise:		
Training objectives:	Plan of action:	
Evacuation to (area):		
Rescue exercise:		
Training objectives:	Plan of action:	
Launched lifeboat no.:	With crew from:	
Safety Instruction ☐ Yes ☐ No	Team:	
Subject:	Cabin inspection:	
Various announcements/information:		
Persons exempt:	Persons not shown:	

Debriefing

Date: Week:	Time:	Officer in charge:
What happened today?		
Did we meet the training objectives?		
Discussion topics:		
☐ What we did well ☐ What could have been done differently ☐ Unusual or unexpected events ☐ Worst case scenario ☐ Other	☐ Team work and communication ☐ Workload ☐ Handling equipment ☐ Firefighting tactics ☐ Maintenance issues ☐ Instructions, information, procedures ☐ Design issues ☐ Deviations from SOP's	
Identified "risk scenarios" and safety issues		
Strengths and improvement suggestions		
Responsible for improvement:		

Figure 15 The debriefing template can be printed on the reverse side of a drill checklist for practical purposes

4.5 Training for complex, deteriorating situations or unprecedented events

Drills are required for compliance, and standard drills generally focus on practicing to respond to anticipated variability in accordance with procedures. However, the ability to handle complex, rapidly changing, fire situations, also requires training the ability to recognize deteriorating circumstances and unprecedented events, when it may be necessary to shift from planned, procedural responses to crisis strategies and priorities (Hollnagel et al., 2017).

While there often is an aim to let drill scenarios be as realistic as possible, this can be difficult to achieve in practice. Drills are generally not conducted in "real time", since it is important to ensure that everybody familiarizes themselves with their duties and with the equipment. Another issue is that communication with the shore is frequently neglected aspect of emergency drills. This can create lack of familiarity with shore-based organizations vice-versa. As it is challenging to organise drills where the entire crew is involved, or to practice complex scenarios, it also becomes difficult for officers to practice leadership and teamwork skills in realistic circumstances.

For this reason, it was seen as important to provide an example of a drill scenario where the capacity for decision making and for team coordination is challenged, for example through imperfect, incomplete information in a changing or rapidly deteriorating situation which requires reassessment or change of strategy.

This type of drill would have a particular focus on those who lead firefighting, and would involve practice in coping with complex, time-critical, high risk situations. Training for a situation where *"things are out of control, we need to reassess and reconsider our strategy"* would fill a significant gap – namely an opportunity for officers to train for the unexpected.

Scenarios which provide high complexity are for example power failures; rapid escalation or explosions; situations demanding collaboration with coast guard or land side firefighters.
Other conditions which can serve this purpose are e.g.:

- Fragmented or otherwise incomplete information about the team, the ship or the fire
- Differences knowledge and capabilities (can be language, skills, any number of things)
- Conflicting understanding of the situation.

Suggested learning objectives in this type of exercise could be:

i. Raised awareness of the limits of procedures and plans
ii. Raised awareness of the importance of continually reassessing situations and strategies in order to see signs of a deteriorating situation
iii. Increased experience and awareness of decision making and team coordination practices

The trainers at SAS recognized the importance of providing opportunity for officers to train these capabilities and invested their skill and resources to organize a complex scenario for demonstration purposes. This would provide an opportunity to gain feedback from the participants about the interest and need for this type of training.

4.6 Evaluation from a Human-Centered Design perspective

The demonstration was used as an opportunity to evaluate the tools from a human-centered design perspective, focusing on their design (usability) and their functionality (usefulness). The HCD evaluation was conducted through group discussions, after use of the tools during the demonstration, and an online questionnaire. The focus of the HCD evaluation for each individual tool is described below.

4.6.1 Questions for the evaluation of WSA

The generic model can serve as a starting point for a local analysis, where each level can be adapted or elaborated for the work system on a specific ship. It is also possible to work from scratch, “bottom-up”, and generate a local model from experiences or accounts of how work is conducted in practice. A bottom-up approach was used in the demonstration, a description of which is provided in the Method section.

1. Did the tool help provide a clear understanding of “what needs to be done”?
2. Did the tool make you think more about finer details in the work during the drill?
3. Did the tool give you increased insight into your colleagues’ work?

4.6.2 Questions for the evaluation of the Debriefing Guide

1. Did the tool support the prebrief?
2. Did the tool help support discussion/reflection?
3. Did the tool help make a clear overview of “what happened”?

4.6.3 Online ratings

An online questionnaire was designed as a way to get participants ratings on the usefulness and ease of use of the tools. A few open-ended questions were also included. The questionnaire items were on a 5-point Likert scale and were based on the UMUX-Lite (Lewis et al., 2013).

- "The system is easy to use"
- "The features meet my needs"

1. The training scenarios simulated more complex and stressful problems than our regular drills
2. It would be useful for firefighting teams to get the opportunity to train complex scenarios in a simulated environment.
3. Work system analysis is a useful way to support thinking and discussing about details of "work as done" in firefighting.
4. Work system analysis is easy to use.
5. Condition cards were useful for thinking about and discussing how different fire scenarios may develop.
6. It was easy to understand how to make and use condition cards.
7. Condition cards can be useful for helping to develop drills.
8. Condition cards can be a way to support reflection and discussion during debriefing.
9. It would be useful to have a tool to support efficient and systematic debriefing
10. I can imagine:
a. Work system analysis being used as part of regular safety work on board
b. Condition cards being used as part of regular safety work on board
c. A debriefing guide being used as part of regular safety work on board
11. What was the best part of the exercises at Centro Jovellanos, for example if you compare to regular drills?

5 Method

Main author of the chapter: Brit-Eli Danielsen, NSR

5.1 Methodological considerations

Main author of the chapter: Torgeir Haavik, NSR

Demonstration and validation of the FRMC was performed ashore, in a lab environment where simulation of credible fire scenarios is made possible due to the mixed simulation opportunities at the Jovellanos training centre. By mixed simulation we mean the mixture of physical fire extinguishment in an outdoor fire-lab, an engine control room and external parties like Vessel Traffic Service (VTS), shipowner representative which is simulated by the mere presence of training centre instructors who communicate with the bridge over radio and telephone, a sophisticated bridge simulator with 360 degrees simulated maritime environment, every necessary bridge equipment including manoeuvring equipment, Electronic Chart Display and Information System (ECDIS), fire alarm panels, fire pump activators, radio communication, CCTV, and more, desktop simulations where the participants brainstorm on work system analysis and fire challenges aided by 'function cards' and 'condition cards' to undertake a Work System Analysis. The demonstration was built around a fire drill scenario constructed for the purpose, through which the bridge, the engine control room and the fire team on location can collaborate on the firefighting of a real fire, including elements such as dangerous goods (magnesium sawdust), and to witness the efficacy of different fire extinguishing agents in a realistic scenario (see Demonstration outline for description of the fire drill scenario).

In order to develop fire drills that first and foremost support learning (and not just the ticking off of mandatory drills), realistic experiences that challenge both problem-solving and decision-making capabilities of the crew are very useful. They also provide a benchmark against which the fire management during a repeated drill can be evaluated. This was exploited as the demonstration of the work system analysis was preceded by a tailor-made drill, which was repeated on day two, after the work system analysis and before the demonstration of the condition cards.

Simulating a work process has several advantages over playing it out under real circumstances. First and foremost, a simulated environment is a forgiving environment, meaning that potentially dangerous operations that cannot be trained on a ship, can still be simulated without risking any serious consequences. This amounts to lighting up a real fire, and to use for example CO_2 in the firefighting. This is possible to perform in a protected area of Jovellanos training centre, but not on a ship at sea, where uncontrolled fire-spread, fire-damages, and asphyxiation would be real risks. Another very powerful advantage with simulation is that anything is possible with respect to scenarios as long as the software/hardware support it and the participants are willing to participate. Further, simulation allows for determining and keeping certain variables stable, while manipulating others, all under controlled conditions. This is also important for evaluation of the solution that is demonstrated, and something we deliberately designed for in the layout of the demonstration where two fire drill scenarios were played out during the demonstration, the latter after the participants had taken part in the work system analysis and thus were primed differently than in the first drill.

The Jovellanos training centre has a sophisticated bridge simulator which allowed for a level of realism difficult to obtain in a low-fidelity analogue simulation. Especially for the bridge officer roles as they were placed in an environment very similar to a real bridge, and empowered to navigate, communicate and command in a similar manner that they are used to, including coordination between bridge and fire teams, in addition to external collaboration such as calls between bridge and VTS, port, company, other vessels etc.

5.2 The Demonstration

The demonstration and evaluation of the solutions developed in this work package was performed at the Jovellanos Maritime Safety Training Centre (hosted by SAS, in Asturias, Spain), an onshore centre providing maritime fire training facilities, on January 18th and 19th, 2023. Five experienced seafarers from one shipping company participated to the demonstration. The participants were all male and two of them were captains, while the others were chief officer, first engineer and first officer in their shipping company. They all had experience from ro-ro ships and some also from ro-pax ships. The participants were all actively contributing to discussions, workshops, and the fire simulations. The demonstration lasted for two days and consisted of theoretical lectures (given by NSR and NTNU), workshops (facilitated by NSR and NTNU) and practical fire simulations (administered by SAS by 2-4 training instructors during different parts of the simulations).

5.2.1 Demonstration outline

DAY 1
09:00-11:00 Introduction
11:00-13:00 Fire Simulation
14:30-15:30 Standard debrief
15:30-17:30 WSA

DAY 2
09:00-11:30 Reflection, Drill Designer and Condition Cards
12:00-13:00 Fire Simulation
14:00-15:00 Drill Designer and Condition Cards cont'd
15:00-16:00 Debriefing Guide
16:00-16:30 Assessment of the two-day demonstration

DAY 1

09:00-11:00 Introduction

Day 1 started with an introduction by SAS including a short presentation round of participants and LASH FIRE project members, information about the Jovellanos training centre, the LASH FIRE research project and the plan for the two upcoming days. Informed consent was signed by all participants. SAS provided a familiarization tour of the facilities, including the bridge simulator and the fire ground.

11:00-13:00 Fire Simulation

The simulated fire scenario was set to be on board the *Magnolia Seaways,* using fire plans and other relevant documents from this ship. The simulated scenario was fire in an APV while the ship was sailing in the Dover channel. Two of the participants acted as captain and first officer on the bridge, one participant acted as the runner while the rest of the participants formed a firefighting group to approach the fire on deck. The bridge was simulated in a bridge simulator (Figure 16) in the Jovellanos facilities. This room was equipped with a complete ship bridge simulator, telephone and VHF radios for communication with the fire team and external parties as well as live video from the fire location to simulate the CCTV on a real ship. The deck was simulated in a separate 'cargo hold' in the outside area of the Jovellanos facilities (Figure 18). The available firefighting equipment in the field consisted of fire blanket, fire hoses, drencher system and foam.

Training instructors from Jovellanos were present at all locations to guide the participants through the exercise. The SAS training instructors located in the “back room” (Figure 17) coordinated the simulation and acted as personnel from other ships, the VTS and shipping company representatives that communicated with the bridge via telephone and VHF. In addition, five researchers from NTNU/NSR observed the participants in the bridge simulator, from the “back room” and in the field. The researchers took notes, pictures, and video in order to document the event for evaluation and further research.

Figure 16. The bridge simulator.

Figure 17. Coordination of the simulation taking place in the "back-room".

Figure 18. The simulated fire ground.

14:30-15:30 Debrief

After completing the fire simulation, training instructors, researchers and participants gathered in the classroom for a debrief session. The debrief was based on the standard debrief sessions as held on board ships after drills. The participants talked through the simulation scenario, what happened, what kind of challenges they encountered, what could have been done better and what went well. The debrief is described in more detail in section 5.3.

15:30-17:30 WSA

This was a classroom section that started with a lecture introducing the theoretical background for developing the tools (NTNU) (Figure 19), before introducing WSA(NSR).

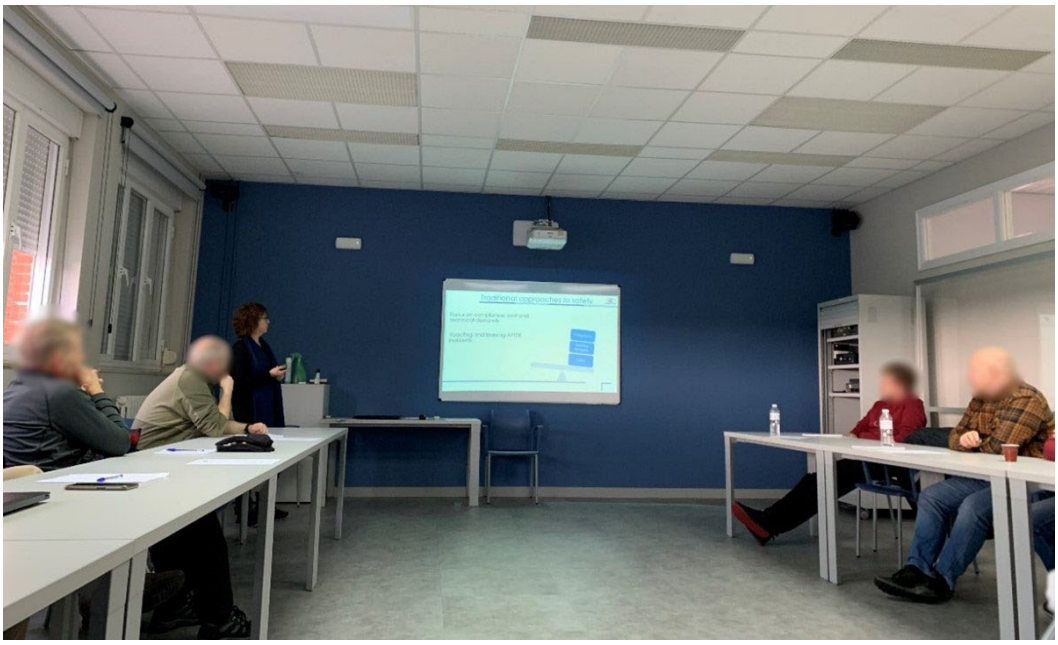


Figure 19. Lecture.

The remainder of this day was a workshop session in which participants were divided in two groups based on their roles during the simulation, the participants from the bridge and the runner in one group and the participants from the fire ground in the other group (Figure 20).

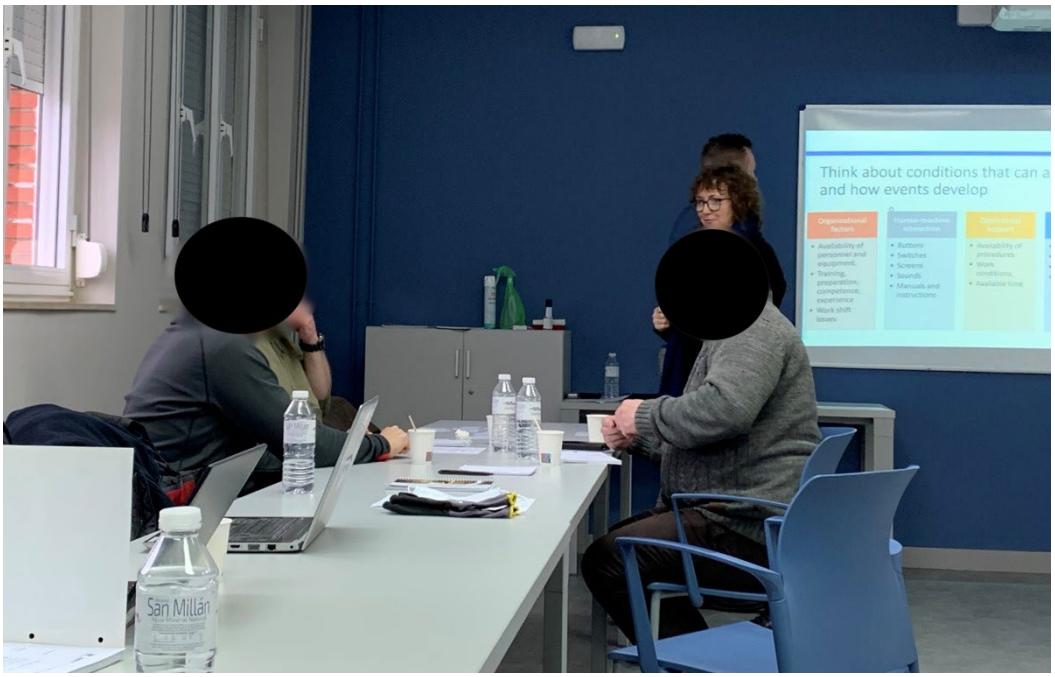


Figure 20. Workshop.

The groups were given the task to develop a Work System Analysis of the firefighting activity based on the simulation they just had participated to. The groups worked with help from a facilitator on demand. They wrote down functions and sub-functions on blank Function Cards and arranged them in their preferred hierarchical order on the table. The workshop session ended with a plenary session in which all participants discussed the work system analysis that had been developed by the two groups. As the two groups had experienced the simulation from different sites, they had emphasized different functions in their analysis which facilitated the reflection and discussion about the different work systems on a ship and their inter-relations.

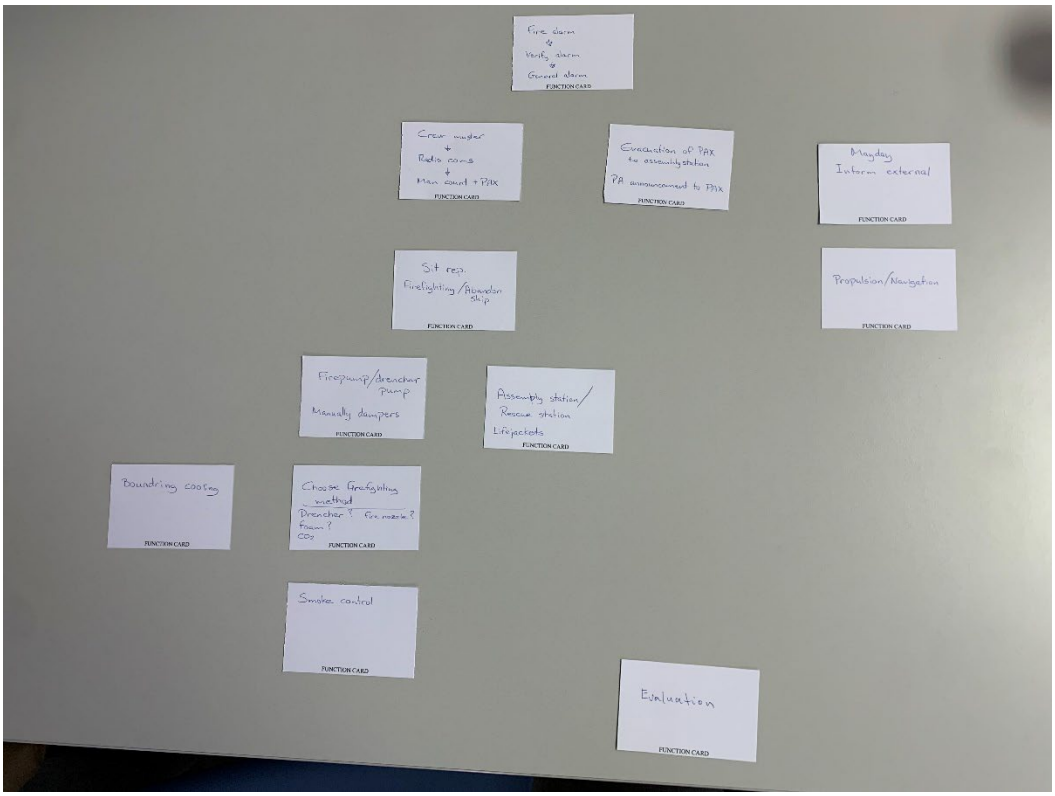


Figure 21. Development of the work system analysis.

DAY 2

09:00-11:30 Reflection and Condition Cards

Day 2 started with a classroom session in which participants reflected on their experience from Day 1, what were useful learning points from the theoretical and practical sessions.

The Condition Cards was introduced in a lecture format (NSR) before a workshop where participants applied Drill Designer was initiated.

The participants formed the groups as in Day 1 and were asked to identify and discuss how the previously established functions in the work system analysis can vary. They wrote down variability on blank Conditions cards and placed them adjacent to their respective functions in their own work system. This workshop session ended with a plenary session in which all participants discussed the identified variabilities.

12:00-13:00 Fire Simulation (repeat of day 1 with a surprise element)

A fire simulation was performed also on Day 2. This simulation replicated the simulated scenario from Day 1, including the participants playing the same roles as the day before. However, the Day 2 scenario had additional (surprise) elements related to the discussion on variability in the previous workshop. The additional elements were placing magnesium in the car on fire and the discovery of an injured person (mannequin in an coverall) that turned out to be a stow away.

14:00-15:00 Condition Cards cont'd

After the fire simulation the demonstration of Condition Cards continued in another classroom session. Condition cards that had been developed up front by the researchers were handed out, and there was a discussion on whether and how this tool can be used to develop the regular drills performed on board ships.

15:00-16:00 Debriefing Guide

A debrief session following the Day 2 fire simulation was facilitated by a researcher (NSR) using the developed debrief template (Debriefing Guide), see also description in section 5.3.

16:00-16:30 Assessment of the two-day demonstration

The final classroom session was also led by a researcher (NSR) with the aim to collected feedback from the participants on the overall experience of the two days as well their impression of the three tools, in particular the usefulness of the tools and what would be critical for these solutions to be successful in real use.

5.3 Debriefing Guide - Debriefing tool demonstration

Debrief day one

After the demonstration each day, the participants met to discuss the event as they had unfolded in the scenario. For the first day, the debriefing session was led by the person being the captain for the demonstration. In this case the captain was asked to run through the debriefing session as he would have done after a regular drill. The debriefing to a large degree consisted with the debriefing leader going through a timeline of the event, with other crew members adding their opinions and thoughts. The debriefing and discussion lasted approximately 30 minutes.

Debrief day two

After the second day demonstration, the debriefing session was led by a member of the research team. The debrief session started by the researcher going through the instructions for the facilitator, and presented these to the crew in a manner the facilitator would have done. Utilizing the facilitator guideline (see Figure 12 Instructions for the person leading a debriefing and Figure 13 Examples of questions to ask during the debriefing) researcher set the stage for the potential of safety improvement and learning from drills through:

- improving communication,
- creating awareness of unexpected events,
- creating awareness of other crewmembers' tasks, adaptations that are made, and implicit knowledge they possess, by explicitly talking about it,
- creating awareness of things that are working well, that one needs to preserve, and
- identifying aspects the land-organization can improve.

Then the facilitator prompted the individuals to be in the right mindset to allow for open and good discussions during the debriefs. This was done by highlighting that:

- all crew members are competent and well-intentioned and working towards the shared goal of being better and safer during a fire-emergency,
- active participation is important,
- what crew members share will be listened and attended to,
- it is acceptable to be uncertain of something,
- speaking out when disagreeing and sharing unpopular ideas is encouraged,
- focus should be on what happened and why, and not who did what.

The facilitator then started on a high level and asked if any participants wanted to say something about what happened today. Depending on who answered, the facilitator ensured that perspectives of the bridge, runner, and fire-crew was promoted. The facilitator utilized the questions in Figure 12 Instructions for the person leading a debriefing (Figure 12) and Figure 13 Examples of questions to ask during the debriefing (Figure 13). Questions included:

- What happened in the exercise today?
- Did anything unexpected happen?
- Was anything challenging, difficult or did not go as expected?
- Can you think of any conditions which would have changed the situation to the better or worse?
- What would happen in a worst-case scenario? How could you and your colleagues handle this?
- What went well (strengths)
- What could have gone better (weaknesses)

This debriefing session lasted approximately 30 minutes.

After the debriefing, the Figure 14 Debriefing template (Figure 14) was presented to the participants and its usefulness and issues with potential implementation in a real-world setting was discussed. The template was already filled out by the researchers based on what happened in the day two demonstration scenario.

After the template discussion, a more general discussion was undertaken where participants were prompted towards discussing their experiences with the second day debriefing. Questions probed whether the day two debrief (besides being led by the researcher) was any different from how they usually do drills, whether spending more time or effort on debriefs makes sense, and is feasible, and whether the format and template can be used to facilitate relevant discussion, improve learning, and involve the land-organization more in issues that are identified.

6 Results and evaluation

Main author of the chapter: Martin Rasmussen Skogstad, NSR

6.1 Results Work system Analysis

In the discussions during the exercise, the participants described how they became aware that each activity could be focused on in increasing detail "*for this part, we could make 50 more cards or 100, firefighting is endless if we start looking at all the different tasks that have to work… We could for example focus on the systems, valves and pumps need to be fed by other valves… in a certain order …"*

The analysis also brought attention to activities that were not performed during the drill, but that in a real life situation would have to be addressed: *"…other things which are important and we did not do at all today- like boundary cooling, which is very very important, and ventilation and handling smoke …".*

By referring to the examples of conditions that can affect the work system which were provided, the participants generated examples of variability (see Annex A for the total results). This was used to create new "condition cards" during the demonstration. The identified variability can be linked to the the generic functions in the work system model as shown in the tables below.

Detection & alarm	Blackout
	Failure in fire detector
	General alarm not working
Muster	Missing crew
	Radio failure
	Faulty firefighting equipment
Fixed systems/ pumps/generators	Failure in bilge pump to drain area leading to list etc
	Fire pump missing pressure
	Broken damper
Evacuation	Missing PAX
	PA system failure
	Lifejacket incorrectly donned, missing, broken
Propulsion	Engine problems

Figure 22 Examples of variability identified by the command team

Detection & Alarm	In port
	«False alarm»
	Wrong location of fire scene
Manual firefighting/Muster	Rushing, risk of injury
	Not familiar with equipment
	Lack of manpower
Communication	Unclear, blurry instructions
Fixed firefighting systems	System not in "normal operation"
	blackout
Drenchers	Changing weather conditions
	Fire restarts
	Ineffective measures

Figure 23 Examples of variability identified by the fire team (in the demonstration these were First officers mainly)

6.2 Results Condition cards

Regarding using condition cards as a way of including variability during fire drills one participant said:

"Some crews are really good at doing this already, but this will really help those who are not that creative, or when you simply don't have the time"

When reviewing the session of creative thinking one participant said:

"*Everything* can go wrong",

This is a commentary on that a creative session can not be exhaustive in *finding* everything that can go wrong. The participant did however agree that the session had made him think about aspects of fire safety that he had not thought about before.

6.2.1 New cards from the demonstration

In addition to the premade cards (included in appendix 10.3), the participants were provided blank cards. The participants made the following cards:

- Unclear/blurry instructions
- Changing weather conditions (wind, waves, night)
- False alarm
- Malfunctioning equipment
- Fire restarts
- Not effective
- Choosing the wrong tactic
- Wrong localization of fire
- Not familiar with the equipment
- Risk of injury due to rushing
- Lack of manpower
- Systems not in "normal operation"
- Communication error choosing the wrong method
- Engine failure/Steering gear failure.
- Failure in fire detector
- General alarm not working
- Missing crew (start search)
- Radio failure
- Fault in firefighting equipment
- Fire pump missing pressure
- Broken damper
- Fault in ventilation resulting in smoke control not possible
- Failure in bilge pump to drain area resulting in list etc.
- Lifejackets not done correctly/missing/broken
- Missing PAX (self evacuation/start search)
- Failure in PA system

6.3 Results Debriefing tool

Day one results

On the first day, the debriefing was led by the participants, and main points of the discussion circled around:

- Communication issues (technical equipment not working) and workarounds.
- Fire team with eyes on the ground make decisions (drencher not effective, fire blanket not effective).
- High realism of too much communication with external actors (vessel traffic service, agent, other ships).
- Questionable realism in only two people on the bridge (usually 5 people on the bridge during emergencies)
- Difference in behaviour real event vs drills.
- The simulation adds stress factor that they don't experience during regular drills on ship.

For this debriefing the captain/leader went through what happened and did most of the talking.

Day two results

In this debriefing session the discussion focused on the following topics:

- Communication issues (technical equipment not working) and workarounds.
- Fire-fighting decisions and trust in fire-crew's decision making.
- The surprise element and making sense of things as they occur.
- The captain delegating responsibility and the expectation that they complete tasks given. The captain only needs information when something goes wrong, or a task is not completed.
- Utilizing other personnel to get more information of a chaotic situation as it is hard to know what everyone is doing at all times (e.g., engine room updates, head cook for passenger information).
- Usually spending time on debriefs are difficult to prioritise.

6.4 HCD evaluation of the tools

Main author of the chapter: Hedvig Aminoff, NTNU

6.4.1 Evaluation of the WSA

The goal of the Work System Analysis is to support analysis and discussions, for example about the details of the work that is done during firefighting, Interactions and dependencies between different roles and activities, how firefighting activities can vary in different conditions and circumstances. The findings from the use of Work System Analysis during the demonstration illustrate how the officers on the bridge had emphasis on decisions and communications, while the chief officers who lead the firefighting on the scene had detailed the firefighting activities. In the discussion, when the participants explained the way they had represented the activities, the participants noted that there were many different ways to break down the activities that they conducted during the scenario, and how they paid attention to different aspects of the work system as a whole.

6.4.2 Evaluation of the Condition Cards

The Condition Cards were extremely well-liked and considered as an easy-to-use way of facilitating creative thinking around fire safety. The concept of using them to introduce novel elements during an ongoing drill was also considered to be a useful way to create engagement and interest in the drills.

Another example of the success of the Condition Cards was that participants asked to keep the prototype cards from the demonstration to show to their crews or use in a similar fashion on their ships.

6.4.3 Evaluation of the Debriefing Guide

The Debriefing Guide is intended to serve as a guide for enhancing reflection about effective strategies and resources, as well as masked challenges and vulnerabilities.

There was agreement that it was important that the officer leading the debriefing keeps the experience of others in mind, and that it was important that both experienced and less experienced participants feel comfortable with contributing. Another topic in this discussion was the importance of a pre-brief and that it is a way to encourage reflections and discussion also during an ongoing drill. A pre-briefing can make the drill go faster so there is more time for debriefing and discussing/learning afterwards.

Regarding facilitation, there was mention of the importance of raising spirits and inspiration: “when the captain makes a joke people loosen up”. Relating to real fire incidents was also mentioned as a way to increase interest and motivation. Similarly, using pictures and videos was also considered to be a good way to “get people talking”.

On the second day of demonstration, talking was more evenly split between the different roles than on the first day. This could be due to the facilitator intentionally changing to other speakers to get their perspective but could also be a partly a result of the facilitator not being involved in the drill scenario and thus would to a greater degree rely on the participants describing the event. Nonetheless, for a debrief to promote learning, and making experiences and knowledge of crew members explicit, it is important that several viewpoints are heard.

Regarding the debriefing template, participants discussed that the debriefing notes currently used is more simple than the template. Issues with using a more comprehensive debriefing template is primarily time constraints. However, a tool that simplifies reporting is wanting, as they currently have to log into several systems to report the results and notes of debriefings. Overall, the participants emphasized that any tool would take some time getting used to, and that it would not be used if it was too complex or if it makes preparation or documentation take longer. In addition, participants were wary of having to use any additional IT-systems, as these already were considered to be a burden.

6.4.4 Questionnaire results

The questionnaire is described in section 0

Online ratings. The results from the questionnaire (included in ANNEX B Questionnaire results) showed strong agreement that the scenario for the exercise during the demonstration was more complex and stressful than regular drills, and that this would be valuable complement to regular training, especially for the senior officers:

> *"We never get a chance to run a full mission drill where the bridge with Captain and officer are included like at the exercises in Oviedo."*
>
> *"I believe the bridge simulator was a huge step up compared to a normal exercise. The possibility of putting the bridge team under a huge work load was very good."*
>
> *"It was very realistic. Communication was poor between bridge and Fireleader. Fire continues to break out. Bridge team are continuously busy with communication. Two well prepare days and fantastic to be a part of."*

There was some agreement that it was a useful way to think in new ways about work: "I saw many fire leaders have different approaches. We saw how (fire leader) approached the fire with means he never have used before. "Others mentioned that the idea of focusing on "what is strong" and not only on "what is wrong" is an important idea that currently does not receive attention. However, the participants stated that the time and effort to understand and apply the analysis was an issue, and 4 of 6 participants could not see it as a part of regular safety work on board.

The condition cards proved to be more easy to use and the participants found that this way of approaching the analysis helped them think in new ways: *"The condition cards were useful and made us think in other ways and imagining things we did not think of at first."* The condition cards were also seen to be a useful tool for helping inspire existing drills as well as designing new drills: *"They could be a very nice tool to develop or even create new drills that have never been conducted on board."* There was less interest in using them in debriefing situations. 5 of 6 participants could see condition cards as a part of regular safety work on board., but there was emphasis on the need for getting accustomed to using this type of tool: *"Yes, but again all up to the Captain and Fireleader. I think they need motivation if they are not familiar with the way of thinking and using the cards."*

A debriefing guide (guideline for the facilitator and example questions) and a debriefing template was also an appreciated concept, under the conditions that it is easy to use and does not add burden to the documentation required by regulations. "I think it can help fireleaders or Captains who struggle to run a good debriefing". 5 of 6 could see a debriefing tool as a part of regular safety work on board.

6.5 Impressions of the value of the training scenario

The overall assessment of the value of the exercise during the demonstration is based on the following participants' statements about their experience of the drill's design and training value.

Quotes from participants:

*"it's so important to really **experience** the stress and complexity"*

"we cannot do this on a normal fire drill, we can't be in traffic and announce that others should stay away "they would try to kill me" (laugh). "We do not get the stress factor with 1000 annoying messages interrupting us all the time"

There are also important differences in the conditions for firefighting on ro-pax and ro-ro ships: *"on a ro-pax the decision to evacuate will be taken much much earlier: ro-pax often have many elderly passengers, they can be disabled which makes evacuation very difficult and a very big stress factor."*

6.6 Feedback from Instructors

Instructors at SAS stated that the crew demonstrated a very strong capacity to respond adaptively even though they were not familiar with the "ship" or equipment. Their feedback was very positive about the WSA and Condition Cards, with them suggesting that it could be something they could use in planning future training modules and debriefing. This is important since trainers represent an important intended user group.

7 Conclusion

Main author of the chapter: Hedvig Aminoff, NTNU

The simulation was well-appreciated by the participants, who repeatedly expressed that they were impressed by the design of the exercise, and also acknowledged the need to practice for complex situations. This not only confirms the need for this type of training, it also validates that the scenario designed by SAS included the types of challenges that constitute complex situation, where both the command group and the responders have the chance to experience the need to adapt creatively to the situation.

Regarding Work System Analysis, the participants agreed to the value of thinking about how conditions and situations can vary and that this is an important way to develop safety awareness. However, they voiced that this value was outweighed by the fact that the WSA exercise took too long. These results can be partly from how the exercise was presented and conducted, and there is good reason to refine the design of the instructions. Another reflection is that the users in the demonstration were not the primary intended users. Hence it would be valuable to get input from landside safety representatives for example, to get feedback if the benefits for this group of users would be better balance the time needed to learn and apply the method.

Condition cards were very popular and seen as useful and easy to use for developing drills. The Condition Cards concept can be seen as a usable and useful tool that fills the important function of contributing to more engaging drills, which is important for motivation and interest. Another major contribution is that the cards are an easy way of adding elements of variability in order to train adaptive responses, when unusual or unexpected events occur and the crew have to respond in real time.

A well-defined debriefing template can be a valuable part of the organisational learning cycle, under the conditions that it is aligned with the IT-systems, and documentation demanded by regulations and the organisation.

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10 ANNEXES

10.1 ANNEX A Work System Analysis Results

This annex shows the tasks and conditions that the officers on the bridge during the demonstration identified in the WSA.

Main task	**Sub-task**	**Variations in conditions**		
Fire Alarm > verify alarm > general alarm	Control button for acknowledgement of alarms + control of equipment	Blackout	Failure in fire detector	General alarm not working
Crew muster > Radio coms > Man count + pax		Missing crew (start search)	Radio failure	Fault in firefighting equipment
	Sit rep Firefighting/abandon ship			
	Firepump/drencher pump, manually dampers	Failure in bilge pump to drain area leading to list etc	Fire pump missing pressure	Broken damper
	Choose firefighting method - drencher? Fire nozzle? Foam? C02	Communication error choosing the wrong method		
	Boundary cooling			
	Smoke control	Fault in ventilation		
Evacuation of pax to assembly station/PA announcement ot PAX		Missing PAX (self evacuation / start search)	Failure in PA system	
	Assembly station/rescue station lifejackets	Lifejackets not donned correctly, missing, broken		
MAYDAY inform external				
Propulsion/ navigation		Engine problem		
Evaluation				

Tasks	**Sub-tasks**			**Variations in conditions**		
Alarm		alarm verified		In port «False alarm»		

	Investigate area			Wrong location of scene of fire		
	Announcement on PA					
	Mustering: Fire group, Evacuation, Bridge			Rushing, risk of injury	Not familiar with equipment	Lack of manpower
Communication with bridge				Unclear, blurry instructions	System not in "normal operation"	
	What is on fire				Car (hybrid, brint, electrical);	accommodation, oil, diesel, cargo
						Multiple places - pyromaniac
Extinguish				Tactic		
		Operative firefighting with equipment	C02 Hoses Nozzles Drencher C02, Hoses, Nozzles, Drenchers, Blankets	Malfunctioning equipment (eg blackout)	Systems not in “normal operation”	
		Cooling with drencher		Changing weather conditions (wind, waves, night)		
		Investigate if still on fire		Fire restarts		
		Use of blanket				
		High expansion foam		Not effective		

10.2 ANNEX B Questionnaire results

	Indicate how strongly you agree with each statement, where -2 = Strongly disagree and 2 = Strongly agree	-2	-1	0	1	2
1	**The training scenarios simulated more complex and stressful problems than our regular drills.**	0	0	0	1	5
	The fact that it was possible to have a fire drill with an actual fire is obviously more complex than an imaginated/simulated fire on board our Ship.					
	we never get a chance to run a full mission drill where the bridge with Captain and officer are included like at the exercises in Oviedo.					
	It will always be more complex and stressful when there's a real fire compared to a simulated fire on board our Ship.					
2	**It would be useful for firefighting teams to get the opportunity to train complex scenarios in a simulated environment.**	0	0	0	2	4
	The more training of complex scenarios will of course be of great help to the fire fighting teams. The more, the better. We are only 'amateurs' on board, so if it was possible to carry out more of these kinds of exercises, it will only be beneficial for the teams.					
	The more training the better. When conducting drills with a real fire in a simulated environment, the firefighting teams gain much more experience compared to simulated fires.					
3	**Work system analysis is a useful way to support thinking and discussing about details of "work as done" in firefighting.**	0	0	2	3	1
	Not really sure about the value of this. It was definitely a new way to attack the safety issue, but I am unsure if the amount of time and effort used for this will have the requested effect. I just believe we used a lot of time on this, and I do not know if it was all the time worth it. Might be because it was just a new way to think about it. Maybe after a couple of times, it would make more and more sense, when we will be more familiar with it.					
	Not sure about the effect of this. We used a long time with this, and yes, we did think alternatively and in other ways than usual, but I am not sure whether or not it has the requested effect when you look into the time and effort we spend on it.					
	I saw that many fire leaders have different approaches. We saw how (fire leader) approached the fire with means he never have used before					
4	**Work system analysis is easy to use.**	0	0	4	1	1
	I think it's a pretty simple analysis - nonetheless, we did not make the tasks/subtasks in the correct way at first. It requires an alternative way of thinking than we normally do. It's quite analytical.					
	At first we did not even do it correctly, but I think it would be more and more easy, the more we use it.					
	I believe everyone can use and understand it with a short intro.					
5	**Condition cards were useful for thinking about and discussing how different fire scenarios may develop.**	1	0	0	2	3
	The condition cards were useful and made us think in other ways and imagining things we did not think of at first.					
	These cards definitely brought inspiration to the possible fire scenarios.					
	It was interesting to see how the different department ¨firefighter and bridge team ¨ approached and came op with cards with different issues					

6	**It was easy to understand how to make and use condition cards.**	1	1	0	2	2
	I believe all crew members on board could make some condition cards once we sit down and explain how it works.					
	Yes, and I think it could be a stand alone exercise					
	Easy to make and us. I believe every crew member could make some relevant cards.					
7	**Condition cards can be useful for helping to develop drills.**	1	0	0	2	3
	They can give inspiration to new drills but also to develop already planned drills. I think they could be very beneficial for planning and adjusting future drills.					
	As we all have different ideas I believe it will guide and help many					
	They could be a very nice tool to develop or even create new drills that have never been conducted on board.					
8	**Condition cards can be a way to support reflection and discussion during debriefing.**	1	0	0	4	1
	They can. However, it has to be done in a smart, quick and easy way. Debriefings should not be longer than the actual drill - then people would lose focus.					
	Personally, I would use the cards more when creating/developing drills and not during debriefing.					
	Yes, often we focus on what did we do wrong- but we should also share what went well so others can benefit from that. A shared pool in the company					
9	**It would be useful to have a tool to support efficient and systematic debriefing.**	0	0	2	2	2
	All comes down to the amount of time, effort and ressources needed to use this tool.					
	It all comes down to the amount of time and effort needed. It has to be an easy tool which does not require too much time.					
	I think it can help fireleaders or Captains who struggle to run a good debriefing					

Question 10. I can imagine the tools being used as part of regular safety work on board

	Yes	No
Work system analysis	2	4
Condition cards	5	1
Debriefing support	5	1

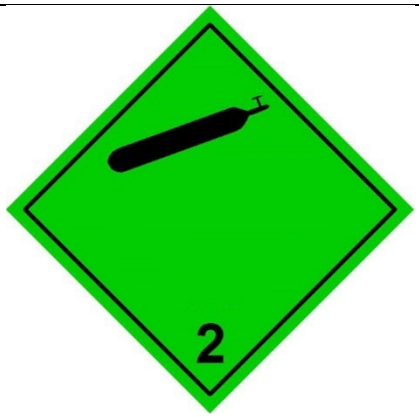
Question 11. What was the best part of the exercises at Centro Jovellanos, for example if you compare to regular drills?

- The combination of Simulated Voyage and fire fighting at the same time
- It is always interesting when there's a real fire, we have to deal with (in a safe environment of course). And the fact that this was possible while the Ship-simulator was sailing in Dover, was definitely out of the ordinary. It was unfortunate with the radio connection to the "Bridge", but other than that, it was 2 very nice drills!

- I believe the bridge simulator was a huge step up compared to a normal exercise. The possibility of putting the bridge team under a huge workload was very good
- It was very realistic. Communication was poor between bridge and Fire leader. Fire continues to break out. Bridge team are continuously busy with communication. Two well prepare days and fantastic to be a part of.
- "There was more hands on, and more time to perform the drills.
- All crew was involved."
- It was nice to try and combine a simulated sailing exercise with a real fire drill.

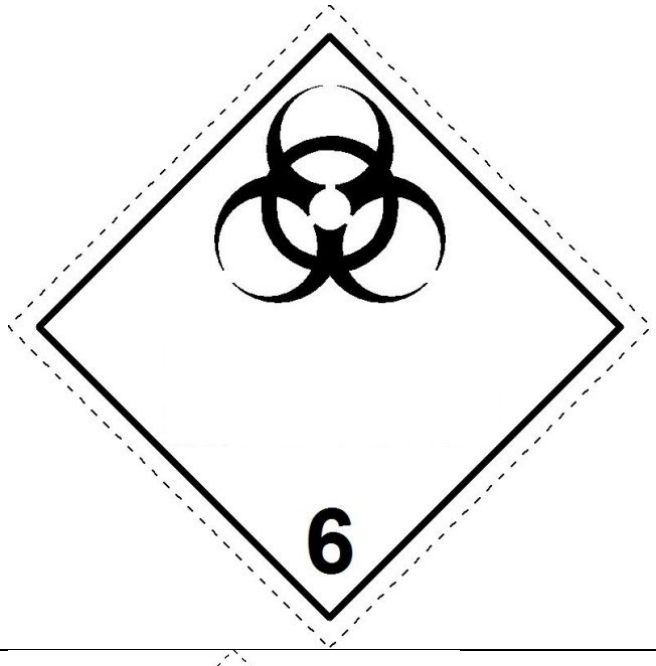
10.3 ANNEX C List of Premade Condition Cards

Name	Description	Reference
Dangerous cargo: Class 1 – Explosives	 Division 1.1: Substances and articles which have a mass explosion hazard	IMDG
Dangerous cargo: Class 1 – Explosives	Division 1.2: Substances and articles which have a projection hazard but not a mass explosion hazard	IMDG
Dangerous cargo: Class 1 – Explosives	Division 1.3: Substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both	IMDG
Dangerous cargo: Class 1 – Explosives	Division 1.4: Substances and articles which present no significant hazard; only a small hazard in the event of ignition or initiation during transport with any effects largely confined to the package	IMDG
Dangerous cargo: Class 1 – Explosives	Division 1.5: Very insensitive substances which have a mass explosion hazard	IMDG
Dangerous cargo: Class 1 – Explosives	Division 1.6: Extremely insensitive articles which do not have a mass explosion hazard	IMDG
Dangerous cargo: Class 2 - Gases	 Division 2.1: Flammable gases	IMDG

Dangerous cargo: Class 2 - Gases	 Division 2.2: Non-flammable, non-toxic gases	IMDG
Dangerous cargo: Class 2 - Gases	 Division 2.3: Toxic gases	IMDG
Dangerous cargo: Class 3 - Flammable Liquids		IMDG
Dangerous cargo: Class 4 – Flammable Solids; Spontaneous Combustibles; 'Dangerous When Wet' Materials	Division 4.1: Flammable solids	IMDG

		
Dangerous cargo: Class 4 – Flammable Solids; Spontaneous Combustibles; 'Dangerous When Wet' Materials	Division 4.2: Substances liable to spontaneous combustion 	IMDG
Dangerous cargo: Class 4 – Flammable Solids; Spontaneous Combustibles; 'Dangerous When Wet' Materials	Division 4.3: Substances which, in contact with water, emit flammable gases 	IMDG
Dangerous cargo: Class 5 - Oxidizers;	Division 5.1: Oxidizing substances	IMDG

Organic Peroxides		
Dangerous cargo: Class 5 - Oxidizers; Organic Peroxides	Division 5.2: Organic peroxides 	IMDG
Dangerous cargo: Class 6 - Toxic Substances; Infectious Substances	Division 6.1: Toxic substances	IMDG

		
Dangerous cargo: Class 6 - Toxic Substances; Infectious Substances	Division 6.2: Infectious substances 	IMDG
Dangerous cargo: Class 7 - Radioactive Material		IMDG

Dangerous cargo: Class 8 - Corrosives		IMDG
Alarm sound can not be turned off at the bridge		
Manual firefighting O2-tanks are empty		
Spilled cargo is preventing water to be drained from cargo hold		
CCTV is not working		
Cargo manifest issue	Cargo manifest is missing	
Cargo manifest issue	Information on dangerous goods is not readily available	
Power is lost as the bridge		
At Night		
At port		
At open sea		
Injured crew member		
You are injured	You are immobilized. You cannot communicate and need medical assistance and evacuation.	
Injured passenger		
Evacuation of passenger in wheelchair		
Passenger Overboard		

Communication issue	 Loud noises in the ECR – Radio communication not possible	Image: Midjourney
Communication issue	 External communication is not working	Image: Midjourney
Communication issue	 The radio/VHF/UHF is not working	Image: Midjourney

Fire Escalation	 The fire has spread to [blank space]	Image: Midjourney
Missing person	 Crew member in the role of [blank space] is not responding	Image: Midjourney

Injured crew member	 The crew member in the role of [blank space] is injured.	Image: Midjourney
Ambiguous instructions	The instructions are ambiguous or unclear. Potential for delayed or wrong decision	
Blackout	 The ship has no electrical power	Image: Midjourney
CCTV Issue	There is no CCTV coverage in the area	
Man overboard	A member of the crew or a passenger has fallen off of the ship into the water and is in need of immediate rescue	