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LASH FIRE

Deliverable D07.8

Design definition and development of firefighting resource management simulator prototype

March 2023

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Abstract

This report presents the conceptual design and development of the firefighting resource management centre (FRMC). The FRMC has been operationalized as a set of tools presented in this report alongside with plans to test them in a simulated environment. The FRMC tools include; Safety assessment tool, Training design tool, Drill debriefing tool, Unmanned Aerial Vehicles (drone) system (presented in a separate report), and a Digital Fire Central (presented in a separate report).

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Contents

1 Executive summary

1.1 Problem definition

The LASH FIRE firefighting resource management centre (FRMC) is a concept that is created to highlight the technical, organisational, and human resources needed for safe and efficient fire emergency response. The concept was defined in LASH FIRE deliverable D07.4 (Skogstad et al., 2022):

> *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.*

Fire emergency scenarios on a ship are unique, dynamic and cannot be fully known in advance, which demands that leadership and crew members can adapt and adjust to the unfolding situation. Thus, a systematic approach to analysing and developing the ship's FRMC can ensure that the ship and its crew are capable of responding to any potential situation.

This report will focus on two aspects of LASH FIRE FRMC development:

1. A presentation of tools that can be used systematically for continuous improvement of a ship's FRMC.
2. A plan for testing and validation of these tools through simulation.

1.2 Method of simulation

Data collection was performed through interviews, remote ethnography and virtual walkthroughs. Data was analysed with the Functional Resonance Analysis Method (FRAM) to develop the safety assessment tool. Data was also analysed iteratively in meetings between the researchers to develop the training design tool, and the debriefing tool.

Testing and validation of these tools will be performed through a simulation at SASEMAR training facilities in Jovellanos. The test will consist of workshops and tabletop exercises, and simulated drill or leadership scenarios facilitated by the research team.

This report builds on the work presented in D07.4 (Skogstad et al., 2022). The current report can be viewed as a protocol or plan of action that will provide input for the simulation of the FRMC concept prototype. The results of the simulation will be presented in report D07.10.

1.3 Results and achievements

Three tools have been developed. In Chapter 4 the background, design prototype (what it is), stakeholders (whom it is for), and validation plans (how it will be tested), for each tool will be presented. In short, the tools are:

a. **Safety assessment tool,** which is based on FRAM, and can be used at any level of the organisation to develop a function map of ship-specific tasks in firefighting management. The tool can provide an overview of the functions that are required in firefighting and how they are connected to other aspects of fire management, such as resources (e.g., personnel available to perform a task, technical systems), dependencies (e.g., opening correct valves for activating a drencher section), and

time-constraints. The safety assessment tool ensures that variability in the identified functions can be detected and solutions for improvement can be sought.

The safety assessment tool will be tested through workshops where elements of the safety assessment process are discussed.

b. **Training design tool,** which provides a methodology for developing training concepts based on FRAM analysis. It provides a structured approach to meet the needs defined in the safety assessment through creating fire drills and other training with specific objectives for these needs.

   The training design tool will be tested through workshops, and interactions with users through discussions and brief surveys.

c. **Debriefing tool,** which provides a facilitated way of improving learning outcomes from existing fire drills, training sessions and occurring events (negative or positive). The tool provides the necessary knowledge to facilitate debriefing sessions, examples for topics and questions that can be used in post-drill debriefing sessions, and suggestions to ensure that the knowledge generated gets utilized.

   The drill debriefing tool will be tested through a simulated drill-scenario and discussed in a workshop session.

The three tools can thus be used iteratively as input to each other, providing continuous improvement of the ship's FRMC. Tools for developing a ship's FRMC also include unmanned aerial vehicles (drones) (report D07.7 – forthcoming), and a digital fire central (D07.5 and D07.6)

In Chapter 5 we present the protocol for the demonstration of the above mentioned FRMC tool prototypes at SASEMAR training facilities in Jovellanos.

1.4 Contribution to LASH FIRE objectives

This report is contributing to LASH FIRE Objective 1, the overall objective of WP07 and specifically Action 7-C.

Objective 1: LASH FIRE will 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.

WP07 Inherently Safe Design: Reduced potential for human error, accelerating time sensitive tasks and providing more comprehensive and effective decision support, by increased uptake of human centred design and improved design of tools, environments, methods, and processes for critical operations in case of fire.

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.

1.5 Exploitation and implementation

The results from this report will be used to demonstrate the feasibility and usability of the FRMC tools in a prototype simulation at SASEMAR training facilities in Jovellanos.

The development of the FRMC tools and the results from the simulation will provide input to LASH FIRE deliverable D07.10.

Several academic publications based on the development of the FRMC tools are planned. Each of the three tools presented in this report is planned to have a separate conference or journal paper, in addition to a paper on the Remote Ethnography methodology developed and used for data collection in this project.

2 List of symbols and abbreviations

DFC	Digital fire central
DPA	Designated person ashore
FRAM	Functional resonance analysis method
FRMC	Firefighting resources management centre
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
UAV	Unmanned aerial vehicle (drone)
WAI	Work-as-imagined
WAD	Work-as-done

3 Introduction

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Proactive approaches to fire safety on ro-ro ferries are becoming increasingly important. Societal pressures, for example the need for decarbonisation, are driving systemic changes to both cargo and means of propulsion. These changes can potentially impact fire safety, and introduce a range of potential hazards and risks, which are not yet fully understood. The rapid pace of development poses challenges for traditional safety methods: it is for example difficult to quantify risks related to electrical vehicles, as there is little historical data, and technological solutions are changing from year to year. Similarly, best practices, training, and regulations for managing fires in electrical vehicles are being developed but are not fully established. The rapid pace of technological change, which contributes to uncertainty, can be expected to continue. Hence, it is not possible to fully anticipate what is beyond the horizon, regarding new hazards and new safety measures in the near future. Slow-moving regulatory frameworks can be expected to lag behind the rapid pace of technological change. This makes it increasingly important to introduce practical methods for proactively uncovering new vulnerabilities and potential hazards, as well as increased efforts to learn about each organization's capabilities for upholding fire safety.

The FRMC is based on a model which is used to identify and raise awareness of factors that directly or indirectly can affect fires and firefighting. This model is the foundation upon which three tools have been developed. These three tools are intended to be useful and usable in practice and will therefore be developed with participation from relevant stakeholders.

3.1 Goals of the FRMC

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 concept is developed to support fire resource management in different (temporal) phases before, during and after actual fire management, through both material/technological and immaterial/organizational measures. In the LASH FIRE deliverable D07.4 (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.*

A brief account for the theoretical resilience perspective, on which the FRMC approach is based, as well as central concepts used in the report, is provided in the next section (see e.g. Hollnagel, 2012 for reference).

3.1.1 Systems safety and resilience

Modern safety research emphasizes that in large work systems, such as RORO-vessels, safety, and hazards, emerge from complex interactions among technical, social, and organizational factors. This perspective is useful for fire safety on ships as it complements traditional approaches to safety work and promotes proactive safety measures. The foundation of working in this way is to increase seafarers' and land-side organizations' learning and understanding of how work is conducted under realistic conditions, both during normal operations, as well as during firefighting.

The resilience engineering perspective is grounded in theoretical and empirical research in managing safety in dynamic, safety critical work systems (Hollnagel, 2013; Hollnagel et al., 2006). It emphasizes how the increasing complexity of work, due to rapid technological development and increasing pressures for effectiveness, must be met with proactive systems approaches to safety, which go beyond detecting and repairing safety compliance problems (Provan et al., 2020). In traditional safety work, priorities are often set based on past incidents and accidents, and efforts focus on removing, or creating barriers to, causes of error. The resilience approach augments this way of working, by adding proactive methods, to strengthen an organisation's ability to recognize and cope with disturbances. One important part of this it to establish feedback loops within the organisation. The proactive focus also helps meet unforeseen challenges in domains which are undergoing rapid change. The focus of these methods is to assess and actively monitor resources and strategies for safety. Within resilience research, the human is seen an essential resource for work system performance in complex and dynamic conditions.

The resilience approach is grounded in a sociotechnical system perspective. A ship, viewed as a sociotechnical system, achieves its purposes through interactions among

- Humans: individuals and teams (the "socio-")
- Technology, work processes, organizational structures, regulations etc (the "technical").

The work system's overall performance, which e.g., can be viewed in terms of efficiency or safety, emerges through dynamics among system elements. Below is a schematic diagram, which shows relationships between and among social and technical elements in a sociotechnical system (Figure 1). Among other things, it shows that changes in tasks or technology, can also cause secondary changes, e.g., in work relationships. A sociotechnical work system can also be subject to external forces: from the overarching organization, society and from the physical world, such as weather and wind.

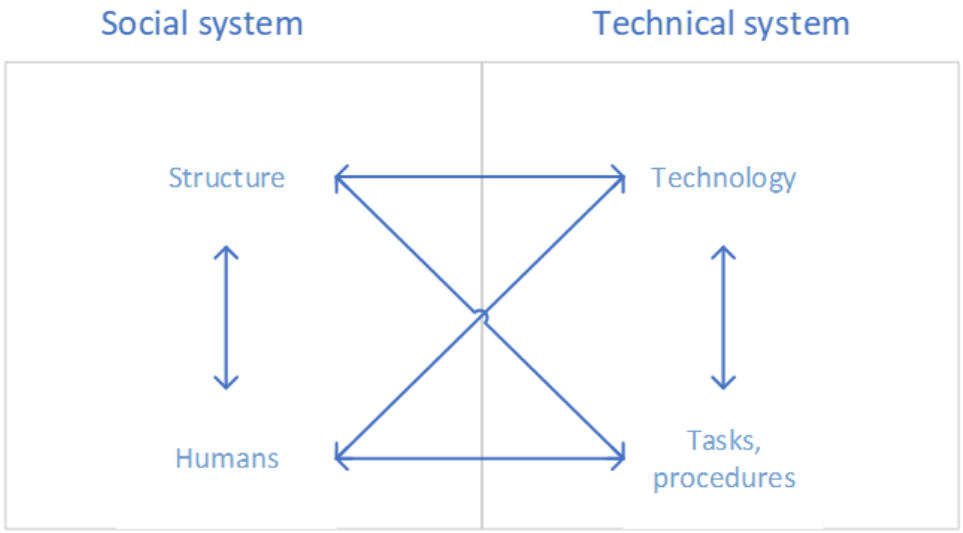

Figure 1. Relationships between and among social and technical elements in a sociotechnical system. Adapted from Bostrom and Heinen (1977).

When work in complex sociotechnical settings is described as well-defined sequences of events, e.g., as in standardized procedures, this description will tend to be underspecified, even with regard to routine, expected situations. The finer details of work in realistic conditions, such as variations in conditions, or the normal dynamics between concurrent activities are not included. In realistic conditions, often many activities are conducted in parallel, and conditions vary, and change. Sometimes the conditions in real life situations even make procedures unapplicable.

Humans are able to cope with everyday work system dynamics and multiple concurrent activities, by using their skill and experience to handle often making approximations and trade-offs, or workarounds in order to make work run smoothly. Hence, how regular work is conducted tends to vary slightly from day to day, as crew and officers anticipate and monitor shifting conditions and demands, and flexibly adapt their behaviour to meet the current situation. Humans' ability to anticipate events, to be flexible, adaptive in response to continuously changing demands and conditions, and make trade-offs in the face of goal conflicts is crucial for working efficiently and for upholding safety.

However, these minor, necessary, daily adjustments, which are part of everyday efforts to make things go right, can also sometimes contribute to unintended or unexpected outcomes, due to unforeseen interactions, with the context or with other activities. Incidents, such as fires, can stem from a conjunction of events, which evades barriers and defences, and leads to a precarious situation.

For these reasons, it is important to have a fine-grained picture of the strategies humans use in their everyday work to succeed, and to have insight into the variability of a work system and its environment. This is a way to proactively strengthen the work system's ability to recognize, adjust and recover from harmful influences. A term for this ability is resilience.

Adaptability is a term used to describe how teams and individuals flexibly adjust their work to work towards common goals such as safety and performance, despite variations, change or disruptions.

Variability refers to the variation both in operative conditions and the execution of work. Variability is both a source to successful execution of work, but also in some cases to failure. Failure occurs when variability in more than one function give rise to mutual amplification through processes of functional resonance. *Individuals and teams with a high level of adaptability can cope with the variability of operations.*

Work-as-imagined (WAI) – WAI refers to how the blunt end perceives and expects work to be carried out. It is common to describe or think about work as a sequence of actions and/or decisions, where the order steps and their outcomes are natural and predictable. This is exemplified in guidelines and procedures.

Work-as-done (WAD) In complex environments, WAD will always be different from WAI. The gap between WAI and WAD is not due to lack of compliance, but due to assumptions within the organisation of how processes and tasks are accomplished, and a reality were practitioners cope through adaptations.

Resilience is a term for how well a work system can recognize, handle and recover from disruptions and variations by adapting its performance. This also includes how well the system can recognize and manage situations which breach the adaptive capacity, and demand a shift from planned responses to crisis strategies (Woods, 2017). Another way of expressing resilience is as "the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions" (Hollnagel, 2013)

Resilience skills - individual and team skills in adjusting performance to maintain safety and efficiency, in expected as well as unexpected situations (Saurin et al., 2014).

Resilience capabilities – the organization's capabilities to respond, monitor, anticipate and learn

Textbox 1. Resilience vocabulary

The FRMC comprises five tools, three presented in this report, to facilitate gradual improvement to fire safety management. The tools are designed to support regular fire safety analysis, help identify situations and skills that can be trained for, strengthen the value of training, and pick up feedback and learning from training situations (Woods, 2017). Resilience principles are emphasized in each tool: in the safety analysis, the identification of training objectives, scenario design as well as in the debriefing.

The tools can be used individually, or together to form a cycle of learning and improvement. The overall goals are to make individuals, teams and the organization more aware of interactions within the work system (variability), to strengthen the ability to anticipate and adapt to expected and unexpected situations (adaptability), and to strengthen individual, team, and organizational ability to recognize, cope and recover from disturbances.

FRMC is a framework to support systematic work to strengthen activities and resources in fire management, which can have impact on several levels of the organisation. For individual crew members and officers, the approach can raise awareness about sources of variability. In this way increasing the capacity to anticipate and respond to fire situations. On a team level this raised awareness can contribute to improving procedures and improving collaborative practices. Finally, on the organizational level this awareness contributes to developing primary work processes, technological aids and design and organisational capabilities.

The "**blunt end"** of operations, i.e., managers, trainers, and designers, has an important role in establishing and maintaining the "**sharp end's**" capacity to respond to fires through establishing and maintaining competence, resources and readiness. It is therefore important that the blunt end strives for insight into how safety is achieved under realistic circumstances, assess whether current approaches have room for improvement, and proactively identify changing conditions that can influence safety.

The FRMC emphasizes that coping with unanticipated or escalating events is also important for the firefighting capabilities on RORO vessels. It is therefore important that the blunt end is aware of performance boundaries, i.e., conditions in which the adaptive capacity to respond to fires is stretched and may break down.

Figure 2. The role of the blunt end (managers, trainers, designers etc) with regard to supporting sharp end adaptivity and resilience.

The FRMC can also be applied at the "sharp end" - for ship-side seafarers involved in everyday operations, as a way to strengthen crew and officer **adaptability** in everyday operations, and also in unexpected and complex events. At the sharp end it is crucial that officers and crew have an ability to recognize escalating and unprecedented situations, and have skills for shifting from controlled, trained responses to ad hoc emergency responses. Currently, this type of training is not demanded by regulations in the maritime industry.

Figure 3. Resilience capabilities at the sharp end (ship-side officers and crew).

In this context, the FRMC can contribute to functional improvement of primary work processes. These may be matters which can be addressed locally (level 1 improvement) or communicated within the organisation (level 2 improvement).

Examples of sharp-end use (safety assessment tool, debriefing tool) in level 1 improvement:

- diagnose shortcomings and potential vulnerabilities in functions/processes, as well as in capabilities such as readiness, communication practices, decision-making and learning from drills or real fires.
- identify and monitor functional resonance (see Textbox 1), and measures to dampen certain resonance.
- for increased control under both normal operations and during a fire situation.
- material/technical adaptations.
- changes in human working conditions.
- organisational changes (e.g., division of labour or communication structures).
- any combinations of these.

This deliverable provides examples of how the framework can be used for overarching safety assessment, development of innovative drill concepts, and evaluation of drills. Figure 4 shows the main elements of the FRMC.

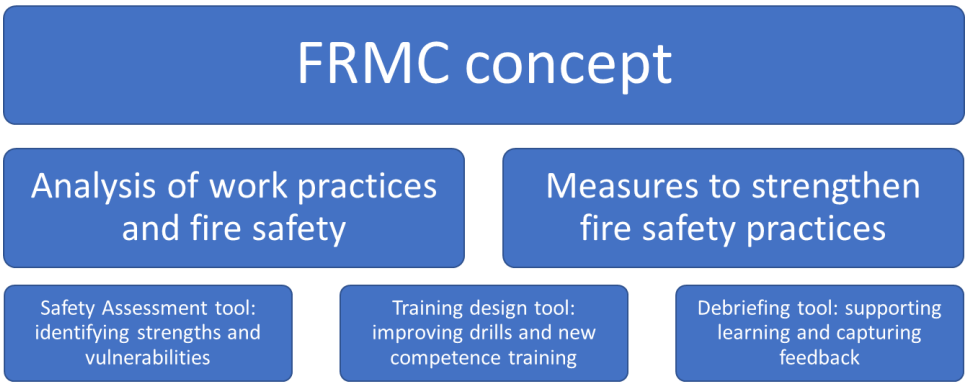

Figure 4. FRMC approach for improvement of fire management

Figure 4 shows for how the tools are to be applied, refined, and validated within the context of the LASH FIRE project.

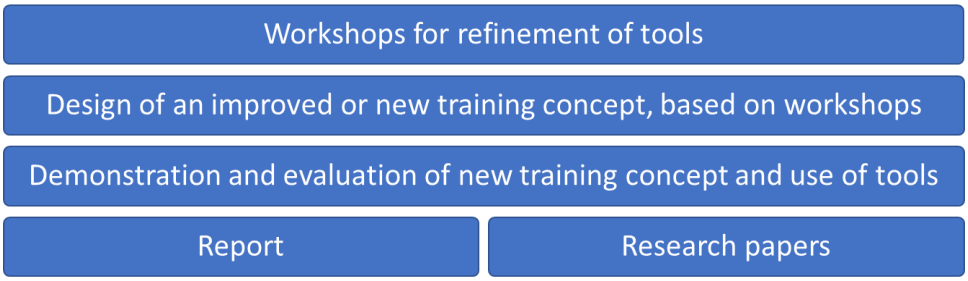

Figure 5 How the tools are to be applied, refined, and validated within the context of the LASH FIRE project.

3.2 Video recording as an analytic tool

Due to the COVID-19 pandemic researchers in the LASH FIRE project had limited possibilities to perform planned ship visits and observations. To overcome this obstacle a new data collection method called remote ethnography was created.

Ethnography does not have a standard definition (Hammersley & Atkinson, 2007), but the term is typically used when people's actions and accounts are researched 'in the field'. A remote version of an ethnography, using several body-cameras to obtain a rich point-of-view data source allowed the LASH FIRE researchers to observe drills and have get acquainted with the crew and equipment on the bridge. The new method led to possibilities of in-depth analysis that would not have been possible using normal observation and note taking techniques.

Video recording and analysis as a method has potential for use in normal drills to obtain more data on performance, a better foundation for post-drill briefings and company analysis. See D07.4 (Skogstad et al., 2022) for a description of the method.

4 FRMC Tools

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This section presents the three FRMC tools, which are examples of how resilience engineering principles can inform proactive and systematic fire safety management. The tools can be used separately or as part of continually ongoing improvement cycles. Figure 6 illustrates how the FRMC tools 1, 2 and 3 can be incorporated into the cycle, and have direct effects on each other.

To secure acceptance and that the tools are possible to implement, they will be continually refined in a human-centred design process, involving representative users, subject matter experts and other stakeholders. This is seen as a part of the validation of the tools.

The tools will finally be used to design the exercise conducted during the upcoming demonstration, and tools 1 and 3 will also be used by participants in the actual demonstration.

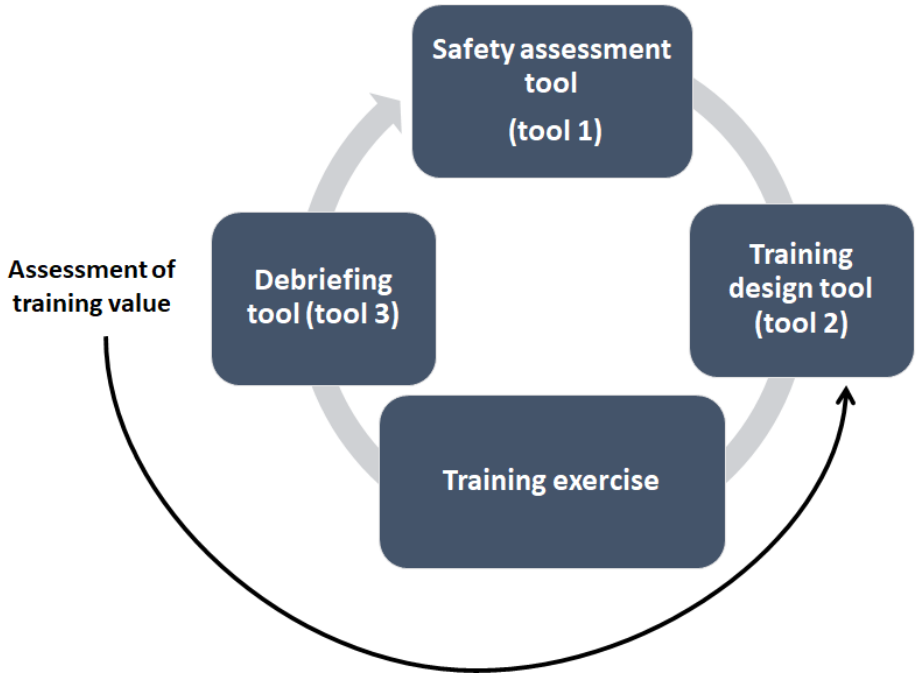

Figure 6 Process logic of the FRMC tools as part of fire resource management

The tools are intended to complement safety management practices and follow a process logic for maintaining and managing the resilience of the firefighting capabilities on a vessel. The basic steps involve knowing the present state, setting goals, and knowing the means for making the changes necessary to move towards the goal. While the current state of safety may be assessed and managed by measuring incidents and adverse outcomes, and efforts to prevent and learn from these events, the

FRMC/resilience approach looks for ways to strengthen “the ability to succeed under varying conditions”. This not only includes reducing failures, but also increasing the number of things that go right (Hollnagel, 2017).

To be able to do that, it is important to have a clear understanding of how work is done under realistic conditions in a specific setting, which tends to be different than the “work as imagined” which is reflected in guidelines and procedures. The three tools are designed to contribute to insight into “work-as-done" for these reasons. Understanding and describing work as done in effective and precise ways helps identify areas where WAD is likely to differ from WAI and provides a strong foundation for identifying improvement needs and for designing improvement measures.

It is also important to continually assess the system’s own performance as well as changes in the environment.

The rationale for the FRMC to support conducting local assessments, designing training exercises and collecting insights and feedback from debriefings, rather than recommending a fixed package of interventions, is that differences in organisational contexts have a large influence on implementation success for improvement efforts. Using the tools is intended to lead to interventions that are adapted to the resources and conditions in the organisational context, and that hence are compatible with the setting in which they are to be implemented.

The FRMC focuses on ways to enhance training and awareness of important capabilities and skills for adaptivity and resilience, which is a counterbalance to the tendency to proceduralize safety. The FRMC aids the design of improvement measures that enhance crew members’ ability, knowledge, and motivation regarding fire safety. Thus, the FRMC tools are intended to support leaders who today often coach crew members towards safety-related behaviours in more informal ways, e.g., raising crew members’ risk awareness through sharing experience-base knowledge, providing performance feedback and asking crew members to envision outcomes (Kim, 2020).

The suggested process logic for improvement of fire resource management is as follows:

The *Safety assessment tool* (tool 1) supports systemic analysis of fire safety on board a RORO vessel. It is based on a generic functional model of firefighting activities, and provides a method for systematically identifying factors, and interactions among factors, that directly, or indirectly, can affect fire safety on a specific vessel. The tool is designed to help raise awareness of how variability can affect operations, and to 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 measures that need to be addressed through organisational measures, regarding design, technology, or resources.

The results from using tool 1 can feed into the *Training design tool* (tool 2) in several ways.

Gaps in knowledge and practices can be addressed by training measures. Similarly, if the safety assessment tool has e.g., identified ways to improve routines, it is important that crew and officers are informed. Changes in practices or other measures can be incorporated and trained in new drills.

The T*raining design tool* (tool 2) is a template to help define training needs and learning objectives, and an aid for generating scenarios for drills or other types of training. Defining training needs and objectives is important for assessing training value and the quality of individual exercises and keeping track of learning over time.

The tool helps generate scenarios which incorporate variability into the drills. This is intended as a way of generating interesting exercises, and also raising the ability to anticipate developments, in order to sustain operations under “normal” fires as well as unexpected conditions.

The *Debriefing tool* (tool 3) is a template for collecting experiences and learning from exercises, which includes successes and things that go right, as well as failures, vulnerabilities and things that go wrong. The tool is intended to strengthen learning though reflection on practice and picking up feedback, which can be used for improving exercises as well as for suggesting improvement needs. Hence, the debriefing tool also includes suggestions for how to document and communicate the findings, for the purposes of both level 1 and level 2 improvement.

The interconnected tools are intended to support proactive safety work and strengthening feedback loop which contribute to increasing understanding of “work as done”, how to support adaptivity and how to develop resilience strategies etc both on the blunt and sharp ends of the organisation.

The tools can be used in an iterative feedback-loop that will provide continuous improvement of the safety and resilience capabilities of the organisation.

4.1 Safety assessment tool

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4.1.1 Background

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The FRMC methodology is grounded in a sociotechnical analysis of firefighting on roro-ships, using the FRAM method (functional resonance analysis method). This is described in LASH FIRE deliverable D07.4 (Skogstad et al., 2022). The work resulted in a generic graphical model, which shows central work activities - functions - which are necessary for achieving important central aims during fire-fighting management. The model also shows interdependencies between the functions. This model is suggested to be used as a basis for various types of analysis.

Figure 7 shows the resulting generic FRAM model: a high-level “function map” of central tasks in firefighting management. The model shows the capabilities and activities involved in effective fire management and is a means for better supporting human performance in fire management.

The FRAM approach focuses on functions/activities, and the representation should not be interpreted as a workflow or process map, as these focus on roles and specific tasks.

In the model, the work involved in fire management is broken down into distinct functions. For each function, necessary resources, and preconditions for the function to be carried out are described (but not visible in this figure). One advantage with such an action-oriented approach is that it provides an easily communicable overview of interdependencies between different activities. Another advantage of focusing on the function rather than the tasks, is that it directs attention towards what has to be done, instead of who should get involved – the latter being considered more as a resource for the first.

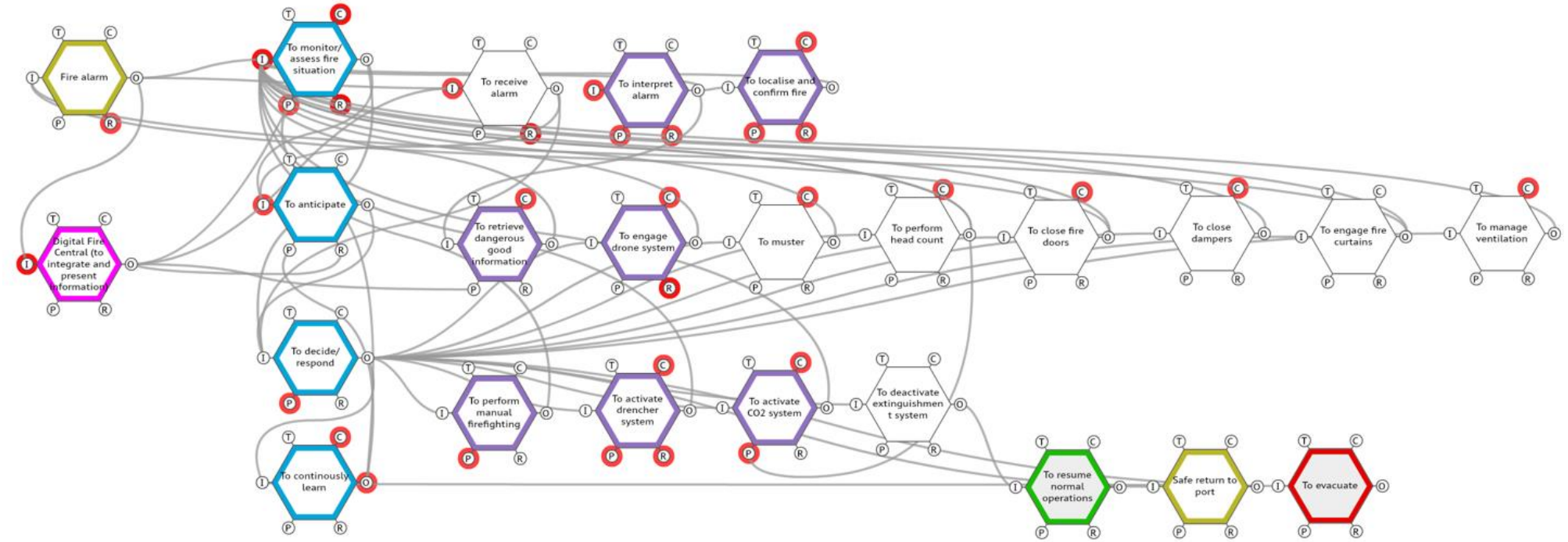

Figure 7. FRAM model informing the FRMC methodology.

Alternatively, the system represented in Figure 7 can be simplified, highlighting higher level categories of functions, as in Figure 8. Here, each particular function is backgrounded and we thus get a more conceptual model showing the first level functions (black frames: initial phase, preparatory and supporting actions and fire extinguishment activation) and second level functions (blue frame: organisational capabilities)[1]

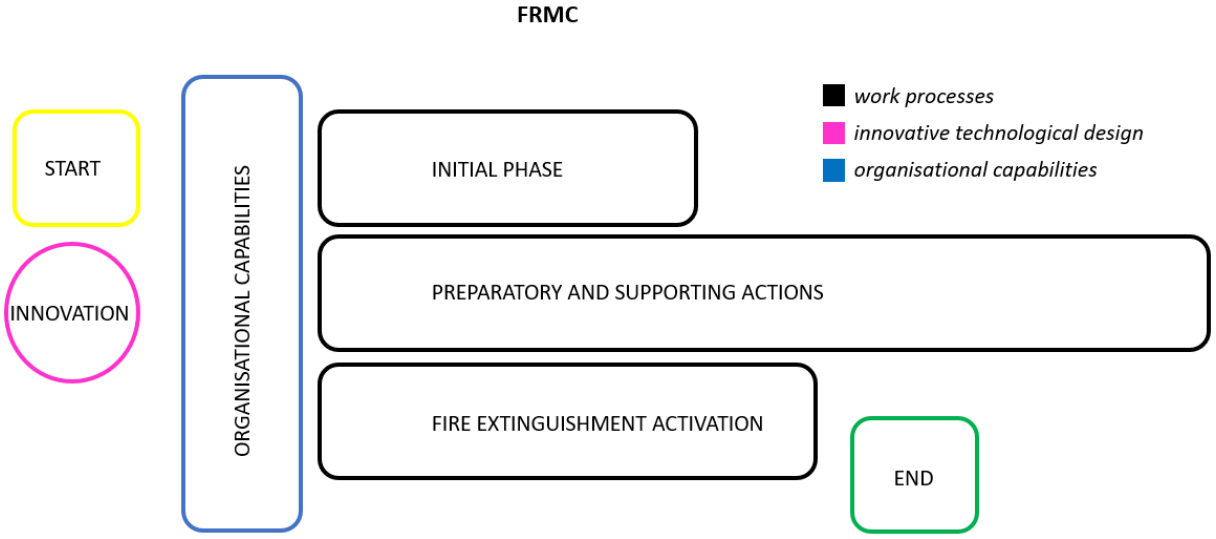

Figure 8. Higher-level categories of FRAM functions.

The work models presented in Figure 7 and 8 are generic and conceptual, which enables them to be useful despite the fact that the details of work and material/technical set-up may differ largely between ships (and ship operators). Expanding and detailing sub-functions to each of the main functions serve as examples of how work *can* be executed in specific instantiations.

Customising the model to a specific vessel is a way to help get detailed insight into systems dynamics, and in this way identify vulnerabilities and gaps in fire management. It can also support related activities, such as developing user requirements for the design of new technical systems, or proactively investigating the potential effects of system modifications (organizational or technical).

Figure 9 provides an example of how the main function "*To activate drencher system"* can be elaborated.

[1] For an explanation of the difference between first level and second level functions (and change), see LASH FIRE deliverable D07.4 Skogstad, M. R., Haavik, T. K., Standal, M., & Petersen, E. S. (2022). *D07.4 – Development of firefighting resource management centre design*. .

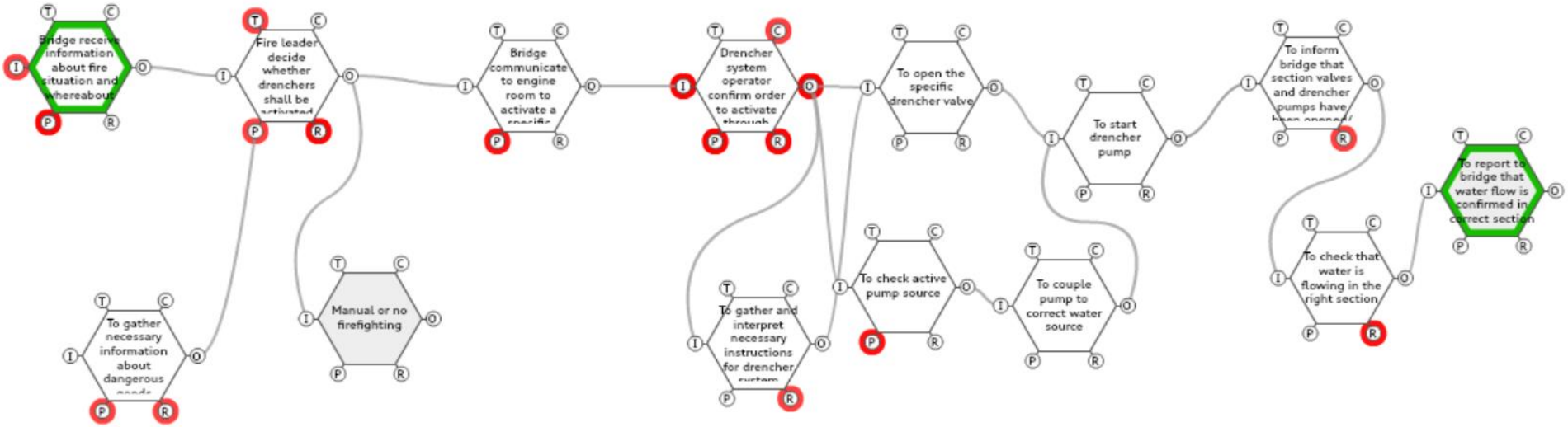

Figure 9. Main function 'To activate drencher system'

The example shows how the model can be used as part of the *Safety assessment*:

The FRMC supports safety assessment and first-level improvement (see Skogstad et al., 2022) of the function "to activate drencher system", by detailing how the resources and preconditions for each sub-function can be evaluated, optimised. If applicable, also other aspects, such as time and control can be elaborated. The FRMC approach also supports second-level improvement of the generalised functions monitoring, anticipation, decision making and learning.

The outcome of this safety assessment will inform the next steps in the FRMC process, where the ship organisation (sea side/land side) will use the model in the development of:

- new types/scenarios of drills that facilitate testing and practising of the new work processes, resources and conditions, and
- new ways of conducting existing drills, including debriefing, to ensure and capture the learning outcome from the drill.

Learning and assessment of drills or other forms of training, can be supported by a debriefing tool, which also refers to the FRMC model, and is designed to fulfil three functions:

- To enhance reflection about effective strategies and resources
- Formulate means for local improvement
- capture and communicate important insights within and between organisations

4.1.2 Needs and design goals (What should it do?)

A number of challenges that should be addressed in a FRAM-based safety assessment have been identified and documented (which will be described in a forthcoming report D07.9). A general concern is that there could be gaps between the land organisation's understanding of the work and working conditions on the ships, and the work as it is experienced by the crews. This gap is evident for example in impractical design solutions leading to cumbersome and time-consuming actions in fire situations. To exemplify with the case of drencher activation (cf Figure 9), challenges include the lack of harmonisation between drencher system references, fire section references and fire detector references, incomplete procedures for dangerous goods management and ambiguous drencher system activation instructions.

The safety assessment tool is a means to gain detailed insight into the conditions and variability of firefighting under realistic circumstances. These insights will provide a foundation for strengthening the organization's adaptive capacity to cope with disturbances, for example through design improvements, organizational changes or training.

The tool for systematic safety assessment builds on the principle that gaining detailed picture of work practices in realistic conditions (work-as-done) will yield important insights for proactive safety work. The tool helps investigate:

- how firefighting activities can vary in different conditions and circumstances
- how operators deal with this variability
- if there are gaps or vulnerabilities in the work system

The tool is intended to support organizations to develop means to support adaptivity and monitor and dampen variability, through e.g., indicators, modifications of work processes, and design measures, and to highlight/determine functions that can be specifically practiced/targeted during a drill/other training.

The design goal is an assessment guide that systematically allows the user to investigate sources of variability among social, technical and organizational factors in the firefighting response. This is done

with help of the model which shows the main functions/activities, combined with a resource to support the identification of variability in these functions. This is a means for identifying strengths as well as vulnerabilities. This detailed insight can then lay the ground for functional improvement of specific processes, as efforts for capacity development, such as technological design, competence and training.

To this end, we suggest that shipping companies start by conducting a systematic safety assessment using the Safety assessment tool.

4.1.3 Stakeholders and users

The Safety assessment tool can be used for first-level and second-level improvement.

Shipping companies are seen as the main stakeholders of the suggested safety assessment process. International codes such as STCW, or ISM establish the minimum requirements for training and drills, but many shipping companies want to go further, and the FRMC safety assessment tool would be a means to upgrade safety assessment from the minimum requirements.

It is also expected that institutional maritime stakeholders, such classification societies, could be interested in the FRMC concept, since they are responsible of classifying ships, considering the safety levels, and compliance with standards and international codes. Similarly, marine insurers may also have interest in methods for proactively strengthening fire safety capabilities.

End users are expected to be both land-side and ship-side officers with managerial or operational responsibilities for fire safety: potentially the captain/first officer/second officer, chief engineer and safety– and designated person ashore (DPA), such as the safety superintendent. Crewmembers will function as important informants in the analyses.

This is why processes are foreseen to be run for each ship, but with involvement from the same DPA to ensure continuity and learning at the company level.

4.1.4 The Safety assessment tool

The tool is developed iteratively, and in this current phase, the model and the instructions are to be appraised and refined through involvement of subject matter experts.

The Safety assessment tool is comprised of three main elements

1. Introduction to important concepts for proactive safety management
2. A generic FRAM model of firefighting on RORO vessel
3. Instructions to support stakeholders in customizing the model to local conditions on a specific ship.

The introduction (1), explains

- Concepts such as variability, adaptivity and resilience.
- How there generally can be gaps between planned operational procedures (work as imagined - WAI) and how work is conducted in practice (work as done - WAD)
- That learning more about variability in normal operations is a way to:
    - shine the light on how crews make things go right
    - uncover gaps between practice and procedures
    - provide insights into the potential for incidents
    - increase the ability for adaptive response in unexpected and unintended situations

The generic FRAM model (2), shows central functions for firefighting (see Figure 7).

The instructions, (3), help the users systematically raise questions regarding the functions in the generic FRAM model. This leads to increasing insight into how the functions are instantiated on a specific ship, or under specific conditions.

The Safety assessment tool can be used repeatedly, to proactively analyse scenarios, or retroactively to analyse events. Using the tool supports proactively uncovering issues that otherwise may be overlooked, such as goal conflicts, social and technical interactions, and sources of variability that may be "hidden" in daily operations.

4.1.5 Validation

This FRMC based approach to safety assessment is co-developed with, and thus subjected to during-development validation by stakeholders from ship operators. The validation takes place through workshops where the elements of the safety assessment process are discussed.

One part of this refinement process is to understand how to best present the FRAM model, to ensure that it is useful and usable, which are preconditions for acceptance. Three ways of presenting the model will be assessed: a) the shape as described in section 4.1, but also b) a simplified FRAM model with support questions, as well as c) a function-specific questionnaire.

This validation will be in the form of workshops, where participants elaborate one or more chosen functions, e.g., "confirmation of fire", and compare methods a), b) and c.

In the questionnaire, the questions in the 'simplified FRAM' are elaborated to ask specific questions related to the function. The three FRAM concepts are discussed with the goal to find a useful method for the users to carry out a safety assessment, taking a reasonable amount of time and effort into account. The workshops also pay particular attention to how the output from the safety assessment can inform the building of drill scenarios and the carrying out of training and drills, cf 4.2.

This user-informed development and validation process ensures relevance as well as usability. The results will be assessed in the following way:

Feasibility	"The tool makes sense and is easy to use"
Usefulness	"The tool is useful"
Effectiveness	"The tool helps me understand sources of variability that I have not been aware of"
Efficiency	"The tool makes analysis of firefighting capability easier and quicker"
Performance	"The tool helps me fulfil my obligation to conducting regular analysis of firefighting capabilities"

4.2 Training Design Tool

Main author of the chapter: Hedvig Aminoff, NTNU

The purpose of this tool is to support practitioners in designing training or drill activities, in a way that emphasizes resilience skills, and incorporate these training exercises in the FRMC cycle of systematic improvement. The tool is a template for defining and detailing central components of training activities:

- Identifying training needs
- Specifying training objectives
- Determining scenarios
- Establishing qualitative and quantitative assessment metrics

4.2.1 Background

Fire drills are a central aspect of the on-board training and form a basis for the evaluations required for compliance with fire safety regulations. Fire drills are performed frequently and hold an enormous potential for conveying relevant and updated information about firefighting and preparing the crew for the situations they could face. Fire drills are thus part of the regulatory demands to periodically identify areas in need of improvement, to ensure competency in fire-fighting skills, and to ensure the operational readiness of the fire-fighting organization. For this reason, it is also important that these types of exercises are designed in a way which ensures motivation, and that training objectives are met.

Shipping companies design exercise plans according to a general international standard, but it is up to them to try to design these exercises for optimal utilisation.

A common approach is to use a set of repeating generic scenarios, which are relatively simple to vary and conduct. Occasionally, the continuous repetition of the same exercise, with the main objective of fulfilling the company's safety management code (ISM code), can make both organisers and participants operate automatically without considering whether the objectives are being met.

The training design tool will support ongoing fire safety management practices and add elements of modern resilience-oriented safety management, such as emphasizing resilience skills for adjusting performance, awareness of production/safety trade-offs, and how to recognize, cope and recover from escalating or unprecedented events (Woods, 2017).

4.2.2 Needs and design goals

The Training Design Tool provides a methodology for developing training concepts based on FRAM analysis. The FRMC concept provides a way to link findings from the safety assessment tool to the development of new drill scenarios which are tailored to strengthen necessary capabilities. The tool provides a structured approach to identify, define, and cover training needs. Partaking in the design of drills and training concepts is also a way to strengthen organizational learning and embedding resilience concepts in overall safety work.

The suggested Training design tool is intended to help vary these types of repeated, generic scenarios, to help secure engagement and learning.

The Training design tool is also intended to support the inclusion of new training themes and developing new exercises. From a resilience perspective, it is important not only to practice predictable fire situations, but also to train for unusual and rare events, and to vary incident severity and consequences.

Major hazards and disastrous events are luckily rare, but this also means that there is limited real experience of very dangerous situations. Training should therefore also include practicing the capabilities for recognizing when the response if breaking down and how to behave in those situations (Woods, 2017a).

The training design tool is intended to augment fire safety training by emphasizing the importance of training resilience skills for adjusting performance, awareness of production/safety trade-offs, and how to recognize, cope and recover from escalating or unprecedented events. In offshore oil and gas industry, there are recommendations to design exercise scenarios which include major hazard scenarios, some of which should involve removal or breakdown of a prevention, mitigation or control measure, and hence have severe consequences. It may also be of value to decide on a certain ratio between “standard” drills and more complex exercises (Charlton, 2012), for example, a third each of:

1. “routine” fire scenarios

2. scenarios with some controls removed, with subsequent severe consequences
3. scenarios that are theoretically possible and credible, but have not ever happened

A similar approach might be a way to complement compliance driven fire safety work, by intentionally covering important aspects of fire safety which are not specifically addressed by regulations, such as the capabilities in identifying and managing new and unforeseen hazards.

It is important that training scenarios are relevant and effective to secure engagement and achieve training objectives. However, there are also necessary trade-offs regarding e.g., the realism and complexity of a scenario, in relation to the time and effort of setting them up and conducting a training exercise. The need for realism depends on the training objectives and task.

While drills are the most common on-board exercises, training can also take other forms, for example as tabletop exercises or workshops. While on-board drills will include important aspects of the people, resources and context, under some circumstances paper-based tabletop exercises can be sufficiently realistic. Training detailed operation of equipment under hazardous conditions may call for simulations of some form. The difficulty of arranging resource-intensive drills, e.g. situations in which evacuation or outside collaboration is required, speaks for also investigating other avenues of training, such as table top exercises. In these cases, a lower degree of physical or organizational realism can be weighed up by attention to making the narrative realistic for the participants (Patterson et al., 2010).

Regarding evaluation, it is important to assess an exercise in itself - its design and how it was conducted – as well as the participants' process during the exercise, and the outcome. This makes it possible to gain useful feedback, and for reinforcing training value.

From the ship side it is important to take the experience of the personnel, and their role in a real emergency, into account during training and drills. It is also important with bottom-up feedback, from crew to officers at the sharp-end, as well as from frontline staff to the on-shore organisation. In the LASH FIRE project, a number of interviews have been conducted with crew members to understand their perception of fire safety, the organisation of the operation and the use of training and exercises. The FRMC tools help provide structure for continuing this type of activity, through which every actor and a more whole picture of fire safety work is included

4.2.3 Stakeholders and users

Use of the FRMC tools helps develop training scenarios, e.g., for a new drill, which are informed by the safety assessment [Section 4.1], company analysis of previous drills as well as crew's reflections from previous drills.

Thus, the training design tool can be used at all levels of the organization, building on data from the other FRMC tools. For instance, for crew members, input from previous reflection tasks [see Section 4.3] can determine which training needs, tasks, and scenarios are to be prioritized. Decision makers such as fire chiefs, or captains can use the tool in a step-by-step manner to make training needs concrete and practicable. Shipping companies' DPA or safety representatives can use the tool to generate scenarios that can be selected by safety officers for training within a diverse set of areas. In this way, scenarios can be transferred across vessels for intra-organisational learning.

4.2.4 The training design tool

The basic main components of developing a training concept are described in the following image:

Figure 10: Basic steps for developing a training concept

1. The first step, identifying training needs, is supported by the Safety assessment tool (Section 4.1), and also through insights from the Debriefing tool (Section 4.3). It is also possible and advisable to use input from other sources, such as safety audits etc.
2. Setting training objectives involves specifying the skills, competencies, and situations that are the focus of the exercise. e.g., how can we avoid losing time during "confirmation of fire"
3. Determining the scenario. This is supported by tool 2, and involves selecting which functions are to be trained, and using the FRAM model to help identify variability that can come into play during the exercise
4. Defining the resources needed for the exercise (people, equipment, time needed), and metrics, that reflect the training value of the exercise in relation to the goals and objectives
5. Conducting the exercise
6. Capturing and communicating learnings. This is supported by the Debriefing tool
7. Assess training value. This assessment will contribute to understanding how learning objectives are met, and to inform future design of exercises.

4.2.4.1 "Drill generator" for double-loop learning

Drills might represent training and learning at two levels. First, drills may be run to rehearse already established and learned patterns of action, where the elements and orders of actions are predetermined. The outcome of such drills typically entails single-loop learning, where one learns within existing frames of reference. Hence, minor – yet still important – adjustments of both individual and collaborative actions can be expected. (Argyris & Schön, 1978) refer to this as *single-loop learning*.

Drills might also be a method to challenge existing patterns of behaviour, that might be congealed and little apt to meet and resolve situations that are of a more surprising and unforeseen character than those populating the more traditional drill scripts. Improving the organisation's ability to handle such situations involves activation of more foundational organisational capabilities (see the 'blue functions' in Figure 7 and Figure 8). Argyris and Schön (1978) refer to this type of learning as *double-loop learning*.

Whereas the ambition of drills within a single-loop learning context is to be better prepared to 'do things right' (known things and known scripts), the ambition with double-loop learning is to develop

the ability to 'do the right things' – which might entail unprecedented paths of sense-making and decision-making in the face of unexpected circumstances. This capability is an important aspect of organisational resilience in the face of emergencies.

The drill generator is a method where capabilities to be practiced are identified from the FRAM analysis in the safety assessment. Based on the role and variability of the different aspects of each function, aspects will be candidates for *action cards*. Action cards are cards that are drawn and combined in the planning phase of a drill. The method is used to produce combinations of conditions for the drill that is new to the participant, and that will require thinking and acting 'out of the box' – to support double-loop learning.

Importantly, the action cards should be created by the ship organisation itself and have a life span parallel to the life span of the safety assessment.

An example of action cards derived from the safety assessment FRAM modelling for the Function Drencher system activation" is provided in Figure 11.

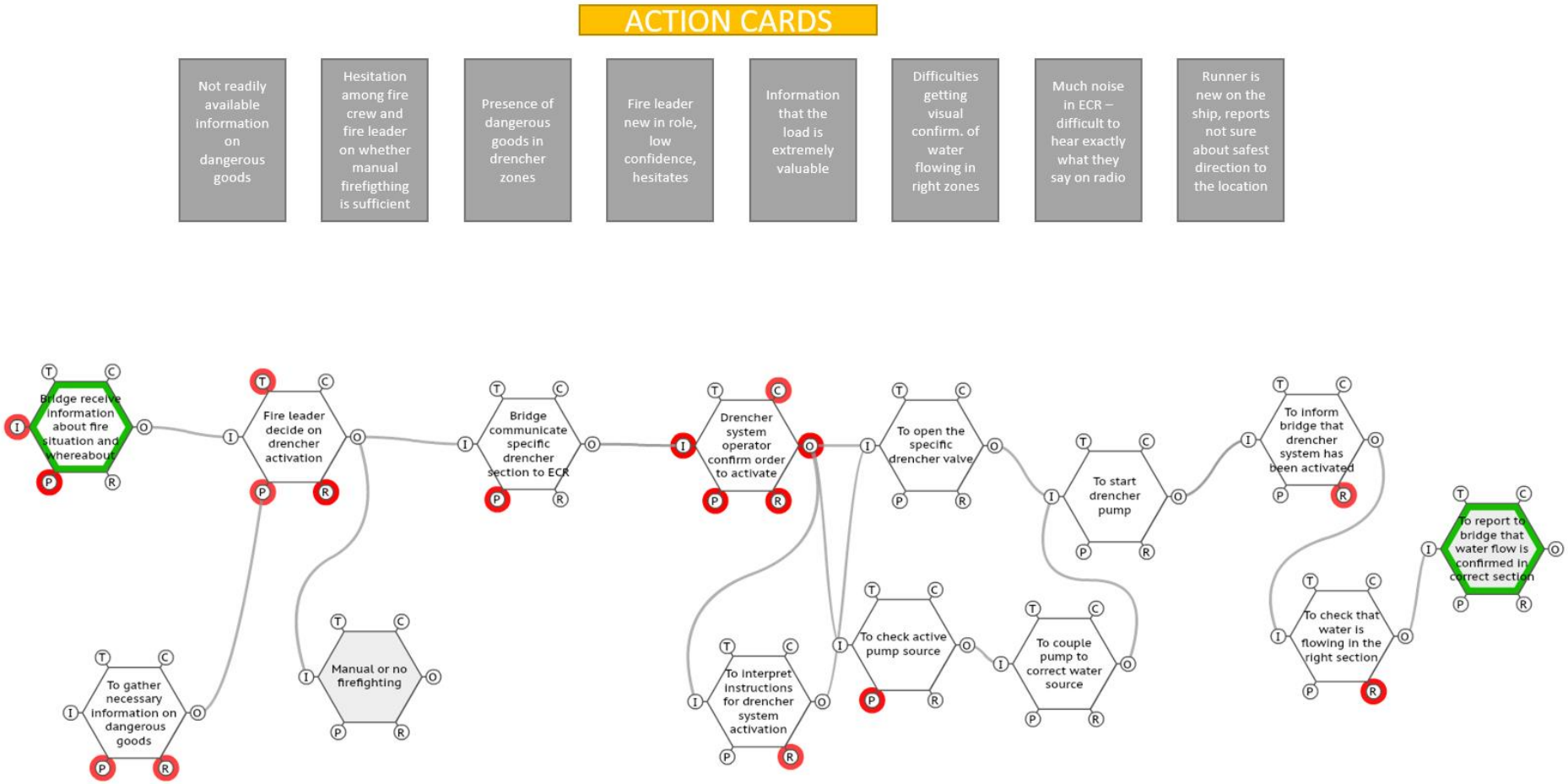

Figure 11. Example of action cards for the function "Activation of drencher system".

When a selection of action cards from the example in Figure 11 is combined to provide framework conditions for a drill, the crew will be faced with a unique combination of decisions that are not commonly practiced in ordinary drills. To the extent that the circumstances for the drill scenario will introduce new actions and challenge the regular practices for sensemaking and decision-making during drills, the scenario warrants double-loop learning in addition to single-loop learning.

4.2.5 Validation

It is important that a tool for helping design training exercises is useful and usable, e.g. that developing scenarios does not take too long, and that they are not unrealistic (Salas 2017).

Validation of the Training design tool will be ongoing during development, as future users and other stakeholders will be invited to provide input and give feedback in workshops: Another round of validation will occur during the demonstration.

User evaluation in connection with the demonstration both be through a questionnaire and semi-structured interview questions, linked to themes which are central when evaluating usability, usefulness, and acceptance. The evaluation will cover

- Feasibility: to which degree the tool makes sense and is easy to use
- Usefulness: to which degree the users think it is a useful tool for the purpose. This item will be broken down into sub-topics:
    - Effectiveness: to which degree the tool facilitates development of useful training or drill scenarios
    - Efficiency: to which degree it complements/makes it easier to achieve lasting change of practices as a result of the drill scenario development tool
    - Performance: whether and to which degree the tool is qualitatively better than the drills based on existing drill scenarios.

4.3 Debriefing tool

Main author of the chapter: Martin Inge Standal, NSR

4.3.1 Background

Debriefing strengthens the value of training exercises, such as drills and scenario-based training (Skogstad et al., 2022; Tannenbaum & Cerasoli, 2013).

Augmenting existing mandatory drills as a tool for learning and continuous improvement of fire resource management could be a cost-effective avenue to increase the fire emergency capabilities of the crew and their organizations. The rationale and research behind the use of drills as a learning tool can be found in D07.4 (Skogstad et al., 2022). The Debriefing tool is designed to generate knowledge about variability and adaptions, as well as understanding resources and constraints in the work system.

4.3.2 Needs and design goals

Team briefings and reflection among crew members can be used before and after a drill scenario in order to improve team preparedness and build shared mental models. Such approaches are based upon decades of research in team improvement (e.g. Reyes et al., 2018). Team debriefing can be used in combination with other tools in the FRMC tool-box, such as safety assessment (to identify shortcomings or improvement potential), scenario building tool (to prepare for, evaluate and improve the specific scenarios that are created), video ethnography (to improve debriefing sessions), and a digital fire central (to highlight information needs that can be included).

The debriefing tool presented here supports the introduction of important safety concepts, such as adaptation, variability, and resilience. It also stresses how insights into practical “work-as-done" is an

important way to uncover strengths, as well as masked challenges and vulnerabilities. The debriefing tool is a way to effectively and efficiently capture insights in direct conjunction to exercises.

The debriefing tool specifically asks questions to help uncover practitioner adaptations and workarounds, when work-as-done differs from work-as-imagined, for example when procedures do not match how work must be done in practice, or design issues that make work cumbersome or risky.

Practitioners also regularly manage to bridge gaps due to uncertain information or other disturbances. Understanding and supporting the way in which practitioners bridge gaps is a way to increase the system's adaptive capacity. However, bridging activities and workarounds etc can be difficult to uncover as they are "just the way things are done", and experienced practitioners may find it hard to reflect about these, but they are important to bring to light (Woods, 2019).

Over time the debriefing tool is also intended to strengthen shared mental models of how safety is upheld, and to contribute to improved collaborative practices. In this way the debriefing tool is intended to contribute to individual, team and systems level performance and resilience.

4.3.3 Stakeholders and users

Drill pre- and post-briefing sessions can be used for first-level and second-level improvement. For first-level improvements through discussions and reflection among crewmembers, potential outcomes are for instance improved learning, shared mental models, ability to self-correct and make adjustments, and identification of potential problems that could manifest in a fire emergency scenario. Second-level improvements could also be achieved by providing output from the briefing and reflection sessions as input to the shipping company which can use this information for more overarching improvements. For example, procurement decisions (e.g., fire central improvement, fire-fighting equipment, signage), documents and guidelines (e.g., procedures, standing orders), or harmonize potential improvements across the operator's fleet.

Thus, the main stakeholders using and benefitting from the drill learning tool are the crews themselves, but other stakeholders are safety responsible individuals in shipping companies, who can use results and output from the drill learning tool to make larger scale improvements to the company's fire resource management.

4.3.4 Debriefing tool

The Debriefing tool is a protocol for debriefing, which is grounded in resilience engineering concepts and other systems safety research. The debriefing tool can be used after any training exercise, even standard drills, which are not developed by using the Training design tool.

It takes the form of a facilitated group "interview" exercise in four stages: introduction, drill description, analysis and take-home points.

The tools consist of

- Instructions for the facilitator
- A poster with important resilience capabilities and terms.
- A guide to facilitate the analysis
- Templates to record take-home points. These can be both strengths as well as vulnerabilities and can be aimed for level 1 or level 2 improvement.

The guide to facilitate the analysis will include instructions for capturing participants' descriptions of events, and questions along the following themes, for delving into more detailed resilience-oriented reflection. The themes and example questions are adapted from published research in safety science (Bentley et al., 2021; Hollnagel, 2017)

Exact phrasing will be refined through feedback from stakeholders in the human-centred development process (see Annex B). Similarly, the template will be evaluated for usability. Annex A show the first versions of the guide to facilitate analysis and the template for recording take-home points.

4.3.4.1 Main steps:

Best practices of a facilitated drill preparation and debrief can be found in LASH-FIRE deliverable D07.4 (Skogstad et al., 2022). In short, the tool will facilitate before drill/training sessions:

- that participants have the right mindset (crew feeling comfortable in exposing their work processes and thoughts, agreeing on the importance of the drill/training)
- that key personnel are capable of leading the team (de)briefing, and
- that a relevant scenario is being tested

After the drill/training the tool will ensure:

- that relevant questions will be asked,
- that strengths are considered and discussed,
- that room for improvement is discussed,
- that work as imagined (procedures, plans) versus work as done (what actually happened) is discussed,
- that all crew members are heard, and
- that relevant information that emerges will be used in future drills/training (first-level improvement) or communicated to an organizational stakeholder (second-level improvement).
- Feedback loop: Ideas for improvement

The lessons to be learned are intended to be recorded in a recognizable and simple format which supports communication and learning within, and between, organisations. These are formulated in plain language and illustrate the complexity of work. In this way they convey more information than simply identifying a problem and fixing it. However, these can also (optional) include a "diagnosis" and be connected to potential solutions. Solutions can be on the same two levels as mentioned previously:

> Level 1 improvements: Immediate, local "what can we do to improve or strengthen this" which help people become aware of their own role for safety and resilience.
> Level 2 improvements: Long-term or blunt end improvement or strengthening suggestions (this creates greater understanding of the organization and long-term safety work among sharp end and communicates "work as done" to blunt end).

4.3.5 Validation

To determine the viability of debriefing after training exercises as a tool for continuous improvement, we will test the Debriefing tool at the training facilities of SASEMAR Jovellanos. This test can also be performed in combination with the Safety assessment tool and the Scenario building tool and will provide feedback on whether team debriefings are a feasible method of improving drill learning. The development of the tool will follow an iterative approach, with feedback from stakeholders as input to further refinement of the tool. This follows a human-centred design approach, and methods used in research where similar types of tools have been developed in other domains (Bentley et al., 2021).

Validation in a training facility is a way to test whether the debriefing tool can facilitate increased learning from training exercises, to strengthen awareness of adaptivity/resilience capabilities, assess training value, and also provide a feedback mechanism to the organization.

In the validation test we will measure:

Feasibility: the degree to which the tool makes sense and is easy to use
Usefulness: the degree to which the users think it is a useful tool for the purpose. This item will be broken down into sub-topics:

- Effectiveness: to which degree the tool facilitates reflections and discussions regarding current practice
- Efficiency: to which degree it complements/makes it easier to achieve lasting change of practices as a result of the debriefing sessions
- Performance: whether and to which degree the tool is qualitatively adds value compared to the current way of using information and feedback collected in fire drills.

Data for the validation are to be collected through feedback from users, and observation from researchers.

The validation sessions will include the following questions, which also be asked in the demonstration (from Bentley et al., 2021)

- Overall, this tool would add/added value in my debriefings.
- This tool is readable as phrased and formatted.
- The questions will be/were understandable to a variety of learners.
- The phrases are clearly linked to concepts indicated in the chart.
- I would likely include this in future debriefings.

5 Demonstration

Main author of the chapter: Martin Rasmussen Skogstad, NSR

The demonstration will be conducted at the SASEMAR Jovellanos facilities, involving a set of officers responsible for managing firefighting, and a training exercise developed by use of the FRMC tools. During the demonstration, participants themselves will also get the opportunity to use tools 1 and 3.

The demonstration serves to assess the tools through a group of intended users who will enact a training exercise developed through the use of the FRMC tools. SAS will coordinate the execution of the exercises. The functionality of the design will be evaluated from a Human Centred Design perspective (NTNU), and scalability and adaptation requirements will be documented (NSR).

The details of the demonstration will be developed through a series of preparatory workshops.

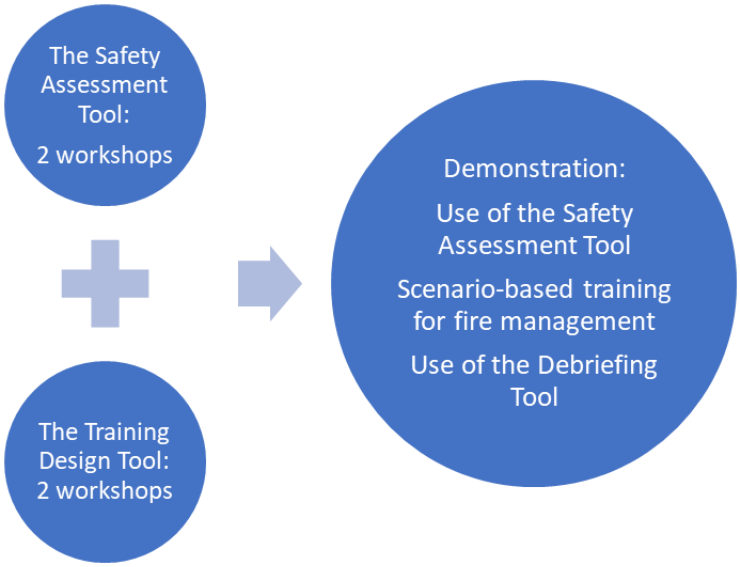

Figure 12 A series of preparatory workshops to refine the FRMC tool and determine details of the demonstration

5.1 Preparatory workshops

Details of the training scenario in the demonstration will have been determined through the application of the Safety Assessment tool and the Training design tool (tools 1 and 2), in a series of workshops. The workshops will involve practitioners that are representative of the intended future users of the tools, as well as subject matter experts and other stakeholders.

In the first and second workshop sessions, experienced practitioners are to contribute with insights about central firefighting functions. This is to be done in a systematic way, using the Safety assessment tool. During these exercises, the focus is on exploring variability and possible responses and outcomes. The aim is to refine the design of the tool, and also to identify a wide range of variability, and document this.

These insights will then be transferred to the third and fourth workshops, where participants will use the Training design tool to outline the design of a training scenario.

The training design, developed as a result of the workshops, will then lay the ground for the demonstration enacted at Jovellanos.

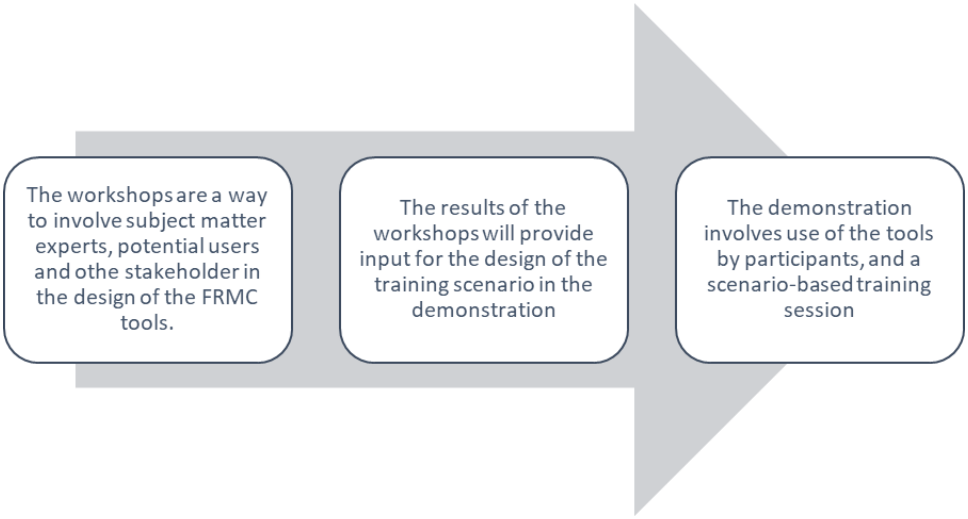

Figure 13 The path towards the demonstration

See Annex B for further details about the development process for the tools and the demonstration.

5.2 Participants

The participants in demonstration will be 5 officers from LASH FIRE partners. These officers can take turns playing the role of other crew members during the scenario-based training. They will collaborate as firefighting managers during the debriefing, where they will use the Debriefing tool.

An alternative option is to involve students from late nautical courses to play the role of fire and equipment first responders.

5.3 Facilities and apparatus

The demonstration will take place at SASEMAR Jovellanos facilities.

5.4 Procedures

The demonstration involves use of the FRMC "tools" by participants, as well as a scenario-based training session which is specially designed for officers responsible for leading firefighting.

The demonstration itself will consist of three main activities:

1. Participants will use the Safety assessment tool to investigate variability around the function that is the focus of the exercise.
2. The training exercise will be conducted.
3. The Debriefing tool will be used, to capture insights and to document and convey these learnings.

The scenario for the demonstration will be designed by using the FRMC tools, in the preparatory workshops, and finalized by Jovellanos who will determine the final details of the training scenario and how it should be run:

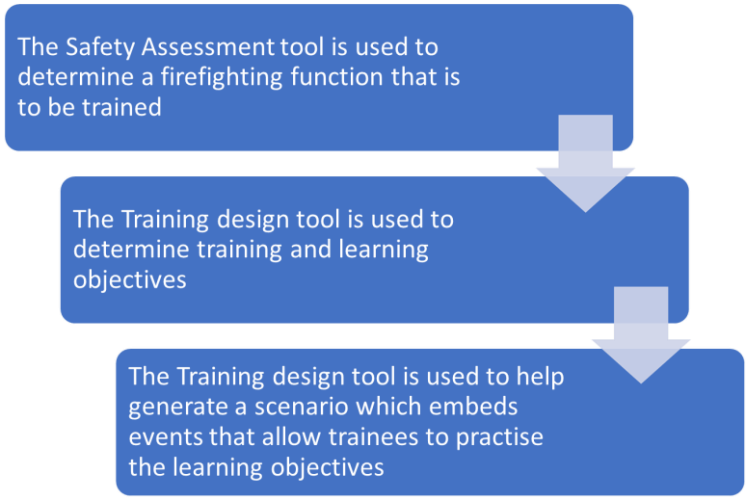

Figure 14 Outline of the activities during the demonstration

The preliminary plan is that the exercise during the demonstration will be a scenario-based training exercise. The generic way of developing scenario-based training (Salas, 2017) fits with the use of the FRMC tools. The first step is analysis, to determine which skills are to be trained. The next step is to define training and learning objectives. This forms the basis for deciding which events to include in a scenario. These events can be linked to various types of performance measures, which supports real-time assessment. In addition, participants should receive feedback, linked to the objectives of the exercise. Feedback should be both about the outcome, and about the process through which the outcome was achieved (ibid.).

The intention is not only to demonstrate the tools, but also to provide an example of training for training resilience capabilities for officers who might face the need to manage challenging fire situations. Currently, many officers rarely, if ever, have the opportunity to specifically train skills for managing unusual or highly complex events.

The scenario is intended to be a dynamic situation where there might not be one single right response and where there may be serious developments, requiring an ability to coordinate information and resources effectively coping with team dynamics, and a possibly deteriorating situation

This aim for choosing this approach is to exemplify how the FRMC tools, in addition to being used to e.g. augment routine drills, also can help design training for types of events where the time and cost for arranging a full scale drill otherwise might be a deterrent.

5.5 Analysis and evaluation

The analysis and evaluation of the demonstration will encompass the process of safety assessment, the scenario design process and the debrief process, all of which are operationalised in the actual simulation of the scenario that was developed.

The demonstration will be analysed and evaluated with respect to three aspects:

1. From the research perspective, how do the work/activities played out in the simulation meet the training objectives as identified in the safety assessment?
2. From the perspective of the participants, how is usability of the process experienced?
3. From the research perspective, what is the learning value of the FRMC toolbox approach?

Important, hence, the analysis and evaluation reflect the value of the tools as experienced both by users and designers. To facilitate high-resolution detailing of participants' experienced usability, a

standardised *System Usability Scale* (SUS) (Lewis, 2018) will be used where participants are asked to score ten items on a scale from *strongly agree* to *strongly disagree*:

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

The analysis from the three aspects will thereafter be summarized into a final evaluation of the FRMC toolbox.

6 Conclusion

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The FRMC has been operationalized as a set of tools. This report presents the FRMC tools and the plans for demonstration several of them. Some of the FRMC tools (UAV and DFC) have separate tests and demonstrations presented in other reports. All the tools presented in this report contribute to the action 7-C objectives of: “reducing the potential for human error, accelerating time sensitive tasks and providing more comprehensive and effective decision support.” The next steps are formatting and formulation the tools in a manner which makes them easy to use in a practical setting, and conducting the test and demonstration planned in January 2023.

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8 Indexes

9 ANNEXES

9.1 ANNEX A: First versions of the guide to facilitate analysis and the template for recording take-home points

The debriefing tool will include questions about the following themes:

Theme	Questions
Situation	Is there anything unusual about the situation, compared to what you might expect? What would you take for granted in this situation? What is the optimal way to perform this work? Is there an optimal way?
Successes/strengths	When did things go right? Were there any positive surprises? What strategies did you use to make things effective, efficient etc
Challenges	What was difficult but went right? How do you make it go right?
Variability	Was there anything unusual about the conditions during this particular event? Did this make you adjust your activities in any way? Can you imagine any conditions which would have changed the situation, to the better or worse? How might this affect you or others?
Adaptive behaviour	What helped you recognize the situation? What went according to plan? What did not? Did anything unexpected happen? How did you respond? Did you have to tailor your actions to the conditions, or to others actions? Why? How did you do this?
Gaps and workarounds	Did plans and procedures fit the situation, or did you have to work in some other way? Did you have all the resources that you needed? What would you do if something was missing? Were there any problematic interactions with other people, with communications technology, or any firefighting equipment?
Team focused behaviours	What team behaviours helped solve the situation? Staff turnover Handovers and coordination Heedful interrelating
Task outcomes	Did it go well? Why, or why not? What could have been avoided? What could have happened in a worst-case scenario?
Unanticipated issues, unwanted indirect outcomes	Did something unexpected happen? Could this have been anticipated somehow? How could this be handled next time?
Positive surprises	

The templates for debriefing summaries and recording take-home points will include the following themes:

Debriefing summary	
Team learnings	Regarding the team What are we good at, what is strong? What can be improved? Can we see similar shortcomings in other situations? Can we transfer these insights to other situations?
Task learnings	What are we good at, what is strong? Can we transfer these insights to other situations? What can be improved? Can we see similar shortcomings in other situations?
Gaps and vulnerabilities	Was there anything in the procedures or regarding equipment, communications, layout that can be improved? Were there any important discrepancies between procedures, design etc, and the ways in which activities need to be conducted in realistic conditions?

9.2 ANNEX B: outline of stakeholder involvement during the iterative development of the FRMC tools

Workshops 1 & 2: the Safety assessment tool	Participants	Potential users Subject matter experts Shipping company representatives
	Use of the Safety assessment tool	
	Outcome 1: a catalogue of variability and gaps	Outcome 2: validation of tool 1
Workshops 3 & 4: the Training Design Tool	Participants	Potential users Subject matter experts Shipping company representatives
	Use of the Training design tool	
	Outcome 1: design of the training exercise to be conducted at Jovellanos	Outcome 2: validation of tool 2
Demonstration at Jovellanos	Participants	Officers responsible for leading firefighting
	Use of the Safety Assessment tool	
	Participation in scenario-based training (SBT) exercise	Training objectives and scenario designed in workshops 3 and 4
	Use of the Debriefing tool	
	Outcome 1: assessment of usefulness, usability and acceptance of tools	Outcome 2: assessment of scalability and implementation challenges of tools