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LASH FIRE

Deliverable D06.5

Development of new standards for effective fire patrols and recommendations for manual screening of cargo fire hazards

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Abstract

This deliverable is an output of the LASH FIRE project, within its Work Package 6, “Effective Manual Operations”. It intends to address the question of fire patrols and manual screening of cargo fire hazards onboard ro-ro passenger ships, ro-ro cargo ships and vehicle carriers by analysing the current state within the sector and providing suggestions for the development of new standards for these operations.

For the development of the tasks that lead to this document, as well as its predecessor, deliverable D06.2 Guidelines for manual screening of cargo fire hazards and effective fire patrols, the project team used a variety of input from internal LASH FIRE documents, research, interviews, ship visits and their own expertise to establish the best possible solutions on important improvements in manual screening of cargo and fire patrols. The objective, as with the whole of LASH FIRE, is to contribute to decreasing fire risks onboard ro-ro ships, as well as endorse a continuous improvement of safety procedures and measures at sea.

In summation, the result of the work conducted within the work package Effective Manual Operations, the predecessor deliverables and input from other partners and documents have allowed the team to develop a better understanding of the difficulties these operations carry, and in what ways, even if in small increments, they can be improved.

This deliverable, along with several other outputs of this work package, work in tandem to provide a suite of risk mitigation proposals and routines, that can hopefully guarantee some increase in fire safety onboard the addressed ships.

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Content

1 Executive summary

Problem definition

This document reports the work conducted in LASH FIRE's "Effective Manual Operations" work package (WP06), action 6-A, namely in the action related to manual screening of cargo fire hazards and effective fire patrols. The issue that the action addresses is improving the current state of fire patrols and the cargo screening for fire hazards within it.

The project experiences there can be enhancements carried out to current IMO guidelines and internal procedures for ship operators when it comes to their screening and patrolling operations. Through this document we will propose ideas, solutions and methods which can benefit those procedures and, eventually, be incorporated into international guidelines.

Technical approach

The approach to this activity was to develop a method that allowed the involved partners to recognize the main issues fire patrols and the screening of cargo fire hazards. It stemmed mostly from work conducted in WP06, namely its predecessor deliverables such as D06.2 "Guidelines for manual screening of cargo fire hazards and effective fire patrols".

From the analysis of current practices, data gathering and the expertise of the consortium involved, an important understanding of what could be done to improve the efficiency of these manual operations, which are so crucial for onboard safety, was achieved, and the proposed guidelines are the reflection of the principal intention of this document: provide practical suggestions to improve the effectiveness of patrolling.

This approach was part of a broader strategy to address the activities in task 6-A which saw the partners discuss the perceived shortcomings of the sector in terms of manual methods and tactics onboard ro-ro/pax ships. The various activities undertaken were thus utilized as input to form the deliverables of which D06.5 is a part. These activities included the cooperation with ship operators in the consortium, ship visits including the collaboration with external entities where the partners were able to gather important data and visualize current best practices in real time, the collection of contributions from the advisory groups that oversee LASH FIRE, as well developed interviews to onboard and onshore staff from operators, all of which have resulted in a thorough technical enterprise from the partners involved in 6-A, and in WP06 as a whole.

Results and achievements

With the work developed in the tasks that supported this deliverable, we have managed to better understand the status of this type of operations in the context of ro-ro/ro-pax ships, to look for ways in which small, incremental improvements can potentially be beneficial in a practical sense, and propose what these improvements could be, considering the context.

The achievements of this deliverable and indeed of the different Actions of WP06 contribute partially to the bigger picture objectives of the Project (as specified below), and will serve as input to further developments and documents that will continue the work that is being done and report on the progress of the partners in this topic.

Contribution to LASH FIRE objectives

This document will contribute to the following LASH FIRE Specific Objectives:

- 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.
- Objective 4: LASH FIRE will propose new regulations and guidelines founded on common positions by drawing upon global research and experience and by facilitating international cooperation.

As well as concrete objectives of the project's work package 06 "Effective Manual Operations":

More effective fire managing operations in all stages of a ro-ro space fire through the design and evaluation of new operations, equipment, training and decision-making guidelines

Exploitation and implementation

The deliverable is intended to serve as recommendations for implementation by international ship operators, as well as regulatory and standardisation bodies. These recommendations are the product of the partners' expertise, research and work, and their dissemination aims to kickstart a process of adoption by important players in the maritime industry, specifically in the ro-ro ship sector. As such, the exploitation of these outcomes is of the utmost importance, and the project has the tools to ensure that entities concerned can pick up on these results on several different channels, such as the project web site and social media (through news articles, document sharing, videos, and other outputs), conferences where partners are present to disseminate LASH FIRE, scientific articles, through the Project's reference groups, eventually even presentations at IMO if possible.

2 List of symbols and abbreviations

AB	Able seaman
DEC	Digital enhanced cordless
EMSA	European Maritime Safety Agency
FRMC	Fire resource management centre
IMO	International Maritime Organisation
IR	Infra-red
ISM	International Safety Management
LED	Light Emitting Diode
MARPOL	The International Convention for the Prevention of Pollution from Ships
MSC	Maritime Safety Committee
OOW	Officer on watch
SOLAS	International Convention for the Safety of Life at Sea
STCW	Standards of Training, Certification, and Watchkeeping
UHF	Ultra High Frequency
VHF	Very High Frequency
WP	Work Package

3 Introduction

Main author of the chapter: Filipe Ribeiro, MAG

Deliverable D06.5 of LASH FIRE intends to develop an understanding of more efficient ways of implementing fire patrols and manual screening of cargo fire hazards within it. In order to do it, the partners will take a look at different factors that influence it, namely – and because this is done in the "Manual Operations" Work Package – the human factor.

3.1 Scope and objectives

The main objectives of the document, besides addressing the Specific Objectives mentioned in Chapter 1, are to find sources of potential improvement within fire patrols and the manual screening of cargo fire hazards in ro-ro/pax ships, in order to put forth recommendations that could see those improvements developed in efficient fashion.

3.2 Methodology and structure

The methodology employed was as follows. The team responsible for developing the deliverable worked together to identify and analyse the current state of fire patrols and define factors that influence it, which, if improved upon, could make these operations more efficient and safer.

Previous work within WP06 was analysed, and the expertise of the partners involved within WP06 and others was studied, namely by the review of reports both internal and public of the Project. A big influence was also brought by the possibility of going on board ro-ro/pax ships and understanding state of the art and the current methods put in place.

As this input was gathered, the document was structured to report on all of this information systematically and, ultimately, propose some recommendations that will improve on the current situation.

3.3 Work within Effective Manual Operations Work Package

Namely, the action proposed a methodology that allows the manual screening of cargo and the implementation of effective fire patrol procedures and routines.

3.4 Relations to other deliverables and actions of LASH FIRE

This Deliverable comes in the follow-up of work conducted, namely in Tasks 06.3 and 06.4 of LASH FIRE, and received specific input from Internal Report 06.8 "Screening of cargo fire hazards", and Deliverable 06.2 "Guidelines for manual screening of cargo fire hazards and effective fire patrols", but also some data from D06.3 "Development of and guidelines for communication of fire confirmation", IR06.6 "Development of new standard for effective fire patrol procedures" and of course other work done previously in the scope of WPR06 and other Work Packages.

4 Human factor for patrolling and manual screening of cargo space on ro-ro ships

Main author of the chapter: Reza Karimpour, MAG

4.1 Role of human element

The human element is an important factor in maritime safety. It is a complex multi-dimensional issue that affects maritime safety, security and marine environmental protection involving the entire spectrum of human activities performed by ships' crews, shore-based management, regulatory bodies and others. 80% of maritime accidents can be attributed in some way to human element failures (EMSA, 2020).

The IMO's International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) 1978 was the first internationally-agreed Convention to address the issue of minimum standards of competence for seafarers. In 1995 the STCW Convention was completely revised and updated to clarify the standards of competence required and provide effective mechanisms for enforcement of its provisions. A comprehensive review of the STCW Convention and in 2010, IMO adopted a significant number of amendments which provide enhanced standards of training for seafarers, entered into force since 2012.

Despite all successes thanks to the IMO Conventions, the maritime industry is still experiencing accidents yearly. In the last two decades, there has been a focus on tackling human errors for reducing maritime accidents in ships. Among all ships, human errors have caused catastrophic accidents in Ro-Ro ships, like the catastrophic capsizing of the passenger/car ferry Herald of Free Enterprise in March 1987 and the even more tragic loss of Estonia in September 1994.

Herald of Free Enterprise, the ship left harbour with her bow door open, and the sea immediately flooded the decks; within minutes, she was lying on her side in shallow water. The immediate cause of the capsizing was found to be negligence by the assistant boatswain, who was asleep in his cabin when he should have been closing the bow door. Fatigue can be one of the contributing factors to such a practice of the watchkeeping boatswain.

Estonia, the official report concluded that the bow door had separated from the ship, pulling the ramp ajar. The ship was already listing because of poor cargo distribution, and the list increased rapidly, flooding the decks and the cabins. The reports criticised the passive attitude of the crew, failing to notice that water was entering the vehicle deck, delaying the alarm, and providing minimal guidance from the bridge. Again, fatigue can be considered to such passive attitude of the crew /watchkeepers, failing to notice that water was entering the vehicle deck.

In response to those incidents, IMO has adopted a series of amendments to the International Convention for the Safety of Life at Sea (SOLAS), which are intended to ensure that incidents of that type would not re-occur, particularly for Ro-Ro ships.

Since the 1980s, IMO has increasingly addressed the people involved in shipping. In 1989, IMO adopted resolution A.647(16) on Guidelines on management for the safe operation of ships and pollution prevention - the forerunner of what became the International Safety Management (ISM) Code, which was made mandatory through the International Convention for the Safety of Life at Sea, 1974 (SOLAS). The ISM Code is intended to improve the safety of international shipping and reduce pollution from ships by impacting how the shipping companies manage and operate. The ISM Code establishes an

international standard for ships' safe management and operation and implements a safety management system (SMS). Application of the ISM Code should support and encourage the development of a safety culture in shipping.

4.2 Regulations and requirements for fire patrol

IMO as the international organization setting regulations for international shipping has addressed the qualifications and necessities for the watchkeepers in different conventions and codes. Below is the list summarised for the discussion in this deliverable to review the current regulations related to fire patrols/watchkeepers, followed by two challenges in the next sections 4.2, and 4.3.

ISM Code: The purpose of the ISM Code is to provide an international standard for the safe management and operation of ships and for pollution prevention. IMO has obliged in the ISM Code responsibilities for the Company that any company operating a ship sets up a Safety Management System (SMS) with identified persons in charge of the relevant duties and procedure to report incidents, prepare for and respond to emergencies. For fire-related emergency situations, the following measures and documentation, required by SOLAS II-2, are to be included in this safety management system:

- Fire patrols, as detailed in the appropriate paragraphs below
- Crew organization for fire-extinguishing

SOLAS: The SOLAS Convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships. The main objective of the SOLAS Convention is to specify minimum standards for the construction, equipment and operation of ships, compatible with their safety.

[SOLAS II-2/15.2.1.3]: Instructions for crew members regarding fire safety on-board and their duty in case of a fire emergency

[SOLAS II-2/15.2.1 & 15.2.2]: Requirements for on-board training are focused on fire-fighting (rather than fire detection). However, the training manual is explicitly to include "general instructions […] procedures for notification of a fire and use of manually operated call points" and "meanings of the ship's alarms"

[SOLAS II-2/15.2.2 & 15.2.3]: A fire safety operational booklet is required on-board each ship and includes "the necessary information and instructions for the safe operation of the ship and cargo handling operations concerning fire safety. The booklet shall include information concerning the crew's responsibilities for the general fire safety of the ship while loading and discharging cargo and while under way"

[SOLAS II-2/16.2]: Passenger ships' crews are required to be so organized "as to ensure that any initial fire alarm is immediately received by a responsible member of the crew"

Fire patrols

SOLAS requires efficient fire patrols to be organized on-board passenger ships carrying more than 36 passengers. The members of the fire patrol are to be:

- "trained to be familiar with the arrangements of the ship as well as the location and operation of any equipment he may be called upon to use."
- "provided with a two-way portable radiotelephone apparatus."

[SOLAS II-2/7.8]: Some Flag Administrations, such as Transport Canada, additionally require that the fire patrols on passenger ships need to be carried out every hour and should cover the entire ship.

[SOLAS II-2/20.4.3.1]:UK Flag Administration clarifies that "inspection of the vehicle decks [is to] be carried out immediately after loading and prior to discharge. The patrol system should be maintained when ships in service are in port. Every part of the ship accessible to the fire patrol should be visited regularly. The value of openings to holds, store and baggage rooms should not be overlooked, as fire can be detected by sight or smell."

[Transport Canada Ship Fire Safety regulations, 117(2)]: The fire patrols are to be included in the safety management system required by the ISM Code. In addition, efficient fire patrols are specifically required in any special category space (i.e., also on passenger ships carrying not more than 36 passengers).

[UK MSIS 12 Ch 10 §4.1.2]: More detailed recommendations for fire patrols in ro-ro spaces can be found in the "Interim guidelines for minimizing the incidence and consequences of fires in ro-ro spaces and special category spaces of new and existing ro-ro passenger ships" recently issued by IMO, including minimum check points during the fire patrol:

- leakages from the vehicles;
- conditions of electrical connections and ship's power supply cables to vehicles; and
- common cargo fire hazards.

[MSC.1/Circ.1615 §1.7.1]: And the recommendation that "portable thermal imaging devices be used for screening during fire rounds and upon suspicion to detect hot areas and overheated electrical equipment."

[MSC.1/Circ.1615 §1.7.2]: Discussing the role of the human element, the incorrect implementation of the procedures such as watchkeeping is often identified as a contributing factor to accidents such as fires in on ro-ro ships **(EMSA, 2018)**. In this regard, below sections reviews two important aspects/issues of watchkeeper competency and watchkeeper fatigue for cargo spaces of ro-ro ships.

4.3 Fire patrol - Fatigue issues

Despite all regulations with the core of the human element in maritime transport, some researches and analyses confirm that the human factor significantly affects the causation of marine accidents. The human element, in particular fatigue, is widely perceived as a contributing factor in marine casualties. In this respect, the IMO Assembly adopted resolution A.772(18) on Fatigue factors in manning and safety. This resolution provides a general description of fatigue and identifies the factors of ship operations contributing to fatigue that should be taken into account when making decisions on ship's operations. The Maritime Safety Committee (MSC) considered the issue of human fatigue and the direction in which IMO efforts should be focused (IMO, 2022).

Fatigue can be defined generally described as a state of feeling tired, weary, or sleepy that results from prolonged mental or physical work, extended periods of anxiety, exposure to harsh environments, or loss of sleep. The result of fatigue is impaired performance and diminished alertness. There is no one-system approach to addressing fatigue, but there are certain principles (e.g., lifestyle habits, rest, medication, workload.) that must be addressed in order to gain the knowledge and the understanding to manage this human element issue. There is no universally accepted technical definition for fatigue. However, IMO's MSC/Circ.813/MEPC/Circ.330, define fatigue as:

"A reduction in physical and/or mental capability as the result of physical, mental or emotional exertion which may impair nearly all physical abilities including strength; speed; reaction time; coordination; decision making; or balance."

Fatigue is a problem for all 24-hour a day in the marine industry. The seafarer must be recognised as a captive of the work environment. Firstly, the average seafarer spends between three to six months working and living away from home on a moving ship subject to unpredictable environmental factors (i.e., weather conditions). Secondly, while serving on board the ship, there is no clear separation between work and recreation. Thirdly, today's crew comprises seafarers from various nationalities and backgrounds who are expected to work and live together for long periods.

The operational aspects associated with shipping become more complex compared with standard industries for reasons such as: variety of ship-types, pattern and length of sea passage, port-rotation, and length of time a ship remains in port. All these aspects present a unique combination of potential causes of fatigue. According to IMO and other researchers, the most common causes of fatigue known to seafarers are lack of sleep, poor quality of rest, stress and excessive workload. There are many other contributors as well, and each will vary depending on the circumstance (i.e., operational, environmental). There are many ways to categorise the causes of fatigue.

How can you recognise fatigue in yourself and others? A seafarer may exhibit one or more changes in behaviour when experiencing fatigue. However, one very important fact to remember is that people experiencing fatigue have difficulty recognising the signs of fatigue themselves. It is difficult for a number of reasons, but largely because fatigue can affect your ability to make judgements or solve complex problems.

Symptoms of fatigue

Fatigue can cause a vast range of other physical, mental and emotional symptoms including: feeling sleepy, feeling low in energy, miss things, becoming grouchy or irritable, feeling mentally slow, lose concentration, becoming forgetful, becoming easily distracted, sore eyes, difficulty planning, etc.

Effects of fatigue

The following list describes how fatigue affects your mind, emotions and body; you may recognise some of these changes in others (with time, you may learn to identify some within yourself):

- Physically: inability to stay awake, difficulty with hand-eye coordination skills, increased frequency of dropping objects like tools or parts, non-specific physical discomfort, and headaches and giddiness, etc.
- Emotionally: increased willingness to take risks, increased intolerance and anti-social behaviour, needless worry and reduced motivation to work well, etc.
- Mentally: slow or no response to normal, abnormal or emergency situations, difficulty concentrating and thinking clearly, and decreased ability to pay attention, etc.

As highlighted in the above effects of fatigue (according to the IMO Resolution), for fire patrol in the cargo space of the ro-ro ships, the effects such as needless worry and reduced motivation to work well, slow or no response to normal, abnormal or emergencies, and difficulty concentrating /thinking clearly, are relevant and can be followed with catastrophic consequences in case of fire.

Causes of fatigue

Fatigue may be caused and/or made worse by one or a combination of things, as listed but not limited to below factors:

• *Boring and repetitive work***.** Boredom can cause fatigue. A seafarer may become bored to the point of fatigue when work is going too easy, repetitive and monotonous and/or bodily movement is restricted.

For ratings and deck officers of the Ro-Ro ships who are engaged in cargo handling and also patrolling the cargo spaces, Boring and repetitive work may be due to taking frequent repetitive rounds in the cargo space of the ship. Check points at patrols in the cargo space of ro-ro ships are very important. To avoid repeated routes that can be boring (as a cause of fatigue discussed in section 4.3) new short routes can be identified for the patrol to follow the check points.

• *Excessive work load.* Working consistently "heavy" workloads can cause fatigue. Workload is considered heavy when one works excessive hours or performs physically demanding or mentally stressful tasks.

For ratings and deck officers of the Ro-Ro ships who are engaged in cargo handling and also patrolling the cargo spaces, excessive workload may happen due to short sea shipping, frequent manoeuvring, etc).

• *Medical conditions and illnesses.* Medical conditions (i.e., heart problems) and illnesses, such as the common cold can cause or aggravate fatigue. The effect depends on the nature of the illness or medical condition and the type of work being carried out. For example, common colds slow response time and affect hand-eye coordination. There are many people, including seafarers have had Covid-19 and recovered. Back to work, however, they still suffer from fatigue as a consequence of this illness, according to the medical reports.

• *Lack of sleep, and Poor quality of sleep*. Only sleep can maintain or restore your performance level. When you do not get enough sleep, fatigue will set in and your alertness will be impaired. Fatigue may be caused by poor quality of sleep. This occurs when you are unable to sleep without interruptions and/or you are unable to fall asleep when your body tells you to. For ratings and deck officers of the Ro-Ro ships involved in cargo handling and patrolling the cargo spaces, lack of sleep and poor sleep quality may happen due to short sea shipping routes, frequent port calls in short periods, frequent manoeuvring, etc.

• *Others*

In general, the studies and marine accident reports recognise factors and causes of lack of sufficient sleep as the cause of some of the accidents, however, rarely they analyse in depth if the fatigue as a root cause of the accident has affected the human errors/mistakes on board.

4.4 Fire patrol - Competencies unclarity

Under the captain's management, the deck department is responsible for the safe navigation and operation of the ship, both at sea and in port. While the ship's safety and everyone on board is your prime responsibility, the team manages all deck operations and maintenance.

Deck officers are a vital part of the onboard management team, taking charge of an expensive ship and its equally valuable crew, guests or cargo. They will take key decisions on manoeuvring the ship and controlling its navigation, communications and security. Deck officers maintain watches on the bridge at sea and the ship in port. They are responsible for passage planning, safe ship navigation, cargo loading and discharge, ship stability, communications and maintenance of the hull and deck equipment.

Specifically for cargo handling, STCW Table A-II/1 of Chapter II (STCW 2010 Resolution 2) put in place the minimum standard of competence for officers in charge of a navigational watch on ships of 500 gross tonnages or more. It clearly states one of the competencies of the navigational officer at the operational level (junior officer) is: ”Monitor the loading, stowage, securing, care during the voyage and the unloading of cargoes”. See below in Figure 1.

Function: Cargo handling and stowage at the operational level

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Monitor the loading, stowage, securing, care during the voyage and the unloading of cargoes	*Cargo handling, stowage and securing* Knowledge of the effect of cargo, including heavy lifts, on the seaworthiness and stability of the ship Knowledge of safe handling, stowage and securing of cargoes, including dangerous, hazardous and harmful cargoes, and their effect on the safety of life and of the ship Ability to establish and maintain effective communications during loading and unloading	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training, where appropriate	Cargo operations are carried out in accordance with the cargo plan or other documents and established safety rules/regulations, equipment operating instructions and shipboard stowage limitations The handling of dangerous, hazardous and harmful cargoes complies with international regulations and recognized standards and codes of safe practice Communications are clear, understood and consistently successful

Figure 1 - Cargo handling and stowage at the operational level

However, have a look at the STCW Table A-II/5 of Chapter II (STCW 2010 Resolution 2), the required specification of minimum standards of competence of ratings as able seafarer deck for cargo handling, it shows that monitor the cargo during the voyage is not defined clearly as one of the competencies! See below table for AB seafarers. It is despite the fact that as a common practice on ro-ro ships, AB (or OS) seafarers are taking rounds in the cargo space of the Ro-Ro ships at night/dark times (20.00– 08.00) under the supervision of the navigational officer.

Function: Cargo handling and stowage at the support level

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Contribute to the handling of cargo and stores	Knowledge of procedures for safe handling, stowage and securing of cargoes and stores, including dangerous, hazardous and harmful substances and liquids Basic knowledge of and precautions to observe in connection with particular types of cargo and identification of IMDG labelling	Assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 practical training .3 examination .4 approved training ship experience .5 approved simulator training, where appropriate	Cargo and stores operations are carried out in accordance with established safety procedures and equipment operating instructions The handling of dangerous, hazardous and harmful cargoes or stores complies with established safety practices

Figure 2 - Cargo handling and stowage at the support level

Considering the navigation officers are not supposed to leave bridges during watches, it remains a question if there is any risk regarding the rating deck crew to take watches(rounds) in the cargo space (parking) of the ro-ro ships during a period of almost 12 hours.

Furthermore, according to MSC1/ Circ.1615 1.7.2 no explicit requirement for systematic cargo screening – with respect to fire safety – has been identified in the regulations, except that the vehicles entering in ro-ro special category spaces are assumed to be inspected for leakage.

5 New Standards/Suggestions for Effective Fire Patrols

Main author of the chapter: Reza Karimpour, MAG

The work conducted towards this section was, as explained, heavily influenced by activities which have also served to inform other documents, namely in deliverable D06.2 “Guidelines for manual screening of cargo fire hazards and effective fire patrols”.

5.1 Input from the development of guidelines

Before proceeding with the proposals, it is important to conclude what, in general, is being considered when mentioning identification of hazards in the context of manual screening and fire patrolling.

As is the ambition of this deliverable and of WP06 to contribute with practical suggestions, the partners worked together to establish hands-on ways of detecting the most common hazards with potential fire risks and what could be done, and in theoretically how much time, to identify them.

As laid out more in detail in deliverable D06.2, it is relevant to look for the following hazards:

The status of reefer units.	Stowaways’ activities.
Substandard electrical connections.	Presence of ignition sources (hot spot/surfaces)
Suspicious noise or smell.	Thermal runaway on Li-ion batteries of APV
Fuel leakage (solid, gas)	Self-reactions with IMDG
Portable fuel containers or added fuel tanks.	Lashing arrangements failure (specifically with bad weather forecast)
Handmade installations on RVs like Christmas trees or heaters.	Other obvious fire hazards (smoke, sparks)

We can estimate what could be done to detect them in practice, where it would be feasible to do so, and in how much time it could be done. This exercise naturally informs the suggestions presented in the next section, as they aid us in understanding what would be necessary, for example, to undertake pre-screening of cargo, or what sort of considerations should be taken to write the instructions for fire patrols. This was attempted to an extent by the partners, who undertook a few tests on a ship visit described in D06.2.

A common problem on ro-pax ships is blind spots in radio communication. It is essential that fire patrol can be in direct contact with the bridge at all times and at all locations on board. If not, time is spent moving into the radio coverage area, real-time information exchange is lost, and a feeling of uncertainty may arise.

Repeaters are in many cases installed, but some ships still show poor coverage. This may partly be overcome by using additional systems such as DEC Telephone or fixed emergency phone system with loss of positive overhearing and increased equipment complexity.

Always, but in cases of poor voice transfer especially, predictability of messages is important for instant understanding and to avoid ambiguity. Also of value is mutual knowledge of what information is important for decision making.

Language issues should be duly considered in multi-native language crews. The conversation should be kept in the mother tongue unless a multi-language crew and English must be used. Communication

should be loud and clear, and excessive talking should be avoided. Use "Simplified Technical English" as few words as possible.

5.2 Fire Communication and Confirmation

An overview of the current rules and regulations regarding fire confirmation and communication can help understand the main strengths and limitations and establish where to go. Current international applicable legislation can be summarised in the table below:

IMO Documents	SOLAS Convention, as amended
	Fire Safety Systems (FSS) Code
	International Code for Application of Fire Test Procedures
	Symbols for Fire Control Plans
	Resolution A.918(22): IMO Standard Marine Communication Phrases
	Resolution A.1021(26): Code On Alerts and Indicators, 2009
	ISM Code – International management code for the safe operation of ships and for pollution prevention
	MSC.1/Circ.1615, Interim Guidelines for minimizing the incidence and consequences of fires in ro-ro spaces and special category spaces of new and existing ro-ro passenger ships
IACS & Class Rules	IACS Blue book dated January 2019
	BV Rules for Steel Ships (NR467), as amended in July 2019

5.2.1 Fire Confirmation

The activities developed previously in the context of the Project (more detail can be found in Annex A of D06.3 Development of and guidelines for communication of fire confirmation) led to the examination of 19 investigation reports to collect information on manual localization and confirmation for both ro-ro and ro-pax fire incidents. The reports' analyses show that the sections dealing directly or indirectly with the phase between the sounding of an alarm and the identification of fire have been carefully examined. In short[1], one of the important findings is the diversity regarding not only terms to refer to the person in charge to localize and confirm the fire manually, but also concerning the different practices through which fire is localized and confirmed in the incidents studied. As stated to some extent in previous deliverables, for quick manual fire confirmation and localization, there can be some suggestions for improvements on fire confirmation.

For example, to improve safety signs and markings to support effective wayfinding and localization, marking mismatches between the ship's different fire management system interfaces can be identified. Another suggestion can be on standardization and formalization of manual fire confirmation and localization, with the description of the role for performance and practical measures to ensure clear communication between bridge and runner during the performance of the task.

As a part of Task T06.6 “Development and demonstration fire confirmation and localization”, we have remotely observed an onboard trial to raise the alarm and confirm the reality and position of fire by crew. As part of that task, it was presented the on-board trial at a Stena ship, and the process leading to it. The ongoing pandemic situation affected the trial's development and execution, making the researchers participate only through mediated technology. The trial was in practice prepared through a cooperation between Stena personnel and RISE researchers, and remotely accessed by the authors

[1] More detail can be found in Annex A of D06.3

of this report. Still, the results gave a rich data material for Action 6-B. The on-board trial provided information that can improve the manual confirmation of fire. Key actors are the officer responsible for fire management (the chief engineer) and the person sent to manually confirm. Important topics are the conditions relevant for their decision-making and situation awareness (such as their technology and procedures for operation, communication, training, familiarization, and drills). Special findings from the trial that not described in prior research are that the runner's information about the fire's detailed localization is vital for the firefighting (since technology cannot be fully trusted). Building upon both the trial and the prior defined conditions, we have suggested topics for a future standard for quick manual fire confirmation, localization and assessment. In particular, the practical measures can be grouped into three different topics: procedures for operation, including familiarization efforts, communication measures, and technology and ship design. These results will inform action 6-B's aim of developing guidelines for manual fire confirmation and localization to improve fire detention.

The analysis of the findings from the trial for identifying requirements for manual fire confirmation and localization, shows some topics come forward as important to quick manual identification of fire. These topics are particularly important for decision-making and can be categorized as overview/sensemaking, communication; procedures; and equipment and system design.

Table 1 - Important topics and insights for quick manual fire confirmation and localization from the trial and following debrief

Topic	Insights
Overview/sensemaking	The runner found the location of the fire quickly, but the cargo space was filled with smoke, so the runner could not give a precise confirmation or description of the fire or location. Runner is essential to provide information about the fire and the concrete localization. Technology is not good enough. It cannot be trusted since CCTV and sensors can fall out during fire. Runner will be also used later during the fire.
Communication	Clear communication on UHF. Communication was smoothly in the drill From debrief: Communication is a skill that really is trained for in drills like this. Communication was smoothly but it is not always as clear. Sometimes radio shadow make communication challenging and several attempts are needed to communicate the requested information. Learning how to communicate via radio is important because it is open for all. It is important that it is not a monologue, that the phrases are short and concise. This is an important aspect that needs to be trained. Sometimes difficult to hear radio communication due to captain's instructions to passengers on PA
Procedures	Going straight to the place suggested by the chief (indicated on the panel)
Equipment and system design	Chief: Information mainly from fire panel, as well as information from runner and ECR's CCTV screens.

Earlier research also indicate that the manual confirmation and identification of fire is rarely talked about on the ships – but that they completely rely on this task being carried out quickly and with vigour (Bram et al., 2019; Leroux & Mindykowski, 2017; Størkersen et al., 2020; Wikman et al., 2017).

The on-board trial went smoothly and showed the optimal manual confirmation and fire management. In addition, we know that the manual fire confirmation and localization is rarely systematized and trained for. Following, the results also contribute to the understanding that it is important to prepare and train for several scenarios where the confirmation is not going that smoothly. Furthermore, the insights confirm the importance of often overlooked sociotechnical factors that need to be in place to ensure a successful performance of the task.

Furthermore, from technical aspects, Television surveillance systems can also be effective for rapid confirmation of a fire after activation of fire alarms, as well as rapid execution of related actions after the confirmation of fire. This supports the activation of the correct deluge section, as well as manual fire-fighting.

5.2.2 Fire Communication

Alarm notifications should follow a consistent alarm presentation scheme (wording, vocabulary, colour, and position) and that alarms are immediately recognizable on the bridge and not compromised by noise or poor placing. The interface should provide alarm addressability to allow the crew to identify the alarm history, the most recent alarm, and the means to suppress alarms while ensuring the alarms with ongoing trigger conditions are still clearly visible.

To facilitate quick communication of fire confirmation and consequent first response – essential in mitigating fire hazards on Ro-ro/ro-pax ship, every ro-ro/ro-pax crew member, carrying portable radio or walkie-talkie. Elimination of radio blind-spots onboard is essential. Repeaters are in many cases installed, but some ships still show poor coverage. This may partly be overcome by using additional systems such as DEC Telephone System or fixed emergency phone system with loss of positive overhearing and increased equipment complexity.

The operator should ensure through thorough analysis that there are no blind spots for the equipment used in crew communication, particularly the one used for fire and safety communication. Radio coverage should be widespread throughout the ship, but if not 100% available, there should be a minimum coverage of 95% in all areas of the ship. Making sure communication is possible no matter the location within the ship is crucial for quick response, fire mitigation and fighting.

Always, but in cases of poor voice transfer especially, predictability of messages is essential for instant understanding and to avoid ambiguity. Also of value is mutual knowledge of what information is important for decision making.

Language is another communication issue and should be duly considered in multi-native language crews. The conversation should be kept in the mother tongue unless a multi-language crew and English must be used. Communication should be loud and clear, and excessive talking should be avoided.

Effective communication with the bridge is another important element for fire patrol. Along with language, it is also important to be quick and efficient in what is being said. Besides utilizing "Simplified Technical English" (in the case of multi-language crews) and as few words as possible, it is important to establish efficient phrases and vocabulary to establish clear and concise communication in these occurrences quickly. About Standard Marine Communication Phrases, as per IMO's resolution A.918(22)[2], some quick examples could be:

[2] https://wwwcdn.imo.org/localresources/en/OurWork/Safety/Documents/A.918(22).pdf

Reporting fire

- *"Fire on board!*
  - *Smoke / fumes / fire / explosion*
    - *~ in the engine room.*
    - *~ in no. ... hold(s) / tank(s).*
    - *~ in superstructure/accommodation.*
    - *~ in ... space.*
    - *~ on deck / ... .*
  - *Smoke / fumes from ventilator(s).*
  - *Burnt smell / fumes in .../ from... ".*
- *"Report injured persons/casualties:*
  - *No person injured.*
  - *Number of injured persons/casualties is... ".*
- *"What is on fire?*
  - *Fuel / cargo / car(s) /truck(s) /waggon(s) / containers (with dangerous goods) / ... on fire.*
  - *No information (yet) ".*

More standard communication phrases can be suggested as below.

- *"Deck 3 Port side, drencher zone 24, Fire in reefer confirmed"*
- *"Fire patrol, report status"*
- *"Vehicle on fire identity WGS 133, open flames from left side mid trailer"*
- *"Fire party 2 entering dk 2 starboard side"*
- *"Weather deck aft, starboard side, dense smoke confirmed"*
- *"Activate drencher zone 14 dk 4, repeat activate drencher zone 14 dk 4"*
- *"Can you use carbon dioxide once again?"*
- *"Can you show me exactly where the fire is?"*
- *"Please give me exact information about the cargo in this hold."*

Important points about fire confirmation and communication were also collected from interviews of/responses from ship operators during the Project works with operators/crew members on board. Below is a list of these pertinent points of information gathered from the inquiries.

- Walkie-talkies work well (no blind spots if the signal is increased)
- Communication of the crew during debriefing is crucial
- Reality is different from formal requirements
- Language is not enough; trust, for instance, is paramount
- New technology can be helpful – good camera and radio coverage
- Everyone should have access to the available radio channel used for emergencies
- Having multiple codes to make sure there is no panic
- An internal telephone system also may be helpful
- PPE is getting better (e.g., radio integrated into helmets), but can be improved
- Coordination between bridge and teams is essential
- Informal information is also helpful (e.g., if a person is more reliable or not)
- Regularity of crews is also beneficial – it helps with a more relaxed and cold-header approach in emergencies

Interviews conducted in the scope of WP6

Contact person in shipping company

Communication between chief officer and the AB seaman by means of walkie-talkie*: "I am entering the deck, I am checking this and that, there is not fire…" When there is an actual fire, they do not go very far because they can smell the smoke or feel the heat, which is a clear indication of fire. But you still want to know the exact location of the fire but at the same time you don't want to put lives on risk. They do not have special equipment.* She portrays communication as unproblematic – walkie-talkies work also well (not blind sports due to extra boosts to increase signal).

She argues that people spend too long time working in the same ship and that can be problematic cause you don't learn from others. At the same time, some affordances. Communication can be better with people you know well. They do not have to say each other what to do, commands will be less because they know what to do and each other very well. Feeling. It can be difficult for someone new to understand what is going on. She has not observed that but she can imagine that.

First officer

Communication: reality is different does not always match formal requirements. To have a good communication language is not enough. Trust is for instance important.

Use English in fire situation*. No problem with language in case of fire. Automatically if you don't speak English, you can´t be employed. In reality, some crew members cannot speak English at a decent level. Yes, I have experienced a watchman which did not speak English good enough, so we had to change him. Also, problem with English speakers who did not the safety rounds properly. It is not easy to find the right watchman.*

5.3 Equipment/Technical Aspects

The importance of the human element in firefighting is undeniable, but it is perhaps worth understanding how it can be circumvented with new modern equipment. Some important points about personal equipment for fire patrol in cargo space that were collected from interviews of/responses from ship operators during the project works with operators/crew members:

- Walkie-talkies work well (no blind spots if the signal is increased)
- An internal telephone system also may be helpful
- PPE is getting better (e.g., radio integrated into helmets), but can be improved

Furthermore, in this regard there should be a focus on new and promising equipment, look towards cases in maritime industry but also other sectors. It can be helpful if to specify some experiences and practices from land-based firefighters.

5.4 Drills and training

Appropriate training and drills are vital for ro-ro ships. Relevant crew members should be trained on fire-fighting strategies and risks associated with alternatively powered vehicles such as battery or gas driven vehicles. These crew should receive adequate training and participate in drills in order to be familiar with the specific arrangements of the ship, as well as the location, operation, and limitations of the fire-fighting systems and appliances that they may be called upon for use in ro-ro spaces and special category spaces.

An important point found through marine accident investigations for the fire in cargo space of Ro-Ro ships, is that crew in charge of cargo handling and also watchkeeping(patrolling) in cargo space are not fully familiar with different classification(sources) of fires in these areas. Familiarisation with Classification of Fires according to vehicles fire (new types of drives for vehicles (hybrid, ethanol, fully electric, and related fires) are crucial nowadays. See Figure 3.

Classification of Fire
Fire in vehicle cab
Electrical fire on vehicle
Electrical fire on reefer
Fire on reefer (other cause)
Vehicle engine fire
Other cause

Figure 3 - Types of fire that can be trained during fire drills

A proposal for implementing periodic training specifically to intensify the importance given to safety operations such as fire patrolling, and provide crewmembers with a higher level of expertise in these activities. Dividing into theoretical and practical aspects of training, this would be done as such:

Theoretical

- Contextualization within current legislation
- Study of main fire hazards in cargo in the context of ro-ro and ro-pax ships
- Lessons learnt from previous occurrences/accidents
- Understanding of conditions and requirements for manual screening of cargo during fire patrols
- Study of equipment to be utilized in the context of manual screening of cargo during fire patrols
- Trained on the route to be followed during patrolling, should be familiar with the whole ship´s layout and the different locations to be inspected. The fire patrol route should be completed without hesitation before commencing a patrol. They must know how to unlock doors and be familiar with loading plans and high-risks units. They must be trained on reaching different decks from different entrances (those different from the standard fire patrol route)
- Awareness to the fact that there is a higher risk of fire incident within the first 1.5 h after departure

Practical

- Training to detect fires in their initial stage and training to provide the first response
- Familiarization with risks associated with APVs; Ability to switch off the main power in case of an emergency
- Training on the use of first firefighting equipment (handheld extinguishers)
- Training to trigger the drencher system
- Training on the use of equipment
- Reading patrol sheet/app for identification of main potential hazards in a practice patrol
- Reading/using patrol sheet/app for identifying locations of main potential hazards in a practice patrol

- Using patrol sheet/app to report on deviations in the status of potentially hazardous cargo in a practice patrol – special focus should be granted to well-known high-risk cases

These routines should not take more than 10% of the allocated time for the Fire Safety Module within the context of Safety Training of a given staff member. At the end of the training, the crew/staff member must correctly identify cargo fire hazards, register and patrol that cargo's specific locations, and update its status within the context of a fire patrol.

5.4.1 Drills promotion

Fire drill is one such drill which holds great importance on ships. It helps the ship's crew to understand the basics of fire prevention and also help prepare the crew in dealing with an emergency situation that may arise because of a fire on board ship. Well-planned drills should exercise important points not usually discussed/conducted in drills (e.g., some confusion amongst a ship's crew on what is the very first action in case of a fire in cargo space).

To ensure developed recommendations are implementable in practice, the partners worked together in an exercise of establishing hands-on ways of detecting the most common hazards with potential fire risks that could be explained, discussed, and be paid attention to in the drills and trainings. The list of collected information on the identified common hazards with potential fire risks is already presented in section 5.1. As explained in D06.2, the partners suggested a guideline for periodic training in fire patrolling.

We take a look now at what is understood by remote ethnography. A major collaboration between the LASH FIRE shipping companies and the researchers in WP6 and WP7, have resulted in empirical data for WP06 and WP07, including the trial to raise the alarm. The methodological approach could be called remote ethnography (Postill 2016), since the researchers stay at home while the crews video record the activities to be studied. In this case, the researchers developed the general approach, while the crews refined it. RISE researchers gave the crews instructions of procedures and technology, while the Stena personnel adapted it to their activities. Stena's contact person and the crew at Stena Jutlandica organized video recordings of a line of activities, including a fire drill. The fire drill constitutes the trial documented this report.

The trial was performed as a common fire drill onboard Stena Jutlandica, with some extra efforts. The Stena personnel well prepared the scenario. A ship company contact followed the bridge personnel closely. Three bridge officers and the company contact had a chest camera that recorded the drill from their perspective. One earlier explored option was that the researchers could participate in the drill through a video meeting at the company contact's phone, and thus be able to ask questions through him, but this proved difficult. However, the four cameras gave a good overview, and was made securely available to the involved researchers before the debrief interview with the chief engineers.

At the debrief interview, the chiefs described that they and the crew had positive experiences with the remote ethnography and preferred this over being subjects to traditional empirical data gathering. Instead of being observed by a group of researchers, they had to wear cameras. The cameras were easier to forget than researchers would have been. In addition, they reckoned that they would be able to watch the videos themselves and use this material to learn and improve their drills. Even if they said it was a relief not having researchers "on their shoulders", they emphasized the importance of carrying out these drills to be more aware of their actions.

As a result, the remote ethnography's empirical (video) material is different, but maybe as rich, as traditionally gathered qualitative data. Action 6-B implied another type of data gathering process with fewer trials and scenarios than planned, since the planification had to be slightly altered after the COVID-19 pandemic affected the implementation of the project. Still, the trial provided knowledge about identify requirements for manual fire confirmation and localization to improve fire detention. Thus, the method was appropriate to achieve the study aims.

Execution of trial to identify requirements for fire confirmation and localization

	Activity	Actors
Preparations, early May 2021	**Development of method**	**Researchers and company contact**
	Instructions of method and equipment	**RISE researchers**
	Handover of video equipment to crew	**RISE researchers and company contact**
	Development of trial	**Company contact, chief engineer and officers**
	Crew introduction	**Company contact, chief engineer, crew**
Preparations May 15 2021	**Camera on chest**	**Bridge officers, company contact**
	No camera	**WAB (runner)**
Trial, May 15	**Fire alarm, bridge**	
	Check panel	**OOW/bridge personnel, chief engineer**
	Call runner on UHF	**OOW**
	Locate fire	**WAB**
	Confirming of fire	**WAB and OOW**
	Activate fire extinguishing systems and firefighting team	**Chief engineer**
Interview, June 11	**Extended debrief, semi-structured research interview**	**Chief engineer, technical officer** **RISE researchers**

Table 2: Steps of the trial

6 Recommendations for Manual Screening of Cargo Fire Hazards

Main author of the chapter: Reza Karimpour, MAG

6.1 Work conducted on the Screening of cargo fire hazards

Something already mentioned in this Deliverable and which is one of the main outputs of the work internally reported in Work Package 06 is equipment. Taking that into account, we can thus see this factor in the following way.

The screening of hazards can be performed under two main situations:

1. During the fire patrol round
2. During the loading/unloading process

The equipment should be light and easy to carry, leaving hands free to operator to act as first responder if needed. The end equipment for screening should match with the equipment for patrolling:

- **Fire patrol clothing** should match with first response clothing as fire patrol member have high chances of act as first responder when discovering a plausible fire. Fire patrol member should wear long sleeve jacket or shirt in combination with long trousers of flame-resistant clothing. Flame resistant clothing is designed and specifically manufactured to protect from potential flames and heat radiation exposure. Fabrics like nylon and polyester that burn slowly but melt in contact with flames should be avoided. Recommended clothing should be made of a blend of several different synthetic materials and cotton. Clothing should be clean without fuel or oil and dry. Clothing should contain reflective straps (at least around the ankles or arms) for high visibility and safety.

- **Check point reader** that can check the label of the location without direct contact with the metal pin-tag reducing the time of the whole fire patrol. The easier and quicker the equipment, the better.

- **Safety torch** (preferably EX-type) with enough LED intensity to detect leaks or smoke under low visibility condition spaces. A flashlight is useful during night patrolling, specially to inspect exposed areas, like weather decks.

- **IR light Handheld camera** can be hung around the neck for hot spot detection. Desired Specs: Dimensions (like a smart-phone, light around 250g, temperature range from bellow cero up to 150ºC). The purpose of IR camera is not the constant screening of cargo. The IR camera should be use when the fire patrol member may suspect the presence of an ignition source like a suspicious noise or smell, smoke or sparks. The use of thermal imaging devices is recommended through the Interim guideline MSC.1 Circ 1615

- **Press to talk bottoms (PTT)** for the portable VHF/UHF radios that allow to keep both hands free to communicate the presence and position of a fire. Keeping both hands for additional actions is prior important. Identifying blind spots during radio communication must be part of the duties of the fire patrol as well as know alternatives means of communication by internal telephones or manually call points buttons.

New proposed equipment will use a booking system as one source and storage place for hazard information. Presentation of information to OOW, safety Centre. Hazard cargo information would be

useful to create a system that automatically identifies any special requirements to the cargo surrounding the fire and bringing up recommendations for the OOW of the next steps of how to handle situation

6.2 Input from the development of guidelines

As we have mentioned the work behind deliverable D06.2 ”Guidelines for manual screening of cargo fire hazards and effective fire patrols” was very important in the build-up to this document and to contextualise the recommendations here presented. In order not to fall into repetition, we share a section of work considered important in this context,

In the case of the screening of cargo for fire hazards, the work and research done, interviews conducted and visits carried out let us conclude a few different relevant conclusions. No detailed and/or specific IMO legislation established for this activity, so despite it being mentioned in SOLAS, there is room for consolidating the practices and guidelines followed by different operators.

In many cases, loading staff must concentrate on loading; during loading, their screening will only notice obvious hazards. Another case is the possibility that the loading process can be carried out by loading two vehicles simultaneously, so the screening becomes even more challenging. Risk identification is about the most obvious issues: fuel leaks, sparks (electrical failures), suspicious noises or even smoke/real fires, but with the technological developments in reefer units, the rise of APV cargo-type and other, constantly changing types of rolling cargo, there is a need to identify new challenges and hazards.

It is important to realize that it is one of the most time-critical tasks within the operation of these ships, which is why any new routine added to the process must aim to be the most efficient possible, consuming the least amount of time with the best possible results.

On the other hand, when talking about the case of fire patrolling, some pertinent points to consider were also agreed. SOLAS has some specific requirements for fire patrolling on board, but not as detailed as necessary. Nevertheless, several international recommendations or guidelines suggest some specific detailed such as IMO’s Circular 1615[3] which suggests that *“portable thermal imaging devices be used for screening during fire rounds and upon suspicion to detect hot areas and overheated electrical equipment.”*. Most inquired crew members reported their only equipment utilized were radios, and the majority suggested using better equipment like infra-red (IR) cameras.

From those inquiries also came the emphasis on the lack of autonomy given to patrolling crew members to act upon emergency systems, such as the fact that most patrolling staff are not able to deploy the emergency system straight away or at all, and as we have described already, quick response is crucial, so this hinders that response; the fact that a big part does not receive written detailed instructions on how to perform the patrol, what kind of hazards to look for, and first response were also important points. It is important to note that despite being information given by inquiries and corresponding to real scenarios that must surely be mitigated, this is not something common in all parts of the world fleet, and thus not a broad overarching situation. It can also come as a result of the fact that patrolling personnel are neither familiar with their duties (under the job description manual of Safety Management System) nor trained with onboard drills that simulate a real case of fire hazard

[3] http://shippingregs.org/Portals/2/SecuredDoc/Circulars/MSC.1-Circ.1615%20-%20Interim%20Guidelines%20For%20Minimizing%20The%20Incidence%20And%20Consequences%20OfFires%20In%20Ro-Ro%20Spaces%20A...%20(Secretariat).pdf?ver=2019-07-25-104758-230

in cargo spaces. The typical fire patrol frequency is between every 45 to 60 minutes (typical fire patrol can be different from ship to ship (depends on size of ship, number of personnel onboard, capacity of cargo, etc…), according to on the safety management system (SMS) of the ship (under ISM Code) developed by the shipping company for that specific ship.); or once during trips with shorter durations, and we know these can include more than two-dozen locations to be controlled. Furthermore, first response is paramount for the success in preventing and fighting any instances.

Coincidentally, during the development of the task in which this Deliverable was done, there was an occurrence onboard a ship from one of the partners: the fire of electrical origin inside a vehicle (not-APV) that was being transported was spotted quickly and the crew managed to act by smashing a window and releasing three fire extinguishers.

6.3 General Recommendations

As understood by the work done in the Project, conditions that can be improved in order to give quick fire confirmation. The trial mentioned in section 5.2.1 has shown that the activity of confirmation is not treated specifically or as a separate activity in the preparations for and descriptions of the drill scenario. One can say that the activity of confirmation is oversimplified or underspecified since it is not seen as complex, although a quick confirmation relies on procedures, experience, communication, common sense and improvisation. It is not in focus, but rather black-boxed and in the background. Yet, we observe that this is an essential activity in the drill, yet only (indirectly) discussed in the debrief after being asked by the researchers about it. The lack of focus on this task is not a problem if operations, drills or real confirmation of fire go according to plans, but since earlier accidents show many problems and vulnerabilities with the confirmation, some measures are needed. Measures can be grouped into three sociotechnical factors: procedures for operation including familiarization efforts, communication measures, and technology and ship design.

Therefore, drawing on the data from the trials as well as our previous study of the conditions for quick manual fire confirmation and localization, we envision the following areas/requirements to be included in guidelines for manual confirmation and identification of fire:

- Company resources such as procedures should sufficiently address this activity and role, including training and practical measures to ensure familiarity
    - Use experienced personnel in positions potentially leading to running (AB watch)
        - change familiarization procedures to make officers need to know both how it looks on the ship and on the panels.
    - More drill scenarios, about running, communication, for the entire crew. Scenarios should include subevents where challenges regarding manual fire confirmation and localization are trained, and improvisation skills practiced. Furthermore, the crew will get familiarized as well with typical signs of an incident, typical personal safety risks and default actions depending on situation.
    - Include discussion of the task in drill debriefs and HSE meetings.

- A good communication is a critical aspect in the performance of the task. Therefore, practical measures to ensure a clear communication between bridge and runner must be deployed.
    - Standard language and terminology in ships with crew members from different nationalities (for instance the uptake and use of IMO Standard Communication Phrases)
    - Identification of blind spots and radio shadows in the ship

    - Alternative solutions for satisfactory communication
    - Use of communication equipment with coverage
- Technology and ship design also provide important conditions to improve wayfinding /situation awareness and decision-making and thus rapid confirmation:
    - Understandable information about drencher zones and decks, and correspondence with the fire alarm panel (FRMC with layers giving right framing/markings?)
    - Clear markings
    - Right equipment for the runner (such as portable radio, IR camera, safety torch and long sleeves working clothes)
    - Ventilation and cargo placement contributing to overview.

Building upon both the trial and the prior defined conditions, for a future standard for quick manual fire confirmation, localization and assessment. In particular, the practical measures can be grouped into three topics: operation procedures including familiarization efforts, communication measures, and technology and ship design. These results will inform action 6-B's aim of developing guidelines for manual fire confirmation and localization to improve fire detention.

One more point is about the check points in cargo space. Check points at patrols in cargo space of Ro-Ro ships are very important. To avoid frequent repeated routes that can be boring (as a cause of fatigue discussed in section 4.3) new short routes can be identified for the patrol to follow the check points. During patrols by crew in ro-ro spaces and special category spaces, the following should be checked, for example, but not limited to:

- leakages from the vehicles;
- conditions of electrical connections and ship's power supply cables to vehicles; and
- common cargo fire hazards.

6.4 Equipment/Technical Aspects

On the other hand, when talking about the case of fire patrolling, some pertinent points to consider were also agreed. SOLAS has some specific requirements for fire patrolling on board, but not as detailed as necessary. Nevertheless, several international recommendations or guidelines suggest some specific detailed such as IMO's Circular 1615[4] which suggests that *"portable thermal imaging devices be used for screening during fire rounds and upon suspicion to detect hot areas and overheated electrical equipment."*. Most inquired crew members reported their only equipment utilized were radios, and the majority suggested using better equipment like infra-red (IR) cameras.

It is recommended that portable thermal imaging devices be used for screening during fire rounds and upon suspicion to detect hot areas and overheated electrical equipment.

To understand better the need of equipment for the fire patrol, some relevant interviews were selected from the work done within WP6. Below summarise the points highlighted for the need of personal equipment for manual screening of the cargo space of the RoRo ships.

[4] http://shippingregs.org/Portals/2/SecuredDoc/Circulars/MSC.1-Circ.1615%20-%20Interim%20Guidelines%20For%20Minimizing%20The%20Incidence%20And%20Consequences%20OfFires%20In%20Ro-Ro%20Spaces%20A...%20(Secretariat).pdf?ver=2019-07-25-104758-230

Interview 3 Officer and AB

We instruct people that when they know a fire, they should give all information regarding how big, have they closed the doors, all these things they should give to the bridge. So, we can respond. Recently, or not recently, we have handheld heat cameras. One is big, and the other is infrared mobile phone size, so the watchman can switch on the smoke and better understand the fire, and identify the area under the truck. Communicating to the bridge through telling the radio … would be amazing to get the picture on the bridge. Tricky with communication, also radio, on the lower decks. But who knows, with 5 G. Wifi spots would work.

Interview 7 - Officer

New technology can help a lot, good camara coverage and radio coverage. Everybody can listen to the radio channel, an advantage, cause someone else can check quicker if they are in the location (flexibility)

Interview 8 -AB nightshift

Things that have improved recently : a common radio channel where everybody receive the information. This improves coordination and reduce time. *Everyone on the same radio channel. We know where to go.*

Interview 12 – RISE researcher

A talk with a researcher from RISE about a boat visit for other project studying equipment and evacuation. She observed the weekly fire drill during the visit**.** What kind of technology were they using to communicate with the runner? Radio. Was there any problem (such as for example blind spots)? No, they said that radio is usually working really well. They have a separate channel for fire, and another one for evacuation. Regarding equipment: do they have what they need? Wishes? Satisfied with the way radio is integrated in their masks, and the way you have to press the bottom on the front, easy to press with globes. The want to be able to attach the flashlight

Effective television surveillance systems should be provided in ro-ro and special category spaces for continuous video monitoring of these spaces and be provided with immediate playback capability to allow for quick identification of fire location, as far as practicable. Continuous monitoring of the video image by the crew needs not be ensured. For closed vehicle, ro-ro spaces, and special category spaces where fixed pressure water-spraying systems are fitted, they should be provided with suitable signage and marking on deck and vertical boundaries to easily identify the sections of the fixed fire-extinguishing system. Signage and markings should be adapted to typical patterns of crew movement and should not be obstructed by fixed installations. Section number signs should be of photoluminescent material complying with ISO 15370. The section numbering indicated inside the space should be the same as the section valve identification and section identification at the safety centre or continuously manned control station.

Guideline for assisting equipment in fire patrolling

Fire patrol members need to be as agile as possible when screening for and identifying potential fire hazards. This is due to the importance that a quick response has on preventing and fighting fire occurrences. Patrolling crew shall then be supplied with assisting equipment that facilitates hands-free utilization,

Some examples are:

- → Check point reader that can check the label of the location without direct contact with the metal pin-tag reducing the time of the whole fire patrol
- → Technology for localization of first responders through digital information processed via network (e.g., smartphones, with Nearest Neighbour Network software: app will send messages (text, audio, video or images) to the crew around the activated fire detector with important safety information); this type of solution can be used instead of check point reader.
- → Light (around 60gr) and robust safety torch that can be magnetically attached to the helmet with enough LED intensity (around 100 lumens) to detect leaks or smoke under low visibility conditions.
- → IR light handheld neck-cord can be hung around the neck for detection of hot spots. Desired Specs: Dimensions (like a smart-phone, light around 250g, temperature range from below zero up to 150ºC). IR handhelds and other thermal imaging instruments render infrared radiation as visible light, permitting to see such areas through low-lit spaces, smoke, and other barriers. They give the quick and efficient possibility of detecting differences in temperatures in a screening or patrol which can sometimes help in the early detection of potential fire hazards.
- → Press to talk buttons (PTT) for the portable VHF/UHF radios that keep both hands free.

Figure 4 - Some equipment examples (check-point reader, light, IR handheld, PTT)

7 Development of new standard

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The work described so far has helped us understand, on the one hand, the activities developed in Action 6-A of LASH FIRE, and on the other hand, the main ideas of the partners regarding what they deem as pertinent, lacking, or otherwise important to keep in mind when developing a new standard for these types of operations.

Thus, as a consolidation of the work conducted, there are a few outputs to keep in mind as main highlights:

- Manual screening of cargo can be incremented yet needs to be done within the context of current loading and/or patrolling operations so there's no loss of efficiency.
- Fire patrols are crucial, but could have smaller routes to focus on high-risk areas;
- The "human element" is often overlooked, fatigue and focus are heavy influences on the capacity for AB to perform, no matter what the standard dictates;
- Simple, practical instruments can and should be utilized to leverage the manual operation;
- Homogenization of communication on board is crucial for time efficiency.

These outputs are highlighted as a result of the combination of them being important to increase fire safety onboard, but also due to the partners proposing that they will not take away from the efficiency and optimization of manual operations in ro-ro ships.

In more detail, and as we have described in this deliverable and others from WP06, manual screening of cargo can be incremented without adding extra workload to the fire patrol members. Also, experience says that the most conflict origin of fires is in the electric reefer connections, so the status of reefer connection should be a priority while patrolling/screening of cargo.

Fire patrol routes are sometimes too long with too many key locations to be inspected. We have seen in ships visits that too many areas (more than 35) should be inspected like ballast systems, lockers, accommodation block, etc. To avoid fatigue and repetitive task, small routes focusing on cargo spaces can be interleaved; long route/short route. Frequency between routes should be 1.5h max.

In order to increase seafarers' efficiency and wellbeing (which will increase the quality of manual operations), specifying that rest periods must be respected on board to maintain full situation awareness and good performance.

In terms of equipment, the partners would focus specifically on: two-way apparatus radio with full coverage, hand held IR camera, safety torch and check point reader.

Finally, reiterating the importance of the IMO's Standard Marine Communication Phrases[5] is paramount in order to have proper, efficient communication between members of the crew to ensure safety (something further explored in other actions of WP06).

So, as for the development of a new standard that can potentially be taken into the industry via regulatory proposals, from the work developed in WP06 we can already understand that these points would certainly have to be taken into account. The routines presented in D06.2 are actually in line with some of these points already, namely the necessity of intensifying screening of cargo, and the

[5] IMO, *Resolution A.918(22) – STANDARD MARINE COMMUNICATION PHRASES*, 2001, https://wwwcdn.imo.org/localresources/en/OurWork/Safety/Documents/A.918(22).pdf

incorporation of specific training to ensure minimization of errors and efficiency losses due to factors such as fatigue.

To sum up, any new standard for efficient fire patrols that intends to normalize these operations will not need to be a revolution in the current state of the art, but instead will have to optimize certain aspects of the human participation cargo screening, at the same time as maintain time efficiency of the work done onboard.

8 Conclusion

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The objectives of Deliverable 06.5 were to consolidate work done in Action 6-A and establish a thorough analysis of potential improvements that can render fire patrols and manual screening of cargo fire hazards onboard ro-ro/pax ships more efficient and safer.

In short, we can summarize the work of WP06 as "the importance of humans in fire safety onboard ro-ro ships". This falls in line, among others, with IMO's "Strategic Direct 6: Address the human element" of their Strategic Plan[6]. This is to say, the focus of the partners has been to understand what are some of the deficiencies and what can potentially be improved in terms of manual operations onboard ro-ro ships. From manual screening of fire hazards and fire patrolling, factors that influence the efficiency of these activities such as routines, training, fatigue, and equipment, the work conducted has been implemented with WP06's main goal in mind: more effective fire managing operations in all stages of a ro-ro space fire through the design and evaluation of new operations, equipment, training and decision-making guidelines.

This, of course, has been done in tandem with other Actions of WP06, as well as other tasks in the scope of parallel Work Packages, and despite the difficulties brought about by the COVID-19 pandemic, we have achieved what we set out to at the beginning of the project, in terms of analysis of *status quo*, understanding of the necessities and shortcomings of the sector, and proposals on the most efficient ways in which new routines and standards can be implemented onboard ro-ro ships.

[6] IMO, *Resolution A.1149(32) - REVISED STRATEGIC PLAN FOR THE ORGANIZATION FOR THE SIX-YEAR PERIOD 2018 TO 2023*; December 2021

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