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Deliverable D06.7

**Evaluation and development of tactics, gear,
equipment, and guidelines for effective first response**

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Abstract

The term “First response” is not fully covered by IMO regulations or shipping operators’ procedures. It is assumed that according to STCW standards any crew member may act as first responder in the meaning of taking initial actions when discover an incipient fire. However, an effective first response action requires suitable gear, training and preparation.

Due to their onboard daily duties, some crew members are more likely to discover a fire and therefore act as first responders. D06.7 is referring to them as “designated first responders”. Designated first responders are crew who has access to restricted areas where the high-risk cargo is stored and where a fire is more likely to occur. According to statistics a fire is more likely to occur in the cargo spaces where reefer units and vehicles are parked.

These members should follow specific instructions and training as the first response will not be an isolated action. In the fire chain of events, all actions are connected from detection to confirmation and localization, continuing with first response, activation of fixed firefighting systems and manual firefighting. Crew members that will take part actively in this process should be aware and mentally prepared to act in case of emergency.

The aim of the current Deliverable is to define the conditions of an effective first response and the tactics, gear, and equipment to facilitate the work of end users in a stressful situation. D06.7 has developed a training module for first responders acting as part of a fire team in presence of Alternative Powered Vehicles. As the line between first response and manual firefighting can be very thin, the training module has covered both aspects.



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1 Executive summary

Problem definition

A first response to firefighting is a concept directly linked to the early detection. If the conditions allow to do so, a quick and safe firefighting action should be provided. However, the concept and role of first response is not widely established and not often included in the ship operators' procedures. Despite, it is a fact that early detection, early confirmation and efficient first response are key factors to avoid fire escalation. When looking into some major marine fire events, there are different causes for a first response failure:

- Late detection. Fire too large and developed to be extinguished with a first response equipment.
- No training/preparedness for first response due to lack of confidence, inability to act as first responder.
- Time slot available after detection but no firefighting suitable method at hand.
- Cargo spacing is too tight. Accessibility problems or that it is not possible to reach the base of the fire with the handheld portable firefighting media (most likely dry chemical powder)

Besides, the line, between *first response* and *manual firefighting* is not clearly defined in neither procedures nor practice. Introducing clear definitions would be of great contribution but must be made with care not to cause confusion. To add to the complexity, it may well be that the same person, during the incident timeline, move from acting as fire patrol/runner to acting as first responder and to preparing for manual firefighting.

The "first responder" concept is not incorporated in maritime regulations. In this deliverable, a distinction is made between "*first responder*" referring to any crew member on board that can discover a fire and take initial actions (the term is not applicable to passengers in ro-pax vessels) and "*designated first responders*" meaning those crew members that due to their routine tasks have more chances to discover a fire and act as "*designated first responders*". These personnel are fire patrol members, able seamen, ordinary seamen and engine control room staff who have access to locked locations where a fire is most likely to occur like restricted cargo spaces. They will receive specific instructions to act as designated first responders, will be trained and familiar with the procedure and equipment needed.

Depending on the ambition level (general or designated) for a first responder, the location of fire stations, and in particular, good access to lighter extinguishment equipment could also be relevant. Regardless the ambition level of the first responder (general or designated) a rapid and good access to the "at-hand" fire equipment, in particular to portable fire extinguishers, is necessary.

D06.7 aims to:

- Establish the first response concept (both for all crew members as well as to the designated first responders).
- Set the immediate actions to be taken when discovering a fire.
- Extend and educate on the use of common handheld fire extinguishers that can be much more effective beyond the general assumption of crew members.

- Propose smart solutions to determine the position of the first responders, facilitating the decision-making process from the bridge in a fire situation.
- Connect the first response and the early detection, enhancing the possibility for safe and efficient first response.

Technical approach

Information about first response onboard ro-ro ships was gathered in earlier LASH FIRE work from regulation bodies (WP04) and on-board requirements definition (WP05).

Besides, several ship visits were carried out on board several ro-pax vessels (“Stena Flavia”- February 2020, “Napoles” - March 2020, “Bahama Mama”- July 2021 and “Abel Matutes”- May 2022) to evaluate the current tactics, gear and equipment for a first response.

This Deliverable has also received input from LASH FIRE Deliverable D06.4 “Background and testing of smart alert system of nearby responders” adding a technical solution for the localization of first responders for the contribution of a quicker fire management on board.

Fire tests, reported in Deliverable D06.8, provided knowledge related to tactics for using hand held extinguishers on electric vehicle fires, showing that if used correctly, they can be effective during the first stage of the fire independently from the extinguishing media selected (dry chemical powder, CO2 or foam)

After testing in October 2022, a fire hands-on training module was developed with 16 crew members at SAS facilities in March 2023. The efficacy of hand-held devices was again evaluated during a debriefing session.

Furthermore, LASHFIRE has launched training videos to teach and disseminate a safe and efficient manual response to APV fires.

Results and achievements

The aim of the current Deliverable is to improve the efficiency of the first response, designating crew to perform specific tasks, and to enable a faster first response in a safer manner.

The first response video can be found in the following link: [\(3\) LASH FIRE - EV Firefighting Film03 First Response - YouTube](#)

If, for any reason the first response is not successful, the fire chain development process will move forward to further actions. This deliverable (D06.7) will feed the system activation process of LASH FIRE deliverable D07.9 “Development and implementation of design guidelines and procedures for extinguishing system activation” and, depending on the fire situation, manual firefighting actions within D06.9 “Guidelines for firefighting gear, equipment and tactics, considering APVs”

Contribution to LASH FIRE objectives

This document will provide contribution 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 result packaged as guidelines and practical training movies are intended for dissemination by maritime organizations, ship operators and ship crews, specifically in the ro-ro sector.

Several short clip videos were recorded during large scale testing and training at SAS' facilities with the aim to share the right procedures on APV firefighting routines, equipment, and tactics among the shipping industry. This is the LAHFIRE link to the video series:

[The LASH FIRE project proudly presents the crew training videos series on Effective Manual AFV Firefighting! | lashfire.eu](http://lashfire.eu)

The dissemination aims to kickstart a process of adoption by important players in the maritime industry, specifically in the ro-ro sector.

2 List of symbols and abbreviations

AB	Able seaman
APV	Alternative Powered Vehicle (IMO terminology)
BA	Breathing Apparatus
BEV	Battery Electric Vehicle
BLEVE	Boiled Liquid Expanded Vapor Explosion
CAF	Compressed Air Foam
CNG	Compressed natural gas
EEBD	Emergency Escape Breathing Device
ECR	Engine Control Room
EMSA	European Maritime Safety Agency
EV	Electric Vehicles
FSS	International Code for Fire Safety Systems
LNG	Liquefied natural gas
IACS	International Association of Classification Societies
ICEV	Internal Combustion Engine Vehicle
IMDG	International Maritime Dangerous Goods Code
IMO	International Maritime Organization
IR	Infra-Red
MOCP	Manually Operated Call Point
ML	Machine Learning
OOW	Officer of the watch
PPE	Personal Protective Equipment
SMAS	SMart Alert System
STCW	The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
SOC	State of Cargo
SOPEP	Shipboard Oil Pollution Emergency Plan
UHF	Ultra High Frequency; Short wave radio, shorter reach than VHF
VHF	Very High Frequency; Short wave radio

3 Introduction

Main author of the chapter: Jaime Bleye, SAS

To start defining a first response to a fire, it is important define the most potential fire hazards that can arise on board, such as:

- Fuel leakage (solid, gas)
- Presence of ignition sources (like sparks or hot spot/surfaces)
- Electrical faults
- Presence of smoke
- Suspicious noises or smell
- Thermal runaway on Li-ion batteries
- Self-reactions with IMDG
- Unsolicited activity
- Handmade electrical installations on vehicles.

Fire causes can be diverse. Electrical faults are seen as the main cause, but there are others which are shown in [Figure 1](#)

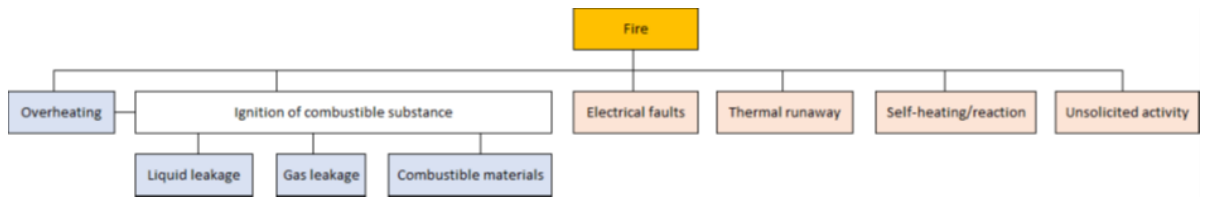


Figure 1 - Simple tree describing different fire causes in ro-ro spaces. (from D04.1)

If one of these hazards may provoke a fire, more particularly in an EV; the current recommendations are available in the EMSA *Guidance on the carriage of AFVs in ro-ro spaces*, which stipulates that *“The activation of the fixed fire-extinguishing system should be the preferred response for a fully developed fire. However, under specific circumstances, a first response through manual means may be effective.”*. This means that according to the following process diagram, the preparation of the fire team and the activation of water fixed firefighting systems (aka drencher) must be performed in parallel with the first response activity.

As shown in the bellow chart extracted from EMSA first response should only be performed when considered safe. Activation of fixed system should always be considered. In case of doubt, active it as is indicated in Figure 2.

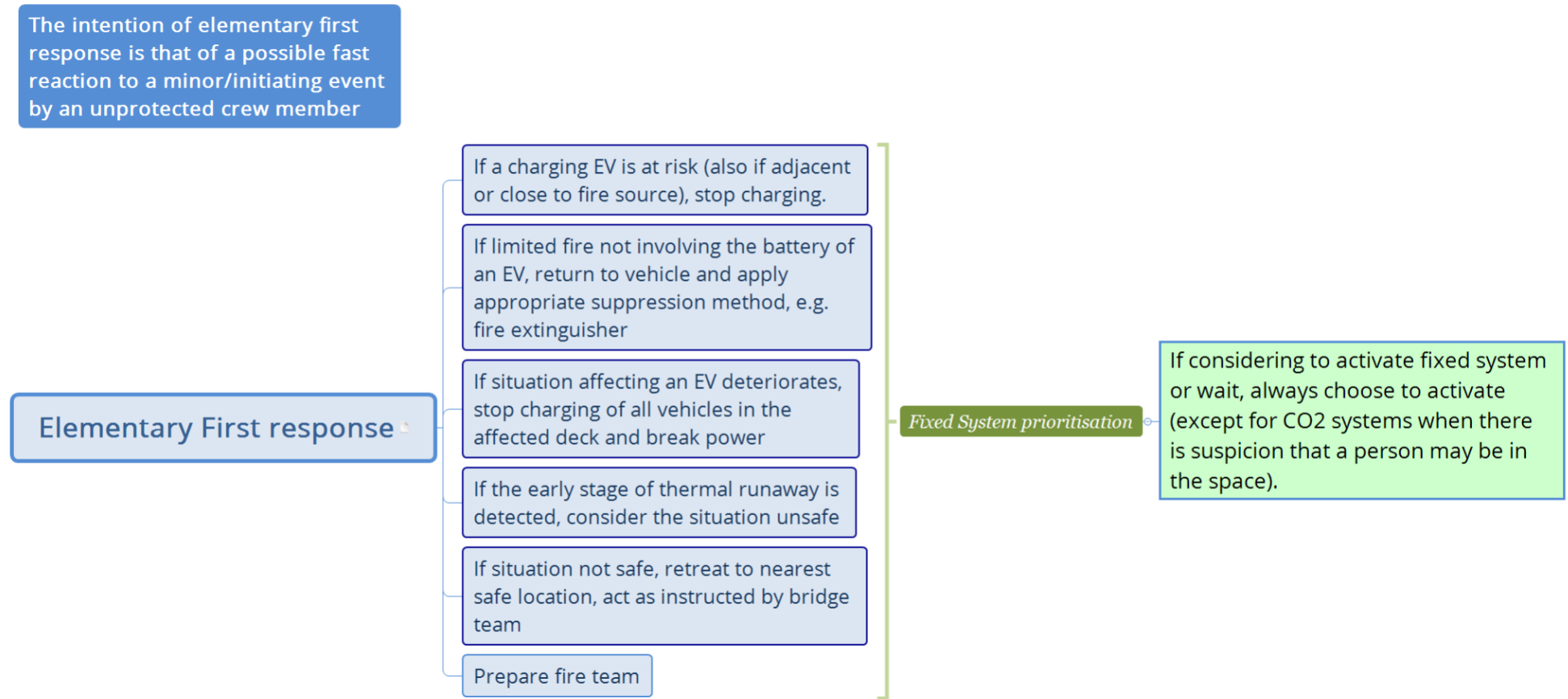


Figure 2. EMSA Operational Guidance in case of AFVs fire incidents.

4 Maritime regulation standpoint with regards to first response

Main author of the chapter: Eric de Carvalho and Blandine Vicard, Bureau Veritas Marine & Offshore (from WP04, “First response regulation review”).

4.1 Scope

This section aims at giving an overview of the requirements applicable in ro-ro spaces regarding Action 6-C, i.e. “efficient first response”.

4.2 Applicable regulations

The present review is based on the currently applicable regulations. Therefore, some of the requirements detailed below may not be applicable on old ships.

Table 1: List of documents used for the review of regulations for Action 6-C

IMO Documents	SOLAS Convention, as amended
	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
	MSC.1/Circ. 1432, as amended by IMO MSC.1/Circ.1516 “revised guidelines for the maintenance and inspection of fire protection systems and appliances”
	STCW convention, as amended
	FSS Code, as amended
IACS & Class Rules	IACS Blue book dated January 2019
	BV Rules for Steel Ships (NR467), as amended in July 2019
	DNVGL Rules for the Classification of Ships, January 2017
	LR Rules and Regulations for the Classification of Ships, July 2016
Flag Administration Rules	MMF (French Flag Administration) Division 221 “Passenger ships engaged in international voyages and cargo ships of more than 500 gross tonnage”, 28/12/17 edition
	US Coast Guard Code of Federal Regulations (CFR) 46, 2019 online edition
	MCA (UK Flag Administration) Guidance on SOLAS Ch.II-2

4.3 Definitions

This section provides the definitions of key terms used in regulations relevant to Action 6-C

4.3.1.1 Ro-ro space, vehicle space and special category space

As per SOLAS II-2/3:

- “Vehicle spaces are cargo spaces intended for carriage of motor vehicles with fuel in their tanks for their own propulsion.”
- “Ro-ro spaces are spaces not normally subdivided in any way and normally extending to either a substantial length or the entire length of the ship in which motor vehicles with fuel in their tanks for their own propulsion and/or goods (packaged or in bulk, in or on rail or road cars, vehicles (including road or rail tankers), trailers, containers, pallets, demountable tanks or in or on similar stowage units or other receptacles) can be loaded and unloaded normally in a horizontal direction.”
- “Special category spaces are those enclosed vehicle spaces above and below the bulkhead deck, into and from which vehicles can be driven and to which passengers have access.

Special category spaces may be accommodated on more than one deck provided that the total overall clear height for vehicles does not exceed 10 m.”

Special category spaces are ro-ro spaces to which passengers have access, possibly during the voyage. Special category spaces are the most frequent type of closed ro-ro spaces on ro-ro passenger ships.

It is to be noted that open ro-ro spaces are not considered as special category spaces.

4.3.1.2 *Closed, open and weather deck*

As per SOLAS II-2/3:

- A “weather deck is a deck which is completely exposed to the weather from above and from at least two sides.”

IACS UI SC 86 additionally details that: “For the purposes of Reg. II-2/19 a ro-ro space fully open above and with full openings in both ends may be treated as a weather deck.”

For practical purposes, drencher fire-extinguishing system cannot be fitted on weather decks due to the absence of deckhead. This criterion is often used for a practical definition of weather decks.

- An open vehicle or ro-ro space is “either open at both ends or [has] an opening at one end and [is] provided with adequate natural ventilation effective over [its] entire length through permanent openings distributed in the side plating or deckhead or from above, having a total area of at least 10% of the total area of the space sides.”

- A closed vehicle or ro-ro space is any vehicle or ro-ro space which is neither open nor a weather deck.

As a reference criterion, it can be considered that a vehicle space that needs mechanical ventilation is a closed vehicle space.

4.4 Requirements

4.4.1 General

It is to be noted that first response to an emergency situation is, per se, an operational matter to be dealt on a case-by-case basis. Therefore, international regulations do usually not cover the first response itself, they rather give provisions to ensure that first response will be possible and relevant, requiring:

- Drills and procedures.
- Equipment; and
- That the equipment is kept in working order.

4.4.2 Onboard organization and crew training

SOLAS includes general requirements requiring that emergency situations including fire scenarios are foreseen to ensure adequate first response: crew members are to be trained to react to fire situations, assigned with a relevant duty in case of a fire and be well aware of that duty. Associated drills and training are to be carried out regularly and all relevant manuals for the use of the firefighting or emergency response equipment are to be available on board.

In addition, regular fire drills simulating evacuation scenarios are required on passenger ships. It should be noted that no specific training is required to train passengers to carry out a first response in case of a fire [SOLAS II-2/15].

In addition to SOLAS, STCW Convention specifies that all crew members shall receive appropriate approved basic training or instruction in fire prevention and firefighting. Table A-VI/1-2 provides the specification of minimum standard of competence in fire prevention and firefighting, i.e., competence, knowledge, understanding and proficiency, methods for demonstrating competence, and criteria for evaluating competence [STCW VI/A-VI/1 Table A-VI/1-2].

4.4.3 Operational readiness and maintenance

SOLAS includes general requirements stating that:

- All fire safety systems are to be kept in proper working order. Especially portable fire-extinguishers are to be immediately replaced when they have been discharged [SOLAS II-2/14.2.1.2].
- Fire-fighting systems and appliances, including fire-fighter's outfits and portable fire extinguishers, are to be regularly maintained and inspected [SOLAS II-2/14.2.2].

IMO recommends the maintenance and inspection plan shown in Table 2 below for first response-related equipment, to be completed by inspection and maintenance according to each manufacturer's instructions. These inspections are to be carried out by the crew on a regular basis [IMO MSC.1/Circ.1432, as amended by IMO MSC.1/Circ.1516].

As a complement, Class Societies carry out third part surveys on a yearly, 3-yearly and 5-yearly basis.

Table 2: Minimum inspection and maintenance plan for first response equipment according to IMO MSC.1/Circ.1432

Equipment	Inspection and maintenance period				
	One Week	One Month	One Year	Five Years	Ten years
Breathing apparatus	Examine all breathing apparatus and EEBD (Emergency Escape Breathing Device) cylinder gauges to confirm they are in the correct pressure range.		<ul style="list-style-type: none"> - Check breathing apparatus air recharging systems, if fitted, for air quality; - Check all breathing apparatus face masks and air demand valves are in serviceable condition; and - Check EEBDs according to maker's instructions. 	Perform hydrostatic testing of all steel self-contained breathing apparatus cylinders. Aluminium and composite cylinders should be tested to the satisfaction of the Administration.	
Portable foam applicators		Verify all portable foam applicators are in place, properly arranged, and are in proper condition.	<ul style="list-style-type: none"> - Verify all portable foam applicators are set to the correct proportioning ratio for the foam concentrate supplied and the equipment is in proper order; - Verify all portable containers or portable tanks containing foam concentrate remain factory sealed, and the manufacturer's recommended service life interval has not been exceeded; - Portable containers or portable tanks containing foam concentrate, excluding protein based concentrates, less than 10 years old, that remain factory sealed can normally be accepted without the periodical foam control tests required in MSC.1/Circ.1312 [6] being carried out; - Protein based foam concentrate portable containers and portable tanks should be thoroughly checked and, if more than five years old, the foam concentrate should be subjected to the periodical foam control tests required in MSC.1/Circ.1312 [6], or renewed; and - The foam concentrates of any non-sealed portable containers and portable tanks, and portable containers and portable tanks where production data is not documented, should be subjected to the periodical foam control tests required in MSC.1/Circ.1312 [6]. 		
Wheeled (mobile) fire extinguishers		Verify all extinguishers are in place, properly arranged, and are in proper condition.	<ul style="list-style-type: none"> - Perform periodical inspections in accordance with the manufacturer's instructions; - Visually inspect all accessible components for proper condition; - Check the hydrostatic test date of each cylinder; and - For dry powder extinguishers, invert extinguisher to ensure powder is agitated. 	Visually examine at least one extinguisher of each type manufactured in the same year and kept on board.	All extinguishers together with propellant cartridges should be hydrostatically tested by specially trained persons in accordance with recognized standards or the manufacturer's instructions.

4.4.4 Equipment

A number of portable equipment are required on board in order to allow first response in case a fire starts in a vehicle or ro-ro space:

- Portable fire extinguishers are to be stored every 20 m within any vehicle or ro-ro open or closed space and at each access to the space [SOLAS II-2/20.6.2.1].
- 3 water-fog applicators are required in each ro-ro or vehicle open or closed space [SOLAS II-2/20.6.2.1].
- 1 portable foam applicator per ro-ro or vehicle open or closed space is also required, with at least 2 applicators to be available on board [SOLAS II-2/20.6.2.2].

FSS Code provides more details about type approval and engineering specifications of fire extinguishers and portable foam applicators [FSS Code Ch 4].

In addition, for passenger ships, it is to be noted that manually operated call points are to be provided every 20 m inside each special category space and close to each access to the space, as part of the fixed fire detection and fire alarm system [SOLAS II-2/20.4.3.2].

Designated first responder and fire patrol will benefit from being familiarized with the vessel in terms of access, obstacles, best approach path adjacent spaces etcetera. Also, he/she should be aware of the stowage situation, in general, and regarding dangerous goods and alternative fuel vehicles in particular.

Officers should keep in mind that personnel appointed as designated first responder cannot be engaged in other work which makes it impossible to act as a first responder.

Designated first responders must, if assigned work that interferes with the possibility to act as first responder, notify superior to have a temporary replacement of the first response task.

At least one designated first responder should be always appointed for assignment in cargo spaces. Depending on type of operation more than one may be appointed, for example one in deck department, one in technical department. However, any crew member may act to a fire in the spirit of first response, both in cargo spaces and other parts of vessel. Cases where more than one candidate is needed is when fire patrol is in a remote position on vessel and other crew members are closer to location of fire.

When looking into some major accident a common denominator is that there is no trace of any activity that can be regarded as “first response”. Possible causes:

- Fire already too large at detection
- No training/preparedness for first response
- Time slot available after detection but before fire growth but no suitable method at hand.

5.1.2 Personal gear, PPE

It is important that a designated first responder wear as outer layer clothing, when approaching a plausible fire, wear long sleeve jacket/shirt and long trousers in a material that is not easily combustible. Typically, coverall material is good, but fleece and polyester are not recommended. Clothing shall be clean, not stained with oily content or similar that increase combustibility. A set of thin material protective long sleeve gloves and safety footwear should also be worn when approaching a fire. Idea is to cover bare skin as much as possible. A radio for communication should always be carried.

First response clothing and equipment shall be same as for fire patrol since it is expected that the fire patrol will carry out first response tasks when a fire is detected during patrol, or when triggered by bridge on other form of fire indication. Fire patrol shall also be equipped with a flashlight and handheld heat camera. It is important that specification of fire patrol or AB general work gear considers fire resistance.

One complexity is the difference in conditions indoor/outdoor especially in bad weather and wintertime. Appointed crew member need be ready for first response action at all locations onboard. Other complexity is that in practice a fire patrol outfit may vary depending on the tasks to be performed before or after patrol round, be it mooring operations in wintertime or bridge outlook duties or something in between.

Correct gear is immensely important to give first responder courage and confidence to act.

5.1.3 Training

First response should be part of scheduled fire drills onboard, for crewmembers normally appointed as designated first responder as well as for all crew members that may be in such situation.

Topics to consider in regard to training for crew members being candidate for being designated first responder:

- Mental preparedness (knowing you are appointed to the role)
- Physical preparedness (i.e., having the right PPE close by at all times when appointed this role, also when performing daily work)
- Use of portable heat camera
- Ready for decision, clear delegations
- Familiarity with vessel, access ways and limitations, keys, radio shadows, marking of drencher zones.
- Familiarity with, in each location, available firefighting equipment and locally stored PPE
- Skilled to use different types of extinguishers, fire blankets and other types of equipment.
- Training in different scenarios with its standard procedures
- Awareness of how other functions in safety organization work
- Communication skills; technology and terminology
- Self-protection, what to avoid and what is safe.

Topics of relevance for possible extended scope of first response:

- Skills in different cargo types and its hazard
- Basic DG, IMDG knowledge and firefighting options
- Basic vehicle and cargo knowledge, main switch locations, specific hazards, common problems etcetera
- Electric power system awareness for reefers or charging of e-cars
- Awareness of experiences from other vessels and colleagues

Familiarization of vessel and current situation onboard:

- New employee's introduction is extremely important.
- Transition period of new crew member until up and running, extra preparedness/overlap from other members of the watch.
- The fire patrol/first responder should be aware of the current stowage of cargo and vehicles, in particular dangerous goods.

5.1.4 Availability of equipment close to seat of fire.

Equipment relevant for first response activities:

- Extinguishers, of different types
- Special equipment such as fire blankets
- Absorbents and gear for handling leakages

Such equipment must be readily available close to a possible fire scene.

5.1.5 Communication & localization

Important success factors:

- Familiarity with UHF or VHF radio equipment, channels to use, how to speak in clear way.
- Terminology to use for predictable and understandable dialogue.
- Awareness of any radio shadows onboard
- Awareness of alternative means of communication in case of radio shadow or malfunction of primary option.

On some vessels a system for automatically alerting key crew members is in operation. In a particular example the fire alarm system feeds the phone system switch board with a text message. The message is automatically relayed to pre-selected users' phones. Such message could be sent to potential first responders. Risk that vigilance of recipients of automated messages will be eroded due to false alarms need be considered. Also, there is a risk that some recipients will have mindset that "someone else will probably respond so I do not have to".

Most important for localization is to secure the spoken communication between any individual acting in the peripheries of the vessel and supporting functions on bridge or elsewhere.

In a ship in general and cargo spaces in particular, adding influence of routine character of duties, and the sudden stress/adrenalin of a unexpected incident, the risk is high that a crew member may hesitate on his location or what direction inf forward or aft. In such situation of when verbal communication cannot take place, automized localization function may support individual on site of support team.

5.1.6 Psychological factors

First step is to make clear what "fist response" means. If this is not clear all involve will hesitate.

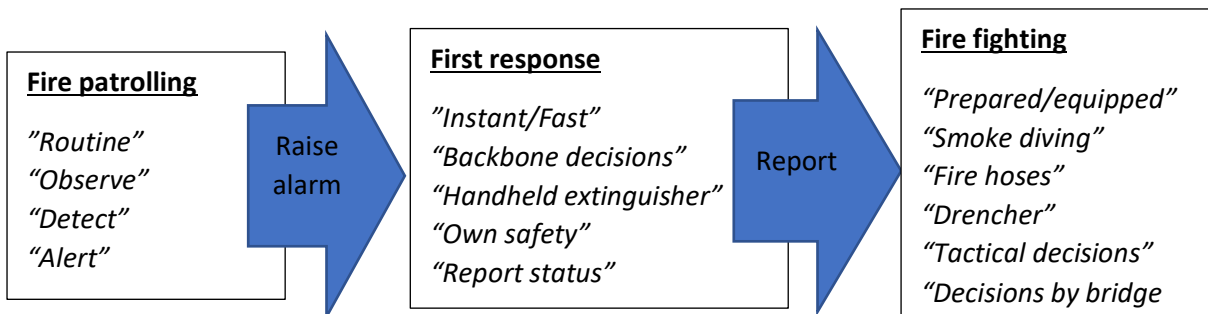
Many factors will influence the success of a first response action, many of them related to mindset, courage, trust etc. By training, clear task, reasonable expectations, proper tools and PPE and support this may be secured for a Designated First responder. And an honest insight that all people does not have right profile for such situations, some are more proactive and stress-tolerant than others.

Delegations and responsibilities must be very clear. Also, the working culture on the vessel such as decision making, trust, openness, blame culture etc. will influence on the outcome.

It may be a challenge to balance the critical importance of correct and decisive actions in early stage of a fire with the ambition that most crew members should be ready and prepared to act in this respect. The function should fill an important gap in today's fire scenario chain of events but must but not be "overloaded" with too high expectations.

5.1.7 Discussion of fire patrol vs first response vs fire fighting

Today there is no defined function between fire patrol and fire fighting in neither rules nor reality. Introducing such would be of great contribution but must be made with care not to cause confusion. To add to the complexity, it may well be that the same person, while present on location, will during the timeline move from acting as fire patrol to acting in first response into (preparing for) firefighting.



Depending on ambition level for a first responder the location of fire stations with access to relevant lighter equipment could be relevant. Additional strategically located equipment such as breathing masks may be considered. Assigning further advanced gear such as aerosol grenades and breathing device to a first responder may be to go too far into firefighting.

In order to open up discussion, below the approach by one operator is described:

“The terms ‘Discoverer’ and ‘Initial Response Team’ is used – very different and impossible to confuse one from the other. It is also important to state that there should never just be a single ‘designated first responder’. The second phase of response, called Initial Response Team, always consists of a minimum of 2 people. This is an important safety point because nobody should ever proceed to the scene of fire/smoke alone.

Regarding the drencher; once our Initial Response Team leader (who is always the Chief Officer) has completed their initial assessment they are to initiate next steps/actions which in most cases (for car deck fires) will include activation of the drencher system. Typically, this will occur within 2-3 minutes of the raising of the initial alarm. If everything is happening correctly the drencher should already be ‘on’ by the time the ship is at Emergency Stations. This is all possible because of the rapid reaction provided by the Initial response Team who, importantly, proceed directly to the scene of the smoke/fire without dressing in fire suits and breathing apparatus.”

Some other reflections from real life incidents related to the decision-making process during the selection of handheld devices, the activation of the drencher system and the disconnection of the reefer’s source of power will appear at the end of this report in ANNEX A “Extracts of first response events from incidents and accident reports”

5.1.8 Scenarios

Crew members expected to act as designated first responder in cargo spaces must be familiar to the most common and critical (potential) fire situations.

Potential fire situations:

- Liquid fuel leakage
- Overheated/melting cables/sockets
- EV thermal runaway
- Gas leakage
- Self-heating cargo
- Overheating reefer unit belts

Fire situations may be:

- Cable (smouldering) fire
- Gas vehicle fire
- Electric vehicle (battery) fires
- Reefer cooling unit fire, fuel based or electric
- Open liquid fuel fire
- Cargo fires
- Electric device fire inside car or driver's cabin

For each case the crewmember must be aware of risks and be skilled in how to act.

Designated first responder candidates also should have basic awareness of the risk characteristics of vehicle types:

- Electric vehicles
- Liquified gas vehicles
- Compressed gas vehicles
- Fossil fuel vehicles

- Most common IMDG cargo

5.2 Design and production aspects

The following aspects shall be considered:

- Logical and easy access points and access ways.
- Clear marking and signage.
- Communication availability ensured from all locations on the vessel.

5.3 Proposal for development and restrictions

5.3.1 Development proposals

Proposals for developments are listed below:

- Calibrate role in most efficient way:

- Best role fit between fire patrol and firefighting team.
 - Best position on the scale between extreme options of (1) an officially appointed, prepared, highly skilled and trained first responder and (2) first response as something most crew should be able to engage in.
- Develop a standard role description to increase awareness of first response concept, since this concept is non existing today.
- Establish a standard training description for first response, including also officer delegating this responsibility.
 - Develop electronic or other learning material than can be shared across the RoRo/RoPax industry.
 - Investigate method/equipment to extend the usability of fire extinguisher to less accessible fire seats such as high places on top of cabins, reefer units.
 - Develop special instructions for electric and gas vehicles. Special focus on identifying type of vehicle, detection of risk indicators, safe approach, thermal runaway confirmation.
 - Develop standard communication terminology protocol to secure prompt understanding.
 - Investigate smartphone-based solutions for information sharing to/from first responder. Investigate decision support.

5.3.2 Restrictions

Some system proposal for localization requires access to wireless communication, be it WIFI or 3G/4G/5G systems or other specialized transponder system.

Mobile network coverage is limited to certain distance from shore and will be absent most parts of voyage, especially on longer routes.

Radio-linked mobile network is one solution implemented; signal is sent to vessel by one directional radio transceiver in each end port.

WIFI coverage on cargo decks may vary from none to full coverage. Since being less technology dependent, WIFI is the likely future solution for communication in cargo areas onboard, as well as for any connectivity onboard. There is very little revenue or customer service argument for operators to install WIFI on car decks since passengers and drivers will spend very short time there. See ANNEX B.

Other type of localization may be based on image/object recognition. For such case one must keep in mind that in case of cargo spaces the environment is in fully loaded situation very volume dense with only narrow open spaces. Also, it is redefined at every port turnaround of vessel when a new cargo configuration is taken onboard.

6 New technological development for smart alert of nearby first responders

Main author of the chapter: Demetris Zeinalipour, UCY.

LASH FIRE deals with the Development of a **Smart Alert System for First Responders**. Particularly, by knowing the precise position of the first responders, manual confirmation of the fire will be faster. Additionally, by improving the communication between first responders and the bridge, the decision-making process will be more effective avoiding time lost on information integration. The aim is to develop an innovative geo-positioning technology that allows more efficient first response to fires in the initial stage. It also develops a Ship indoor information system and an application-based platform of a ro-ro indoor navigation and indoor fire intelligence system.

When it comes to first responders' technology, there is limited control and slow coordination in first minutes of incident. Different technologies and interoperability issues. We aim to make first respond more integrated, quicker, and smarter. By equipping first responders with powerful mobile computing devices will allow them to **increase their cyber-physical senses** (i.e., multiple sensing devices like heat scanner in a tiny device), be **connected** (with the bridge and other personnel, discarding possibly outdated communication gear), be **informed** (e.g., carrying bulky manuals and maps in digital form) and **location-aware** (i.e., localization, navigation and tracking of mobile and static assets). These are all dimensions that will increase fire safety by the means of **state-of-the-art information technology** that has proven itself in **everyday life scenarios** and that is for the same reason also **unobtrusive**, with a **low learning curve**.

Although Wi-Fi, 4G and 5G is available or will become available to some limited degree on vessels to provide network (and Internet) connectivity to personnel and passengers, dense deployment of radio antennas necessary to provide accurate localization is not available . Providing multiple reference points (i.e., Antennas) for the task of localization is critical in the complete spectrum of the localization landscape (i.e., Satellite GNSS, Beacon, Light, Sound, Wi-Fi, UWB to name a few). Unfortunately, such dense antenna deployments will not be available on RoRo vessels in the years to come, due to the installation and maintenance costs but also relevant risks (radio signals might be a fire safety hazard in their own right). This led to the design and development of an innovative geo-positioning technology with "zero" infrastructure. Particularly, the aim was to offer similar accuracy to Wi-Fi localization (i.e., room-level accuracy to about 1-10 meters and low installation and maintenance cost) without relying on Wi-Fi access points as reference points but rather use static elements of vessel spaces as reference points to cameras (e.g., deck patterns, bulkhead patterns, hoses, fixed installations, signs, control buttons) and their spatial location as collected through a crowdsourcing task during a one-off installation process.

In our context, all crew members may act as first responders but there are some of them (fire patrol member, able seamen, personnel form the engine control room) that are more likely to act as first responders due to their normal access to restricted cargo decks spaces. Fire patrol members are designated first responders and are the target personnel for the technology that we are developing for localization of nearby first responders.

Our proposed architecture comprises data, localization, and network layers, in a complete **SMart Alert System (SMAS)**. SMAS is the application exploiting the Anyplace A4IoT localization architecture to enable localization, advanced patrolling and efficient first response. The SMAS innovative geo-positioning technology will allow more efficient first response to initial fires. The SMAS app will implement nearest neighbour algorithm to make the computation of the closest members possible

(user defined parameter). The SMAS chat interface (supporting a voice interface and currently in development) will provide the first responders all primitive alerting operations through a clean user interface. It will be a very primitive user interface with the “ALERT” functionality as a highlight. However, it will also provide in the background a chat interface to allow the crew to interact around specific alarms (e.g., exchange images, comments, etc. as we do on WhatsApp etc.) During patrolling, the first responder will gain immediate access to “ALERT” with very little effort. However, if needed to discuss some emerging situation the SMAS (Smart Alert System) will be the right place to do so.

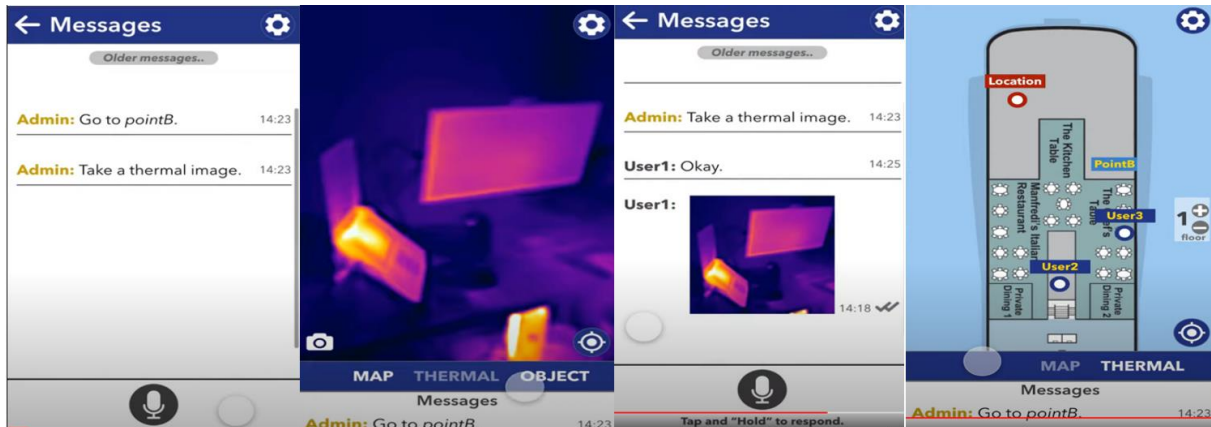


Figure 3. Visual Design of the SMart Alert System (coined SMAS) on the smartphone terminal of the first responder.

It is important to remember that a fire containment requires rapid fire identification (i.e., within a few seconds to a few minutes) as the fire rapidly expands in size.

Particularly, a fire of medium growth is exponential reaching 50kW after 1 minute, 400kW after 3 minutes, 5MW after 5 minutes (equivalent to 1 m² of diesel on fire). Particularly, all crew members may act as first responders but there are some of them (fire patrol member, able seamen, personnel from the engine control room) that are more likely to act as first responders due to their normal access to restricted cargo decks spaces.

Fire patrol members are designated first responders and are the target personnel for the technology that we are developing for localization of nearby first responders.

The technology ecosystem of Anyplace, which is Wi-Fi localization, navigation, crowdsourcing and indoor modeling platform developed over the years at the University of Cyprus. Given that Wi-Fi technology is not widely available on ro-ro vessels and interactions within LASH FIRE have shown that dense telecommunications deployments, which are necessary to provide multiple reference points for the task of localization, will not be available on ro-ro vessels in the years to come, led the foundations for the development of groundbreaking technology extensions to Anyplace that exploits the static assets of an indoor space (e.g., floor patterns, wall patterns, hoses, drenches, signs, control buttons etc.) As such, we will provide a technology to localize with room-level accuracy (1-10 meters) with “zero” infrastructure using computer vision localization from deep learning models. In the context of this deliverable, we outline the background and preliminary testing of such a state-of-the-art system available to nearby responders that relies on an infrastructure-free localization method we develop that can run on commodity smartphone devices carried (or attached to) nearby responders.

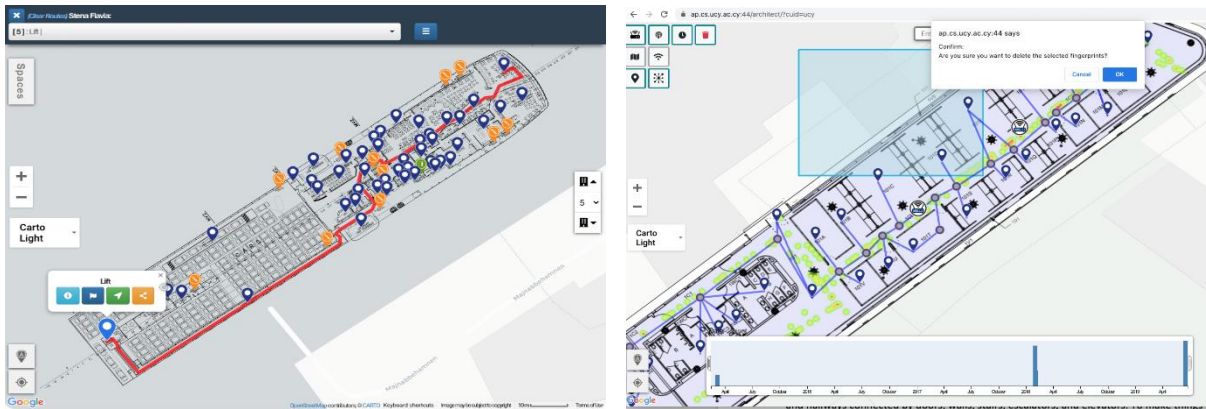


Figure 4. Visual Design of the SMart Alert System (coined SMAS) we are developing in the context of T06.10, on the Smartphone terminal of the Control Center installed at the Bridge or the Cloud.

The proposed method relies on three stages: **(i) Training:** vessel owners supply video recordings of the vessel’s interior spaces with a particular camera lens focus on static objects to the software team. The video recordings are analyzed on a deep learning data center to produce a so-called Machine Learning **Model**. This process is carried out once per vessel type (or vessel family – in case multiple vessels have similar internal objects); **(ii) Logging:** Subsequently, the model is loaded to a smartphone app provided to the vessel owners, which are asked to associate surrounding objects with their location by clicking on a map yielding a **Fingerprint database**. Logging is carried out once per unique vessel; **(iii) Localization:** The first responders utilize a smartphone application using the fingerprint database that shows both to them and any nearby user (who is connected to a telecommunication network) the location of the responders using the app (e.g., also on the bridge). Steps (i) and (ii) are one-off steps and the primary focus of D06.4. Within D06.4 we also report on the design philosophy of step (iii) but also integration aspects that where necessary to the Anyplace 4.0 software stack.



Figure 5 The SMAS platform relies on state-of-the-art deep learning on a datacentre where train the Machine Learning (ML) models that recognize objects particular to vessels. The ML models are then transferred to the Smartphone app.

Computer Vision localization comprises of state-of-the-art information technology, which is novel in the domain of fire protection of ro-ro ships. Particularly, will use:

- Deep learning of video for the purpose of recognizing accurately objects that has a proven track record in autonomous cars and other domains and can be extremely useful top strengthen the independent fire protection of ro-ro ships.
- Infrastructure-free fingerprint localization algorithms that have mainly focused over the years on radio signals form cellular towers, Bluetooth, and Wi-Fi but not Computer Vision signals are developed and will be available to accurate localization on vessels.

- State-of-the-art rugged smartphone devices that can introduce an extended battery life for a variety of “smart” applications by the vessel personnel. These devices can replace static scanning devices (IR heat scanners) by a smartphone technology that can sense-communicate-automate a variety of complementary tasks and provision “smarter” and contextually relevant responses to signals coming from the environment. One example brought forward in the context of this deliverable is that of sharing information (i.e., heat camera images to the bridge and other fire responders through a nearest neighbour information network automatically when threats are identified, as opposed to manual heat scanning of objects).

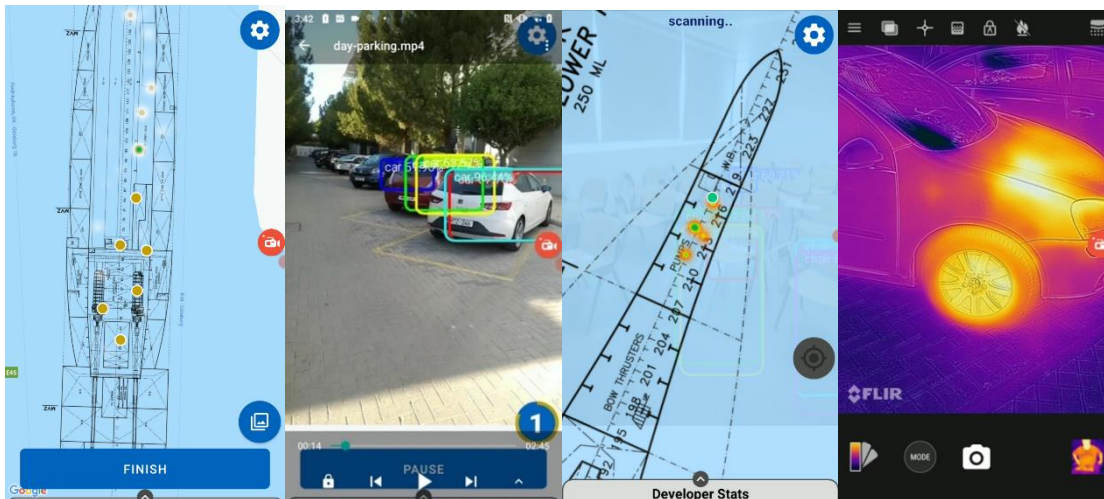


Figure 6 SMAS provides a mobile application that allows associating physical objects with their location on a map (i.e., called logging). The SMAS application then provides the location of a user using a localization algorithm we have developed in the scope of the LASHFIRE project. Additionally, it enables heat scanning and will provide a communication chat.

Overall, the proposed solution is expected to significantly improve **fire safety on vessels** for the below reasons:

- As human and cargo assets can be localized introducing better overview of fire hazard situations and operations before an incident.
- The bridge and port can have access to patrol data before or after an incident, analyzing it through a visual interface and identify important aspects of vessel safety that require improvement.
- Certain smartphones, feature a heat camera that allows fire responders and patrol personnel to continuously monitor in an unobtrusive way hazardous condition on vessel and communicate this information seamlessly to the bridge.
- The developed technology introduces no additional fire hazards as it relies on no installed infrastructure (i.e., infrastructure-free means that the installation of technology, batteries or moving objects on a vessel are not necessary), which might be a source of fire in their own right. It is worth keeping in mind that any new technology involving machines powered by electricity, may also be potential sources of ignition and in out platform the device is handled by a user (similarly to airplanes where smartphones are permitted in cabin but not in luggage as in the latter space devices might go undetected in case of thermal runaway).
- The developed technology can easily fall back to QR codes (that also requires a camera) – again being a solution with almost “zero” hardware investment. Finally, given that the localization

happens on the smartphone of the patrol personnel, there are no privacy barriers (i.e., we don't capture video but rather extract on the device features from the environment).

7 Training for APVs first response and manual firefighting tactics

Main author of the chapter: Jaime Bleye, SAS, Martin Carlsson, STL & Jonatan Gehandler, RISE

In LASH FIRE, a training curriculum was developed and a training session of first response and manual firefighting of fires in APVs conducted.

The training session was carried out in the <https://www.centrojovellanos.es/> that belongs to SASEMAR (SAS)- Spain, during the 18 & 19th of October 2022.



Figure 7 Jovellanos Safety Training Centre. Gijon Maritime Rescue Coordinator Centre. Aerial picture

The training session included not only hands-on training on the first response tactics and proposal of equipment, but also manual firefighting and post extinguishing actions.

Although initially planned exclusively as a first response training session, we also established the conditions for a manual firefighting intervention in the meaning that the fire was attacked beyond the initial stage or for any reason the first response intervention had not been effective.

First response and manual firefighting are directly linked in the fire chain of events. Manual firefighting might not be necessary if first response has been effective, but in the event of a fire on board, it is common practice to prepare a fire team ready to intervene according to Muster list in case manual firefighting will be finally needed regardless the fire size (See Annex C- On board Muster list for manual firefighting)

Target group of the training session was a group of STENA LINES ro-pax crewmembers with different positions on board from Captain, fire chief or ECR members. All of them had previous experience on firefighting.

Different drills were performed during training:

- Drill 0: Dry test
- Drill 1: Pressurized jet fires
- Drill 2: EV Free burn safety awareness and Firefighting procedures
- Drill 3 which was divided into (a) First response & (b) Firefighting methods. Both outdoor
- Drill 4: Indoor EV manual firefighting methods in combination with or without drencher system and ventilation, and
- Drill 5: Post extinguishing treatment (boundary cool down and healthy working environment. Procedures for safe undressing)

The training session lasted for 2 days following the bellow schedule:

FIRST RESPONSE & MANUAL FIREFIGHTING TRAINING ON APV

DATES: 18 and 19th October 2022

Day 1

08:00–08:30	Safety introduction. Healthy working environment- classroom
08:30-09:00	Objectives of the training. Pre-briefing start meeting.
09:00-09:30	Donning of PPE
09:30-09:45	Equipment familiarization fire hoses and couplings, foam inductors, breathing apparatus, fire gear and PPE, water nozzles, fog nail, boundary cooling device and fire blanket.
09:45-11:00	DRILL 0. Dry tests (Fire blanket, Boundary cooling device) 3 x 3 car configuration, no fire, water connected.
11:00-11:15	BLEVE demo
11:15-11:45	Coffee/snack break (fireground)
11:45-13:00	DRILL 1. Pressurized LPG jet fires. Training drill. Defensive strategy. 1.1 Lay out of the fire hoses. 1.2 Ignition of the LPG jet fire 1.3 Approach to the fire. 2 teams- 4 members of 45 mm hose each 1.4 Defensive strategy with the right cone angle. Directing the fire to a safe zone putting a car in the direction zone to protect. rotate the teams. one team cool down the vehicle and the other cool down the tank. 1.5 ALBERO nozzle as boundary cooling device for protection of vehicle. 1.6 Staying at protection position for 4 minutes leaving time to the flame to decrease in size. No EXTINCTION
13:00-15.00	DRILL2. EV Free burn safety awareness and Firefighting procedures. Practical exercise (safety distances, thermal runaway acknowledgement, possibility of projectiles, tires explosions, calculation of run-off water). No scratch car around. (OUTDOOR) 2.1 Preparation of the EV. SOC close to 90%. Calibration of the gas burner pointing to the Li-Ion Battery. Safety distance 2.2 Two 45 mm hoses, 4 members each as backup for safety

	<p>2.3 Ignition</p> <p>2.4 Observation of the fire development (possible TR, heat release rate, emission of smoke, projections, explosions)</p> <p>2.5 Application of boundary cooling devices</p> <p>2.6 Application of fire blanket</p> <p>2.7 Extinction with water. Calculation of time for extinguishment. Volume of water needed. Selection of the right angle of approach between hoses</p>
15:00-15:30	Lunch at restaurant
15:30-16:30	Debriefing and conclusions.

Day 2

08:00-09:00	<p>Pre- briefing start meeting. Development of APV fires in ro-ro spaces going into training session. Objectives of the training. Classroom</p> <ul style="list-style-type: none"> - DRILL 3a & b content - DRILL 4 content - DRILL 5 content
09:00-09:30	Hose deployment and size selection. BA donning. Communication test.
09:30-10:00	Coffee/snack break (fireground)
10:00-12:00	<p>DRILL 3. (a) First response & (b) Firefighting methods (OUTDOOR). Raise the alarm. Attempt to put out the fire in the initial stage with handheld extinguishers (dry chemical powder, CO2 and foam). Fog nail, cooling device and fire blanket:</p> <p>3.1 Preparation of equipment. EV in one corner. Surrounded by 8 scratch cars. Communication test</p> <p>3.2 Ignition.</p> <p>3a.3 First response with two CO2 handheld extinguishers at the early stage of the fire (0.5 minute) extinction</p> <p>3a.4 re-ignition</p> <p>3a.5 First response with two 9kg dry chemical powder extinguishers at the very early stage of the fire (0.5 minute). Extinction</p> <p>3a.6 second re-ignition</p> <p>3a.7 First response with two handheld foam extinguishers at the growing stage of the fire (1 minute). Extinction. TR is expected to happen at this stage.</p> <p>3b.8 Water shield and cooling device, same time each side.</p> <p>3b.9 Application of fire blanket</p> <p>3b.10 Extinguish with water</p>

12:00-14:00	<p>DRILL 4. Indoor EV manual firefighting methods in combination with or without drencher system and ventilation. Post extinguishing methods (cooling device, fire blanket).</p> <p>4.1 Preparation of equipment (one 25 mm fire hose with 2 members, one with fog nail 2 members). EV in one corner. Surrounded by 3 scratch cars. Communication test</p> <p>4.2 Ignition. Growing phase fire (5 minutes)</p> <p>4.3 Horizontal ventilation. Observation of the benefits of Positive pressure ventilation (IR Camera)</p> <p>4.4 Stop forced ventilation.</p> <p>4.5 Activation of drencher system</p> <p>4.6 Manual firefighting. Two teams attacking the fire. Extinction.</p> <p>4.7 Drencher Off. Reignition.</p> <p>4.8 Application of ALBERO cooling device.</p> <p>4.9 Remove cooling devices.</p> <p>4.10 Application of fire blanket to secure the fire (2 members)</p>
14:00-14:30	<p>DRILL 5 Post extinguishing treatment (boundary cool down and healthy working environment. Procedures for safe undressing)</p>
14:30-15:30	<p>Debriefing and conclusions</p>

The raw conclusions and feedback from trainees just after training were:

General feelings:

A fire is dynamic, and it is good with a toolbox to be flexible and adapt to the situation. Fire chief takes the decision what to use.

The fire can power up even if you think it is in the end phase.

It took long time for the battery to ignite.

It was really good to see free burning electric car live, to burn out the whole car (battery car). And to have another car on side.

Explosion of tire is more to be afraid of than thermal runaway. Projectiles of different pieces from a car.

Possibility to have access to system that can give more information about the vehicle that is on fire/hazardous. Information on a tablet, giving the number plate to the system and output is what kind of fuel, battery location, age etc. you can use this for decision support.

In some scenarios we do not want to much water, at some point we want to reduce the water and then the blanket is good.

Water mist nozzle:

Positive to have around.

Mainly positive impression. Training was fun. Extinguishing was working. Easy applying.

Create better moisture in the car (than ordinary fire hose).

A hammer with a nail to make a hole and then use the fog nail. Tried in a B15 door.

It was a big effort to use the fog nail in the car. Easier to first make a whole and use the tool.

Fire blanket:

Fire chief onboard who takes the decision, but it is a tool we can use. Good to have tools to use.

Expanding the blanket is a challenge. The car deck is normally full. The blanket is heavy and big. How easy it to access in different parts of the car deck? In a corner?

If we use the wider side, we can cover 3 cars but reach 1.

How to reach over vans or higher vehicles? It is a lot about technique, big or small people can use it. There have been both examples (injured arm for example).

You can cover cars that you want to protect from fires, so the fire does not spread. So, you can concentrate on a small space.

The blanket together with other devices is possible. We used water from underneath.

We concentrated to cover the car that was on fire, but we can use the blanket to cover a car not on fire to protect from fire. The ICEV would be covered, that caught fire faster than EV.

Boundary cooling device:

Good to create water shield. It works for its purpose to be located between two cars/vehicles. And then you can go away from there and control it.

This is the second version of the prototype.

Would be good to have a ring with a rope or something like be able to pull it. Good. It depends also here you are located.

It is a good device.

It takes some time to get the equipment in place, we need to keep that in mind.

The drencher can cool from above, this tool can cool from side and from underneath.

We have used as a barrier, at it has worked quite well. Not for extinguishing purposes.

Drencher is working similar to battery car (EV) and gasoline car (ICEV). 10 mm/min.

Water shield:

It is a small piece of equipment, easy to carry. You can have it on each deck, in each corner.

We train it on trucks, to put it underneath the truck.

You can leave it and do something else that is needed.

Fire hoses:

25 mm hose. It is light and comfortable but does not give enough water. Could be good for initial attack. 25 mm hose you can manage with one person, other hoses you need two persons.

Other equipment:

IR cameras are also available and useful.

8 Development for guidelines

Main author of the chapter: Jaime Bleye,SAS

During several on-board visits, WP06 has studied the current conditions for first fire response. In addition, tests and other sources of information has been analyzed.

The fire equipment stored in the fire lockers (BA sets, fire suits, nozzles, hoses) does not belong to the proposed fire equipment for first responders.

Portable fire extinguishers will be stored all over the entire ship, and it is crucial to have them in mind for a first response intervention. According to own experience if firefighting media (water, dry chemical, CO₂ or foam) of a portable extinguisher (less than 20kg) is properly applied, they will be very effective for fires in the early or semi-developed fire stage.

Obviously, real fires simulations cannot be performed on board.

Generally speaking, crew members are fully aware that their own safety at sea will depend of their own level of performance. The larger the experience of the firefighter, the bigger chances to success.

On most ships visited within the Project, the crews report that anyone is allowed and urged to make the decision and to start the drenchers if they notice a fire, be they officers or ABs. However, neither formal procedures nor drills that we have observed reflect this.

First, in the drills we have observed, the practice seems to be that decision about drencher activation is taken by the formal fire leader on the bridge. It will often be the chief engineer that has the role of fire leader, and the coordination of fire management and the decision to activate drenchers tend to be the chief engineer's responsibility. On ships where the chief engineer musters to the engine control room, decisions of drencher activation are still made on the bridge, and orders are given from there to the chief engineer in the control room, if drenchers cannot be activated directly from the bridge.

Second, formal procedures for drencher activation may counter the statements that anyone are allowed and urged to make the decision and to start the drenchers. The facsimile below (Figure 8) clearly states that the decision and the command to start the drencher system must come from the bridge.

While the two conflicting 'stories' of who may make the decision and activate the drencher system may live well side by side under normal conditions, in an emergency situation there may be ambiguity associated with which rule to follow. In the case of ro-pax drencher activation, one could anticipate conflict of interpretation arising when initiative to activate the drenchers coming from other crew members than the fire commander on the bridge is confronted with operating instructions similar to the one in [Figure 8](#)

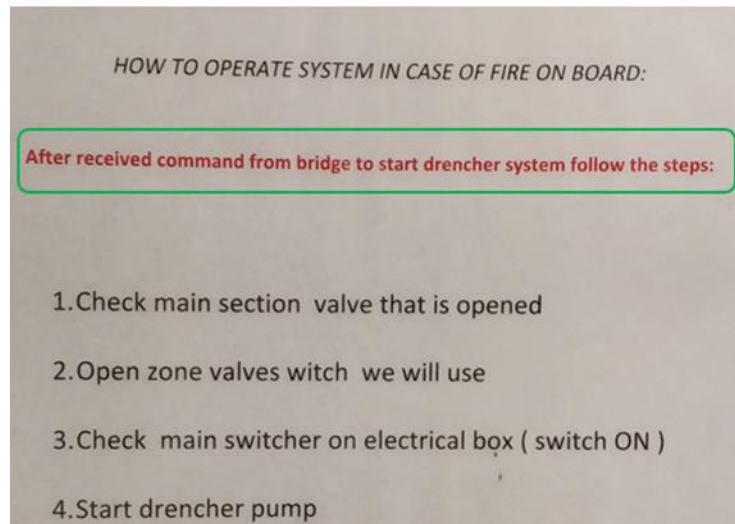


Figure 8. Facsimile of operating instructions for drencher system. Green square added by report authors.

9 Guidelines for effective first response firefighting tactics, gear and equipment

9.1 Introduction

The purpose of these guidelines is to support the first response tactics, gear, and equipment onboard ro-ro ships.

These guidelines are intended for those who work with fire management onboard ships, and in particular any crew member that may act as a first responder to fire.

This guideline is developed in the project LASH FIRE.



The project has received founding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 81497.

This guideline reflects only the authors' view and neither the Agency (CINEA) nor the members of the LASH FIRE consortium are responsible for any use that may be made of the information in this guideline."

9.2 Application

End users of current guidelines are crew members for newbuilt and existing ro-ro cargo ships, ro-pax ships and vehicle carriers.

9.3 Definitions and abbreviations

First response	The action to a fight a fire in the initial stage without specific protection (only working clothes).
First responder	Can be any crewmember acting in response to a fire (Passengers are not included in the task).
Designated first responder	Designated person, specially prepared for response activity, such as crew members with access to high-risk areas (e.g., a fire patrol member, an AB, or staff from the ECR).
High risk area	Specific space on a ro-ro ship where a fire is more likely to occur. Most of them are locked with restricted access (cargo spaces like main or car deck, bunkering stations, engine control room)
Fire in the initial stage	A fire that can be suppressed with a hand-held device. Approx. intensity 100 kW – 1 MW
AB	Able Seaman
CAF	Compressed Air Foam
DG	Dangerous Goods
ECR	Engine Control Room
IMDG	International Maritime Dangerous Goods
kW	kilowatt (watt is a measure of power)

MW Megawatt

MOC Manually Operated Call Point

OOW Officer on the Watch

PPE Personal Protective Equipment

9.4 Organization

- Any crew member may act as **first responder**. All crew should know how to raise the alarm and how to use a portable fire extinguisher.
- There should be more skilled personnel with access to restricted cargo spaces that should be trained as **designated first responders**.
- Awareness on raising the alarm is the first action to be taken. Different ways of raising the alarm are:
 - Via portable radio (UHF or VHF)
 - Through a manually operated call point (see Figure 9)
 - Via internal telephone
 - By shouting 3 times “FIRE, FIRE, FIRE” ensuring that another crew member has received the message that has to be transmitted to the OOW.



Figure 9. Manually Operated Call Point for raising the fire alarm. Ro-pax NAPOLIS January 2020

- The operator should establish a role description for **designated** first responder.
- Handheld portable fire extinguishers are efficient to put out a fire in the initial stage if you apply them correctly
- Special instructions for APV should be followed. Special focus on identifying type of vehicle, detection of risk indicators, safe approach, and thermal runaway confirmation.

- A standard communication terminology protocol should be used when raising the alarm to secure prompt understanding. Reference to IMO Standard Marine Communication Phrases

9.5 Gear & equipment

Equipment relevant for general first response activities should be readily available in proximity to possible fire scenes. the equipment should be available and ready for use:

- Extinguishers of different types are stipulated in SOLAS Ch II-2/10.3.



Figure 10. On-board disposal of hand-held (lighter than 20kg) portable fire extinguishers

- Absorbents and gear for handling leakages



Figure 11 . SOPEP equipment. NAPLES ro-pax. BALEARIA. Spain. January 2020

In addition, the **designated** first responder, should wear:

- Outer layer clothing, when approaching a plausible fire, wear long sleeve jacket/shirt and long trousers in a material that is not easily combustible. Typically, coverall material is good, fleece and polyester should be avoided. Clothing shall be clean, not stained with oily content or similar that increase combustibility. A set of thin material protective long sleeve gloves and safety footwear should also be worn when approaching a fire. The idea is to cover bare skin as much as possible. A radio for communication should always be carried. One complexity is the difference in conditions indoor/outdoor especially in bad weather and wintertime. Appointed crew member need be ready for first response action at all locations onboard. Another complexity is that in practice a fire patrol outfit may vary depending on the tasks to be performed before or after patrol round, be it mooring operations in wintertime or bridge outlook duties or something in between. Correct gear and training is important to give **designated** first responder courage and confidence to act.
- Fire patrol crew should wear the same clothing and equipment as the designated first responder, since it is expected that the fire patrol will carry out first response tasks when a fire is detected during patrol, or when triggered by bridge on other form of fire indication. Fire patrol shall also be equipped with two-way portable UHF/VHF radio, safety torch and handheld IR camera.

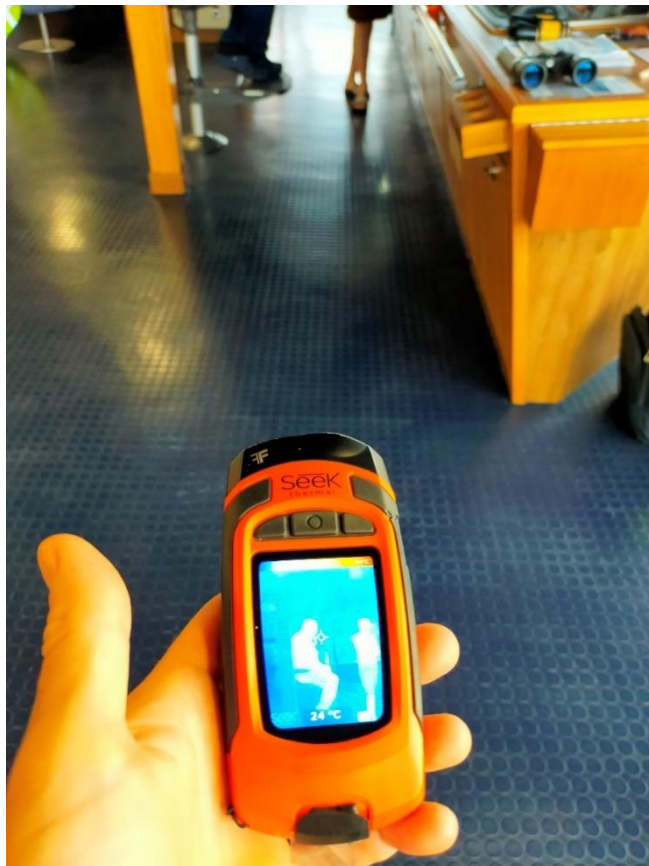


Figure 12. Handheld IR camera. Piece of equipment for fire patrol member. Ro-pax "BAHAMA MAMA" July 2020. Port of Malaga (Spain)

Technology that will show and alert the position of the first responders can be part of the equipment of the fire patrol member and therefore of the first response member. The technology consists of a Bluetooth camera with strap for helm connected to a rugged android device stored in a pocket (see Chapter 6.)

9.6 Efficient response & tactics

9.6.1 Actions to be taken as first responder in presence of a fire in the initial stage.

- i. Keep calm. Look for possible dangerous situations making a “place composition.” or quick risk assessment
- ii. Extract quick signs about the origin of the fire, smoke production and potential zones to be affected.
- iii. Report the presence of the fire by any means. Preferably with portable radio, pushing the MOCP or shouting “fire,fire,fire!”
- iv. Assess if a first response is possible in relation to the fire location and size, as well as your level of confidence and experience. If so,
- v. Grab the nearest portable extinguisher at hand. Make a quick check confirmation about the media inside the device and possible limitations like accessibility limitations or risks.
- vi. Keep a safe distance between the fire object (Minimum 1.5 meters)
- vii. Try to protect yourself from possible jet flames or sudden flash fire.
- viii. Apply all the extinguishing media trying to reach the base of the flames.
- ix. Make a quick evaluation if your action has made an impact on the fire.
- x. If fire continues, report again and start the drencher system.

9.6.2 Using handheld fire extinguisher

The instructions how to use a handheld fire extinguisher are:

- Pull out the safety pin.
- Aim at the base of the fire, keeping a safety distance between 1.5-5 meters.
- Use, if possible, a vehicle as a physical barrier between the first responder and the site of the fire. Bear in mind that the barrier should not preclude the application of the extinguishing media over the fire.
- Squeeze the top handle so that it releases the pressurized agent (Nitrogen) inside the extinguisher.
- Sweep from side to side until the fire is completely out (with the wind at your back for weather decks).
- Once the fire is out, keep an eye on the fire object in case it re-ignites.



Figure 13: Training. First responder in working clothes with handheld dry powder extinguishing to put out the fire in the early stage.

9.7 Activation of the drencher system

Although activation of drencher when the fire is confirmed is not considered a first response action; it is important to highlight the importance of the early activation of the drencher system if first response has not been effective or possible.

Activation of drencher must be an intermediate step before the deployment of the manual firefighting team.

9.7.1 Location from where drenchers are activated.

On different ships, there are different setups regarding possible locations for drencher activation. No standards apply, so different ships offer different possibilities both with respect to drencher pumps activation and section valves management.



Fig14. Example of drencher section valves. Colored code for sections.

9.7.2 Responsibility for drencher activation (decision and execution)

There shall be clear procedures for drencher activation. The Drencher should stop the fire to be spread to other vehicles or locations. Despite that drencher activation is not part of the first response action, the sooner the system will be triggered, the better. Therefore, once the fire would be confirmed, try a first response. If this fails, start the drencher without delay and prepare for the manual firefighting.

9.8 Training

Training on first response shall be included in every ship operator's procedures and compulsory fire drills for those crew members that will probably act as first responders in a real case. Crew members with insufficient training may put themselves at risk, make wrong decisions or actions.

First response training should be performed on board focusing on the familiarization with the ship's layout and configuration of spaces, disposal of "at-hand" firefighting devices for first response and proper gear and equipment.

Alternatively, specific hands-on firefighting training module beyond the compulsory STCW courses, can be performed at a specialized shore training centres so that first responders will gain confidence in the efficacy of portable fire extinguishers and will assess the real fire behaviour and its development in vehicles.

First response practice should be part of scheduled fire drills onboard for designated first responders.

Topics to consider regarding training for first response are as follows:

- Mental preparedness
- Awareness that the first action when discovering a fire is raising the alarm
- Physical preparedness (a fire extinguisher weigh about 9kg)
- Use of portable heat camera
- Ready for decision, clear instructions
- Familiarity with vessel, access ways and limitations, keys, radio shadows, marking of drencher zones

- Familiarity with, in each location, available firefighting extinguishers and locally stored PPE
- Skill to use different types of extinguishers, fire blankets and new types of equipment like CAF backpacks or smartphones for localization
- Awareness of how other functions in the safety organization work
- Communication skills including technology and terminology with standard phrases
- Self-protection, what to avoid and what to use
- Skills in different cargo types and its hazards
- Basic DG, IMDG knowledge and firefighting options and knowledge of the DG's storage
- Basic vehicle and cargo knowledge, main switch locations and specific hazards
- Electric power system awareness for reefers or charging of electric cars
- Awareness of experiences from other vessels and colleagues (lessons learnt)
- New crew members introduction and familiarization with the vessel is extremely important
- Transition period of new crew member until up and running, extra preparedness/overlap from other members of the watch
- Drencher activation procedures

10 Conclusion

Main author of the chapter: Jaime Bleye, SAS

A first responder can potentially be any crew member onboard that discovers a fire.

All crew members should have the competence to deal with a fire in its initial stage. The primary focus of the IMO marine firefighting training programs is to provide the crew with the knowledge and skills to confidently deal with a fire onboard during the initial stage complying the well-defined standards and requirements set in table A-VI/1-2 of the STCW Code.

To have a clear methodology and according to the instructions from the offshore sector, it should be stated that the first action to be taken when discovering a fire must be raising the alarm, regardless the fire size and position and then start first firefighting actions having considered the available equipment and limitations.

It is highly possible that the first responder would be a fire patrol member, who will be well familiarized with the vessel in terms of access, obstacles, and the best approach to reach adjacent spaces or even an AB or staff from the ECR. These personnel should boost the mental preparedness to act as designated first responders and they should be trained for it.

An efficient first response is a key factor to attack the fire in the initial stage and avoiding the escalation of a potential major fire. But many factors may affect the performance of an efficient first response, putting themselves at risk, such as:

- Preparation through theoretical knowledge and practical hands-on training.
- Experience and level of confidence. Not all crew members have the right profile to deal with an emergency, as some are more proactive and stress-tolerant than others.
- Adherence to clear written instructions. The working culture on the vessel such as decision making, trust, openness, blame culture etc. will influence the outcome.
- Physical barriers that can obstruct reaching the site of the fire, like accessibility between vehicles, visibility, or movement (rolling/pitching) of the ship due to bad weather.
- Failure during the communication with the OOW

In comparison with other firefighting activities like a manual firefighting operation, a first response will be supposed to be carried out by one single person who might be the fire patrol member or an AB on duty checking cargo spaces.

Extra bullet points from the current report are:

Context of first response: It is the action to fight a fire in the initial stage without specific protection.

Target group: Any crew member may act as first responders but there is a group of seafarers with access to the high-risk areas that will more likely act as first responder. We call them “designated first responders.”

Role description:

- xi. Keep calm. Look for possible dangerous situations making a quick risk assessment
- xii. Report the presence of the fire.
- xiii. Assess if a first response is possible in relation to the fire location and size, as well as your level of confidence and experience. If so,
- xiv. Grab the nearest portable extinguisher at hand. Make a quick check confirmation about the media inside the device and possible limitations like accessibility limitations or risks.
- xv. Keep a safe distance between the fire object (Minimum 1.5 meters)
- xvi. Try to protect yourself from possible jet flames or sudden flash fire.
- xvii. Apply all the extinguishing media trying to reach the base of the flames.
- xviii. Make a quick evaluation if your action has made an impact on the fire.

Relevant equipment for designated first responders: A first responder is not a planned task or position on board, it is a training and readiness to be useful in a specific situation. Therefore, there is not a specific equipment for them. There is a recommendation with regards clothing for wearing, non-flammable working clothes with long sleeve, safety shoes.

Communication protocol: Inform to the bridge/OOW about who you are, where you are and what is happening. If you don't have a radio apparatus with you or the radio coverage is poor, try to find other ways to raise the alarm like pushing the manually operated call point.

Special instructions for APVs: As APV are a reality on board it is important to identify the type of APV and the associated risks. In case a pressure relief valve from a gas tank or a TR from the battery will be triggered, a first response action **should not be performed**. As a proactive measure, if a TR is suspected. take an approach angle of approximately 45° to avoid being affected by a potential TR or jet flame and be prepared for further actions like drencher activation or manual firefighting.

Battery electric risks: If the vehicle is charging, disconnect the charger from the charging port. High voltage is still present in all lithium-ion battery packs even after fire. Do not touch, cut or open high-voltage (orange) cables, components or batteries. Avoid toxic gases and fumes produced during lithium-ion battery fires.

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13 ANNEXES

13.1 ANNEX A. Extracts of first response events from incidents and accident reports

*“Vessel was delayed at sailing time when a crew member reported vapour coming from a drum in a car trailer. Sailing was deferred pending investigation. The chief officer left the bridge to investigate. Engines were stopped. The driver of the vehicle was called down along with 2 artic drivers with the intention of removing the trailer from the vessel. The starboard stern door was opened, and the operations manager was called. While the C/O and the driver were discussing the source of the vapour the driver removed a polythene covering and there was an immediate flare up with dense smoke. **Crew members used 2 foam extinguishers and 1 dry powder extinguisher to suppress the burning contents of the drum.** The chief officer activated the drencher system for the appropriate zone. The crew were able to push the trailer off on to the linkspan ramp where the fire was completely extinguished. No one was injured and only 2 drivers were soaked by the drenchers. Passengers were kept informed throughout.”*

*“During loading operations in Dublin, the bosun notified the loading officer that when he tried to plug in the ship’s connection to a fridge trailer on deck 5, the unit and plug connection started to spark. Me and the loading officer then proceeded to deck 5 upon arriving at the trailer I could immediately see embers falling onto the deck, the bosun took another look and could see visible flames through a small vent in the bottom of the unit. I immediately informed the bridge and captain of the situation, the bosun informed shoreside and requested an empty tug to attend deck 5 to take the trailer off the deck. The bridge asked if we would have to go to incident stage, I was confident that the fire was small enough to be handled by an extinguisher and asked 2nd Officer where the nearest CO2 extinguisher was, she informed me of one in the Semsafe room, which I retrieved. The fire had not grown in size but was still burning and was visible through the bottom vents (as visible in the attached pictures, where the vent is white is where the CO2 was used). **I aimed the extinguisher at the vents and used short bursts until I was happy the fire was out we then opened the cabinet of the unit and we could see the fire was clearly out.** The tug driver was then waved in to take it off the deck and to the patch ashore, we gave him the extinguisher in case it reignited on the way down the ramp.”*

*“During changing over fridge unit from diesel to plug in, fridge started finally on plug in, and after few minutes the sparks came out , and small flame occurred. **Crew member disconnected plug in immediately, and completely switched off fridge unit.**”*

*“Seaman plugged in refrigerated trailer once it was parked on deck 5. When ships power was turned on the bosun noticed that the fridge started to spark and smoke. **The power was immediately turned off and the cable unplugged. A fire extinguisher was quickly collected in case it was required.** Smoking reduced. The patch was called to remove the trailer. Email sent to Dublin Port to inform them of the situation.”*

“Box Van WB 3897N requested a 5 Pin 440 V plug in off the Shore loader in HH and the Bosun was told this on deck 5. The box van was sent to deck 5 where he in fact needed a 3 pin 230 V plug in. The Bosun

*gave the Driver the ships cable for this and the driver plugged the unit in himself to ships supply. The Bosun advised him to remain at his vehicle for at least 10 mins to ensure his reefer was working correctly. The driver did this, told the Bosun he was satisfied and then went into the accommodation. A few mins later one of the loading crew noticed the vans reefer unit smoking and alerted the Bosun and bridge. The unit was immediately switched off and disconnected from the ships supply. The driver was also located and returned to the car deck. The unit continued to smoke, and as the loading was completed the box van could not be discharged ashore. Still smoking and the unit hot, **2 x fire Ext were discharged into the reefer**. The smoking then stopped and there was a marked reduction in the reefer's temperature. With the unit cooled and not smoking, car deck fans were started to clear the small amount of smoke and fumes. A fire watch was maintained on the unit for the rest of the passage, which passed without incident."*

*"While loading trailers in LRP one of the ABs noticed smoke and flames coming from under one of the trailers. He raised the Alarm and with the help of the other ABs on deck they managed to put the fire out before it could take hold **using a foam extinguisher from the blue stairwell DK3.**"*

*"In the early hours of 17th January there was a major fire in the lower hold of the vessel which burnt for nearly 6 hours and caused major damage to trucks and the vessel. The lower hold, deck 1, is below the main vehicle deck, deck 3, and the vehicle access is down two ramps, one at each end, from deck 3 which have hydraulically operated locking covers. At 02.39 a fire alarm sounded on the bridge and as per usual practice the watchman was sent down to investigate. The fire head involved was on the starboard side of 1 deck just forward of midships. The watchman found a fire behind the cab of an articulated lorry in front of the fifth wheel. He raised the alarm and **attacked the fire with fire extinguishers, but he was unable to extinguish it**. At 02.52 the drencher system was activated, the Mate Master (night master) was called to the bridge and the crew were called to emergency stations (Working party red). The Mate Master left for the fire station as he is in charge of the working party and the Master came to the bridge and took over on the bridge. EMPROC was activated, the Coast Guard and the port of Harwich, our destination, were informed and the ship proceeded in to port at maximum speed. A crew member was sent to unlock the lids to the lower hold in case the fire damaged the locks thus preventing the lids being opened later. At 03.00 two men in B.A. sets entered the lower hold but were unable to extinguish the fire. At 03.13 the first fire team left the lower hold and were replaced by another team. The general emergency alarm was sounded and the ship went to general emergency. Announcements were made for all passengers to proceed to the muster stations on deck 9. Further announcement to the passengers were made throughout the emergency to keep them informed. At 03.21 the second team exited believing the fire to be out however on further entry it was discovered that the fire had re-ignited and until the vessel docked further teams entered fighting the fire with the drenchers were running continuously. 19 breathing apparatus air bottles were used. The vessel arrived in Harwich at 05.14 and on arrival the Essex Fire Brigade took control of the situation. On arrival in Harwich the foot passengers were discharged via the gangway. Most vehicles and drivers were discharged immediately. First the freight vehicles on 3 deck and then the freight vehicles on 5 deck with the passenger cars on 3 deck last. The drivers of the trucks in the lower hold remained on board in the Taste Restaurant as we needed them with their keys to help us get the trucks out. The trailers which were mainly on deck 7 were discharged later. The fire brigade entered the space and on their instruction, we opened the ramp covers at around 06.30. The fire brigade informed us that the fire had finally been extinguished at 08.45. Once the smoke had cleared drivers were called down one by one so that their trucks could be unlocked and in some cases driven off. Of the 22 articulated trucks in the lower hold 9 appeared to be undamaged and 13 were damaged or completely burnt out. The lower hold was severely damaged, however the rest of the ship was unaffected. The last damaged vehicle, which was probably the one where the fire started, was removed at 17.30. The fire brigade*

eventually had 10 fire engines in attendance and they classified it as a major incident. The cause of the fire is not known at present.”

*“Small fire on reefer unit road train. When berthing at Kiel between 0905-0915 local time we get a fire push bottom indication from car deck 4 aft area. The engine and some of the deck crew observed the fire and immediately **start the firefighting with portable extinguishers and firehoses**. At 0915 just after the fire was put out, 2 crewmembers with smoke diving apparatus watched the unit until it was unloaded from the vessel. 3 crewmembers were sent to hospital in Kiel for medical check, due to inhalation of smoke.”*

*“A small fire occurred under the battery station of a truck driver unit. Cause is unknown. Watchman discovered smoke coming out of the unit, later saw flames coming out. Did not hesitate called the bridge for alarm and **extinguished the fire with a powder extinguisher**. Fire was directly out and under control. Chief Officer woke up the driver to get the keys if needed. Went to the scene and confirmed the fire is out.”*

*“The watchman, not being able to contact the bridge via radio (VHF), started to **extinguish the fire with a 50 kg transportable powder extinguisher**. He attempted to put out the fire approaching from the rear, left side of the truck, but powder jets did not reach the area of the flames.”*

13.2 ANNEX B. Example of WIFI coverage of cargo decks of a RoPax vessel

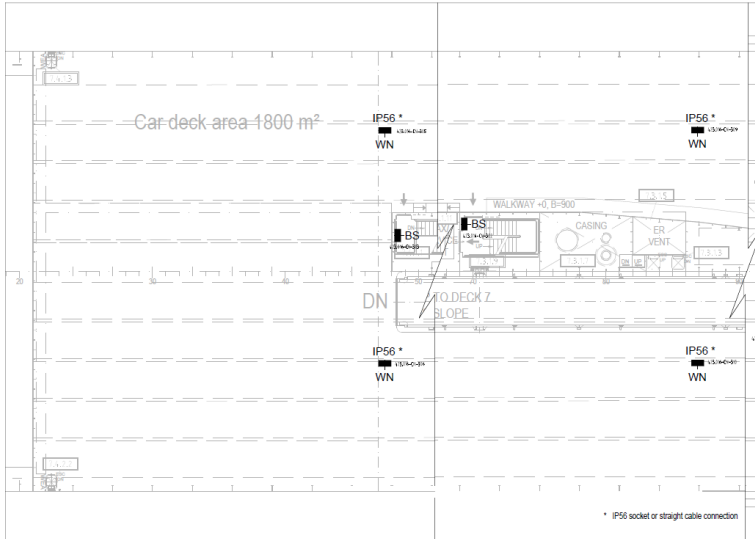


Figure 1. WIFI Access points (“WN”), car deck 7

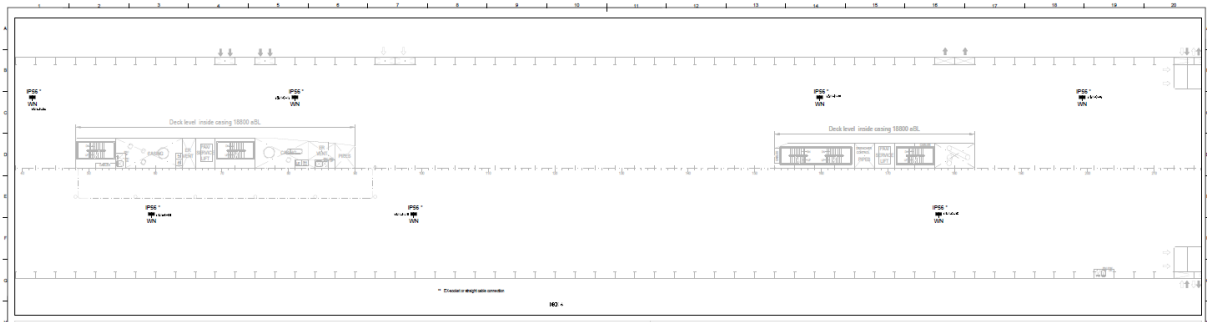


Figure 2. WIFI Access points (“WN”), cargo deck 5

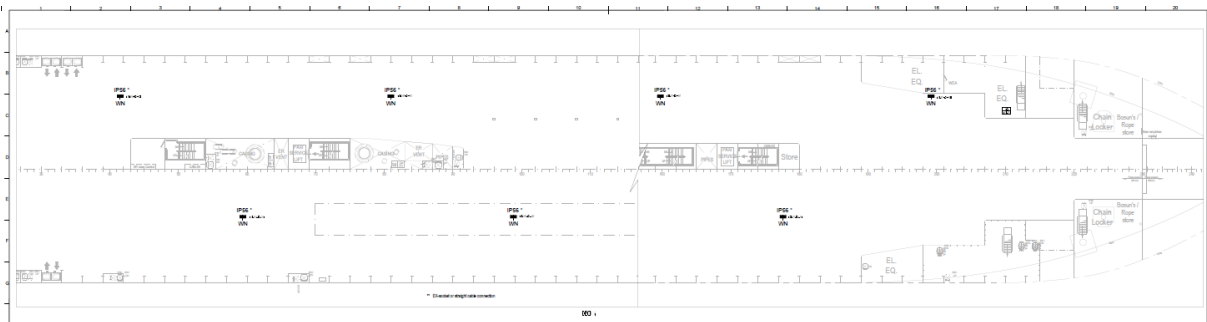


Figure 3. WIFI Access points (“WN”), cargo deck 3

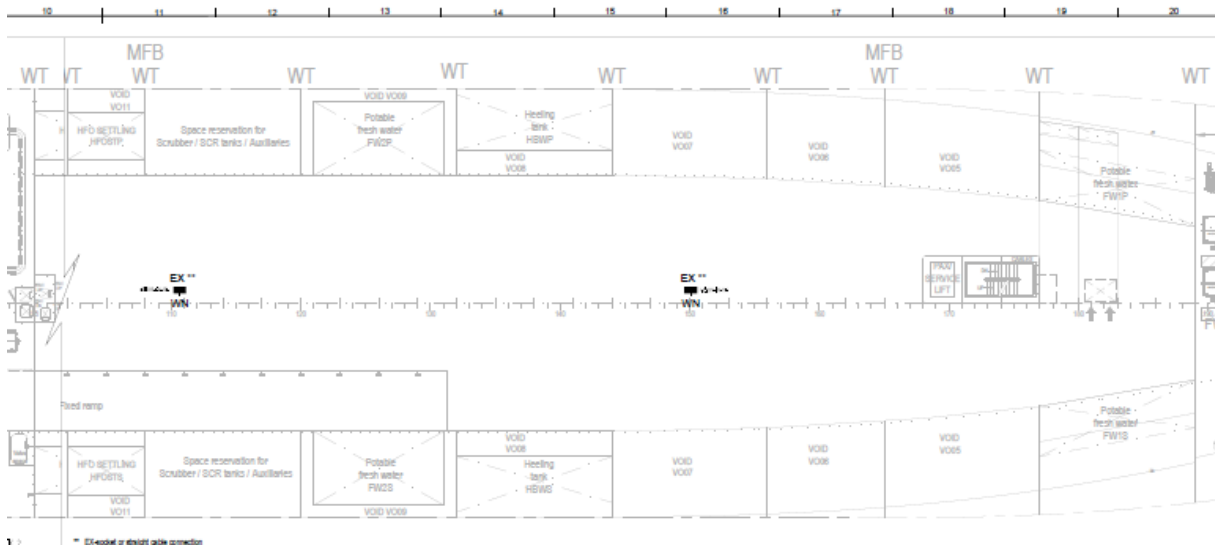


Figure 4. WiFi Access points (“WN”), cargo deck 1

13.3 ANNEX C. Sample of on-board Muster list for manual interventions beyond first response

Muster list - Skåne		StenaLine	
Version No.	1	Document ID.	SOM-2141
Revision Date.	2020-03-01	Page.	1

SOM chapter: 7.1

Validity: Skåne

SMM reference: SMM-0243

Assembly stations:
 Deck 7 Port Side – Lifeboat recess
 Deck 7 SB Side – Lifeboat recess

Muster list M/S SKÅNE
 To find your safety no, consult the appendix to this muster list
 All group leaders shall carry walkie-talkie

GENERAL EMERGENCY SIGNAL: ■■■■■■■■■■
 SEVEN OR MORE SHORT BLASTS FOLLOWED BY ONE LONG BLAST ON SHIPS WHISTLE OR SIREN. THIS SIGNAL WILL BE REPEATED ON THE SHIPS ALARM SOUNDER
 ALL PERSONS WILL PROCEED TO THEIR INCIDENT / EMERGENCY STATION AS LISTED BELOW
ABANDON SHIP SIGNAL: THE ORDER TO ABANDON SHIP WILL BE GIVEN VERBALLY BY THE MASTER OR OFFICER IN CHARGE OVER P/A
MANOVERBOARD SIGNAL: MANOVERBOARD SIGNAL WILL BE GIVEN VERBALLY BY THE OFFICER IN CHARGE OVER P/A. ASSIGNED PERSONNEL PROCEED TO MANOVERBOARD STATIONS'

BRIDGE TEAM Station: Bridge (Back up stn, Aft Bridge)	SAFETY TEAM 1 Fire station 4 (D 10) Fire fighting & Flooding Damage Control	SAFETY TEAM 2 Fire station 5 (O3) Fire fighting- & Flooding Damage Control	EVACUATION TEAM 1 Station 1 Reception	EVACUATION TEAM 2 Station 2 Conference room deck 10	EVACUATION TEAM 3 Station 3 Reception	LSA TEAM Station: Assembly station
101 Overall Command 201 Fire Chief (note 3) 301 I/C, Evacuation leader 103 External communication GMDS (note 1) 320 Communicator 102 LSA leader (note 2)	104 Team leader 113 Dep. Team leader 114 Fire Fighter 115 Fire Fighter 116 Fire Fighter	203 Team leader 212 Dep. Team leader 213 Fire Fighter 214 Fire Fighter 215 Fire Fighter	311 Team leader 312 Dep. Team leader 315 Assists	313 Team leader 314 Dep. Team leader 317 Assists	316 Team leader 318 Dep. Team leader 319 Assists	111 Team leader 117 Assists
CONTROL ROOM (Back up stn, Aft bridge)	119 Assists 120 Assists	215 Fire Fighter 216 Assists 217 Assists	320 Assists 324 Assists Evacuates deck 9 forward of the reception and deck 8	322 Assists 325 Assists Evacuates cabins on deck 10	321 Assists 323 Assists 326 Assists Evacuates cabins on deck 9	118 Assists Make ready/liferaising equipment, muster of passengers, hand out life jackets and blankets, seeing that they are suitably clad and have donned their lifejacket correctly

EVACUATION TEAMS ARE ALSO FIRST AID TEAM
 1. 2nd Officer '103' is responsible for closing of watertight doors, fire doors, valves, scuppers, sidescullies and other similar openings in the ship, this task may be delegated.
 2. Chief Officer '102' is to ensure that life-saving appliances are maintained in good condition and are ready for immediate use.
 3. Chief Engineer '201' is to ensure that fire-fighting equipment and fire appliances are maintained in good condition and are ready for immediate use.
 4. The members of the evacuation teams are to warn the passengers, assembling passengers at the muster stations, keeping order in the passageways and on the stairways, and generally controlling the movements of the passengers.

ABANDON SHIP

LIFEBOAT PORT	LIFEBOAT SB	RESCUEBOAT PORT	RESCUEBOAT SB	MES STATION PORT	MES STATION SB
102 Boat leader, Brings SART and VHF-radio 112 Dep. Boat leader 202 Engine attendant 204 Assists 212 Assists	101 Boat leader, Brings SART and VHF-radio 111 Dep. Boat leader 203 Engine attendant 201 Assists 211 Assists	104 Boat leader 114 Dep. Boat leader	103 Boat leader 115 Dep. Boat leader	116 Team leader 214 Dep. Team leader 314 Assists 316 Assists 318 Assists 301 Assists	113 Team leader 213 Dep. Team leader 313 Assists 315 Assists 317 Assists 319 Assists
320 Assists 118 Assists 120 Assists 216 Assists	117 Assists 215 Assists 119 Assists 217 Assists	MAN OVERBOARD Rescueboat port or sb is manned by Deck Officer off duty (Survival suit) AB on watch (Survival suit) AB on watch (Survival suit) Remaining deck crew prepares both rescue boats		322 Assists 324 Assists 326 Assists	321 Assists 323 Assists 325 Assists 326 Assists