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Deliverable D04.8

Impact on regulations by new solutions and consolidation of new proposals for regulations

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Abstract

The Formal Safety Assessment carried out in LASH FIRE requires the development of proposals for rule-making, based on the current International Maritime Organization (IMO) regulations and the technical basis provided by the project.

For this purpose, firstly, a regulatory review of the fourteen cost-effective Risk Control Options and five low-hanging fruits developed by the project was performed. The objective was to assess their compatibility with the existing IMO regulations, i.e., identify the relevant impacted IMO instruments, any potential conflicting regulations or barriers to their implementation.

Then, based on the final recommendations from the Development & Demonstration Work Packages, more than 20 proposals for regulations were developed in the form of amendments to the various IMO instruments. The regulatory proposals were developed in a way to be directly used by the IMO stakeholders and submitted to the relevant IMO bodies. As far as possible, the recent amendments drafted by IMO stakeholders were considered.

The present deliverable, D04.8, presents this work. It is the final deliverable of Work Package 4 *Formal Safety Assessment* and the conclusion of LASH FIRE objective 3:

“LASH FIRE will provide a technical basis for future revisions of regulations by assessing risk reduction and economic properties of solutions.”



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1 Executive summary

1.1 Problem definition

The LASH FIRE project aims to develop solutions to enhance fire safety in ro-ro spaces by the development of innovative technologies as well as by the modification of operations and applications. An evaluation of each solution developed in the project has been carried out, in line with the IMO Formal Safety Assessment (FSA) procedures [1]. This will support definition of recommendations to decision makers.

The development of recommendations for decision-making constitutes the step 5 (final) of an FSA. The recommendations are based on the results of the cost-effectiveness assessment. In LASH FIRE, the recommendations will be provided in the form of proposals for regulations, which should ease any future potential use of the results at IMO.

This work was done in parallel with IMO developments on the same topic. The context of recent IMO developments related to fire safety in ro-ro spaces is summarized in Chapter 4.

1.2 Technical approach

Firstly, a regulatory review of the cost-effective Risk Control options (RCOs) and low-hanging fruits (LHFs) (presented in Chapter 5) was performed (Chapter 6). The purpose was to assess their compatibility with the existing regulations, i.e., identify the relevant impacted IMO instruments, any potential conflicting regulations or barriers to their implementation.

Then, based on final recommendations from the Development & Demonstration (D&D) WPs, several proposals for regulations were developed in the form of amendments to the various IMO instruments. The regulatory proposals were developed in a way to be directly used by the IMO stakeholders (following the instructions provided in the IMO Circular MSC.1/Circ.1500/Rev.2) and submitted to the relevant IMO bodies. As far as possible, the recent amendments drafted by IMO stakeholders were considered.

1.3 Results and achievements

Fourteen cost-effective RCOs and five low-hanging fruits were reviewed regarding their regulatory compatibility.

More than twenty proposals for regulations were developed in the form of amendments to the various IMO instruments, i.e.:

- SOLAS Ch. II-1 Reg. 45 – *Precautions against Shock, Fire and Other Hazards of Electrical Origin*;
- SOLAS Ch. II-2, in particular, Reg. 15 – *Instructions, On-Board Training and Drills*, Reg. 16 – *Operations* and Reg. 20 – *Protection of Vehicle, Special Category and Ro-Ro Spaces*;
- FSS Code;
- STCW Code; or
- IMO Circulars.

1.4 Contribution to LASH FIRE objectives

The IMO strategic plan for 2018-2023 highlights the importance of integrating new and advancing technologies in the regulatory framework. One of the objectives of LASH FIRE is to support the aforementioned strategic plan regarding marine accident response, in part through this deliverable. This deliverable will furthermore lay the groundwork for achieving the LASH FIRE objective 3:

LASH FIRE will provide a **technical basis** for future revisions of regulations by **assessing risk reduction and economic properties of solutions**.

This is particularly achieved by contributing to the goal of action 4-C:

Cost-effectiveness assessment results exploitation: Preparation of guidelines and **proposals for rule-making**, based on current regulations and the technical basis provided by the project, as well as application, as far as practicable, of the FSA methodology for evaluation of new fire safety solutions developed in the project.

1.5 Exploitation and implementation

The proposals can be used by any IMO Member State for submission to the relevant IMO bodies.

They may be also used by Classification Societies or Insurance Companies for the development of their own rules.

2 List of symbols and abbreviations

AFV	Alternative Fuel Vehicle
APV	Alternatively Powered Vehicle
CCTV	Closed-Circuit Television
Circ.	IMO Circular
CO ₂	Carbon dioxide
CRS	Closed ro-ro space
D&D WPs	Development and Demonstration Work Packages
DG	Dangerous Good
DPA	Designated Person Ashore
ECR	Engine Control Room
EEBD	Emergency Escape Breathing Device
EMSA	European Maritime Safety Agency
EV	Electric Vehicle
Ex	Existing ships
FP	Fire Protection
FRP	Fibre Reinforced Plastic
FSA	Formal Safety Assessment
FSI	IMO sub-committee on Flag State Implementation, now named III
FSS	Fire Safety Systems code (IMO)
FTP	Fire Test Procedures code (IMO)
GA	General Arrangement
ICEV	Internal Combustion Engine Vehicle
IACS	International Association of Classification Societies
III	IMO sub-committee on Implementation of IMO Instruments
IMO	International Maritime Organization
ISO	International Organization for Standardization
ISM	International Safety Management code (IMO)
LSA	Life-Saving Appliances
MSC	IMO Maritime Safety Committee
NB	Newbuildings
OOW	Officer On the Watch
ORS	Open ro-ro space
PPE	Personal Protective Equipment
Q&A	Questions and Answers
RCM	Risk Control Measure
RCO	Risk Control Option
REC	Reflection, Evaluation and Change
Ro-Pax	Ro-ro passenger ships
Ro-Ro	Ro-ro cargo ships
SMS	Safety Management System
SOLAS	International convention for the Safety Of Life At Sea (IMO)
SSE	IMO sub-committee on Ship Systems and Equipment
STCW	International convention on standards of Training, Certification and Watchkeeping of seafarers and code (IMO)
TRL	Technology Readiness Level

UHF	Ultra High Frequency
UR	Unified Requirements (IACS)
VC	Vehicle carriers
VTS	Vessel Traffic Service
WD	Weather deck

3 Introduction

Main author of the chapter: Eric De Carvalho, BV

Started in 2019, the LASH FIRE project funded by the European Union's Horizon 2020 research and innovation programme aims at providing a technical basis for future revisions of regulations by assessing risk reduction and economic properties of design and operational solutions for all types of ro-ro ships and all types of ro-ro spaces. Throughout the project, an evaluation of the developed safety solutions has been conducted in line with the IMO Formal Safety Assessment (FSA) methodology.

Development of recommendations for decision-making constitutes step 5 (the final step) of the FSA, as described in the IMO FSA guidelines [1]. It aims at exploiting the results of the cost-effectiveness assessment (step 4 of FSA) in order to define recommendations which should be presented to the relevant decision makers in an auditable and traceable manner.

In LASH FIRE, the cost-effective Risk Control Options (RCOs) and low-hanging fruits of LASH FIRE were further assessed against the current state of the regulations to identify the relevant IMO instruments and any potential conflicting regulations or barriers to their implementation. Then, the recommendations for decision-making were drafted in the form of new proposals for regulations. This form eases any future potential use of the results at IMO.

This document summarizes the development of recommendations for decision-making. Chapter 4 summarizes the recent IMO developments related to the fire safety in ro-ro spaces. Chapter 5 recaps the main steps of the FSA study conducted in LASH FIRE and the final results of the cost-effectiveness assessment. Chapter 6 details the regulatory review and compatibility of each cost-effective RCOs and low-hanging fruits. Lastly, Chapter 7 provides the recommendations for decision-making (i.e., new proposals for regulations).

4 Recent IMO developments

Main author of the chapter: Eric De Carvalho, BV

Reference is also made to deliverable D03.5 “First proposal on updated rules and regulations on fire safety” [2], which also provides a summary of recent IMO developments in a different way.

4.1 General fire safety in ro-ro spaces of ro-ro passenger ships

4.1.1 Challenge

Ro-ro passenger ships are an important component of the global transportation system and one of the most successful types of vessels today. However, the ro-ro spaces (including weather decks where vehicles are stowed) represent a great challenge in terms of fire safety. Those spaces occupy a large proportion of the ship, without any vertical structural fire protection between them and, for weather decks, without any fire detection and fixed fire-extinguishing system. A moderately sized fire can spread rapidly throughout a deck and into adjacent vehicle stowage areas (FSI 20/5/3 [3]). There was a number of significant fire incidents on ro-ro passenger vehicle decks from 1994 to 2011 and there was no sign of these diminishing during this period (Figure 1) (FSI 21/5 [4]).

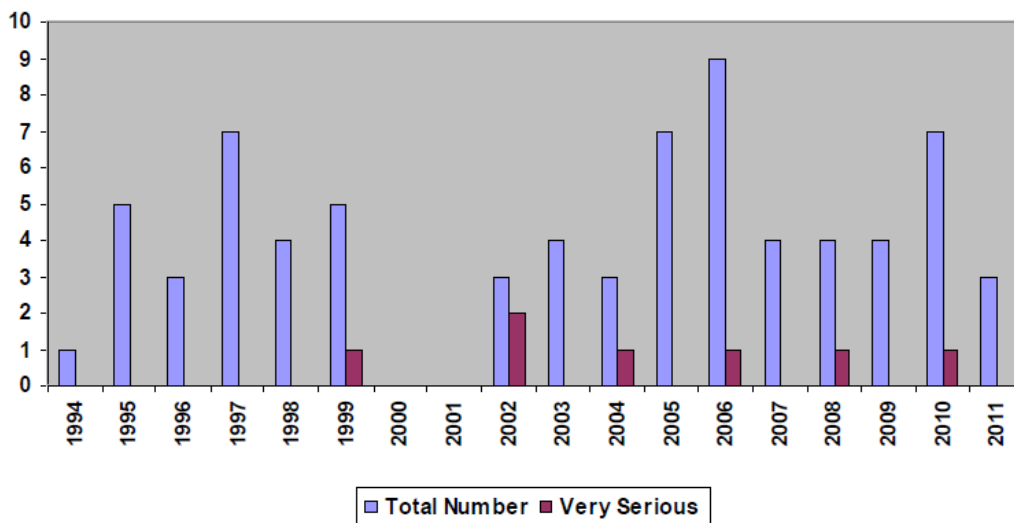


Figure 1. Ro-Ro passenger vehicle deck fires 1994-2011 [4].

4.1.2 IMO response

In November 2016, based on a proposal from the European Commission, the Maritime Safety Committee (MSC) agreed to include a new output “Review of SOLAS Chapter II-2 and associated codes to minimize the incidence and consequences of fires on ro-ro spaces and special category spaces of new and existing ro-ro passenger ships” in the agenda of the Sub-Committee on Ship Systems and Equipment (SSE) (MSC 97/19/3 [5]).

In March 2017, the SSE Sub-Committee drafted a work plan and agreed on a two-step approach for the new output (SSE 4/WP.5 [6]):

- To develop an interim guideline; and then
- To develop amendments to SOLAS Chapter II-2 and the associated codes.

It was decided that the work should address the full chain of the fire safety, i.e.:

1. Prevention of ignition;
2. Detection and decision;

3. Extinguishment;
4. Containment; and
5. Integrity of Life-Saving Appliances (LSA) and evacuation.

After three SSE Sub-Committees (SSE4, 5 and 6 from 2017 to 2019) and the establishment of a Correspondence Group on Fire Protection (FP), the MSC approved in June 2019 the “Interim guidelines for minimizing the incidence and consequences of fires in ro-ro spaces and special category spaces of new and existing ro-ro passenger ships” (MSC.1/Circ.1615 [7]). The circular provides a set of fire safety technical and operational recommendations. It is to be noted, however, that it sets out guidelines and is therefore applicable only on a voluntary basis.

In parallel, from 2016 to 2018, the European Maritime Safety Agency (EMSA) contracted Bureau Veritas, RISE, and Stena to conduct the FIRESAFE I and FIRESAFE II studies [8, 9] in order to investigate cost-effective measures for reducing the risk from fires on ro-ro passenger ships. 21 RCOs were investigated and assessed. In November 2019, the FIRESAFE studies were reviewed by the IMO’s FSA Expert Group according to the terms of reference of the Experts Group provided in the IMO FSA guidelines [1] and the outcomes of the review were reported to the SSE Sub-Committee (SSE 7/6 [10]). In addition, the final recommendations for decision-making from the FIRESAFE studies were reported to SSE7 by the European Commission (SSE 7/6/1 [11]).

In March 2020, the SSE Sub-Committee re-established the Correspondence Group on FP to draft amendments to SOLAS Chapter II-2 and the associated codes (SSE 7/WP.4 [12]). Given the complexity of the task, the Correspondence Group initially focused on selected items from SSE 7/6/1 [11] that were deemed appropriate for new ro-ro passenger ships constructed on or after 1 January 2024:

1. Restricting or banning of side and end openings;
2. Combined heat and smoke detection;
3. Decision related RCOs;
4. Fire monitors on weather decks;
5. Safety distance between LSAs and openings;
6. Closed-circuit television (CCTV) in ro-ro spaces;
7. Fire detection system for weather decks; and
8. Containment.

Topics related to training, operations, or Alternatively Powered Vehicles (APVs)¹ were discussed but not fully addressed. The Correspondence Group worked for three years drafting new amendments for new and existing ro-ro passenger ships.

In March 2022 and in March 2023, the proposed amendments to SOLAS Chapter II-2/20 and FSS Code Chapter 7 and 9 were reported to the SSE Sub-Committee (SSE 9/WP.4, Annex 1 and 4 [13]), including:

- A. “Weather decks intended for carriage of vehicles” will be addressed in SOLAS Chapter II-2/20;
- B. Fire patrols shall be maintained (and no more an alternative to fixed fire detection system) in special category spaces;
- C. For new ro-ro passenger ships – constructed on or after 1 January 2026 (if adopted before 1 July 2024 by MSC):

¹ In this report, Alternatively Powered Vehicles (APVs) and Alternative Fuel Vehicles (AFVs) mean the same.

- Combined smoke and heat detectors in closed and open ro-ro spaces and enhanced fire alarm interface. Linear heat detectors accepted as an alternative to point heat detectors;
 - Fixed fire detection system on weather decks;
 - Video monitoring in closed and open ro-ro spaces;
 - Specification of structural fire protection of decks within ro-ro spaces when the drencher system cannot cover both levels;
 - Arrangement of openings in ro-ro and special category spaces;
 - Arrangement of weather deck intended for the carriage of vehicles;
 - Fixed water-based fire-extinguishing on weather decks based on monitor(s); and
 - Suitable signage and marking aligned with drencher zones/fire detection and fire alarm sections/video monitoring in closed and open ro-ro spaces.
- D. For existing ro-ro passenger ships – first survey after 1 January 2028 as the implementation date (if adopted before 1 July 2024 by MSC):
- Combined smoke and heat detectors in closed and open ro-ro spaces;
 - Video monitoring in closed and open ro-ro spaces;
 - Fixed water-based fire-extinguishing on weather decks based on monitor(s); and
 - Suitable signage and marking aligned with drencher zones and video monitoring in closed and open ro-ro spaces.
- E. For new ro-ro cargo ships and vehicle carriers – constructed on or after 1 January 2026:
- Linear heat detectors accepted as an alternative to point heat detectors.

The work on the output had been completed by the SSE Sub-Committee. The draft amendments were finalized and approved by MSC107 (June 2023), with a view to adoption at MSC108 (April 2024).

4.1.3 Conclusion

The IMO amendments related to general fire safety in ro-ro spaces of ro-ro passenger have been finalized. The proposed measures address the ro-ro passenger ships, mostly new ships and are mainly technical.

The LASH FIRE project goes a step beyond the IMO amendments, addressing:

- All types of ro-ro ships (not only ro-ro passenger ships, but also ro-ro cargo ships and vehicle carriers);
- Further areas and both technical and operational measures; and
- Further specifications to the IMO amendments.

4.2 Fire safety in ro-ro spaces reducing the fire risk of ships carrying new energy vehicles

4.2.1 Challenge

The decarbonisation of road vehicles is inherent to the change of fuel type of vehicles: from Internal Combustion Engine Vehicles (ICEVs) to Alternatively Powered Vehicles (APVs), such as electric vehicles (EV) or hydrogen fuelled vehicles. It directly leads to a transformation of the cargo transported by the ro-ro ships and may draw new fire safety challenges. As an example, some fire accidents involving EVs on board ro-ro ships were reported in the past years (Pearl of Scandinavia in 2010, Felicity Ace in 2022, and Ah Shin in 2023).

4.2.2 IMO response

In May 2014, the MSC adopted the regulation 20-1 “Requirements for Vehicle Carriers Carrying Motor Vehicles with Compressed Hydrogen or Natural Gas in their Tanks for their Own Propulsion as Cargo” of SOLAS Chapter II-2 (MSC 93/3 [14]). This regulation provides additional safety measures for vehicle carriers with vehicle and ro-ro spaces intended for carriage of motor vehicles with compressed hydrogen in their tanks for their own propulsion as cargo.

More recently, and in parallel to the output related to general fire safety in ro-ro spaces of ro-ro passenger ships (discussed in section 4.1), China raised the topic of the carriage of electric vehicles (EVs) powered by lithium-ion batteries to the SSE Sub-Committee (SSE 5/7/4 [15]). Two years later, several fire safety proposals were provided (SSE 7/6/6 [16]). In parallel, the Correspondence Group on FP of SSE Sub-Committee discussed the implications on the fire safety of ro-ro spaces from new type of vehicles, such as battery powered electric vehicles and alternatively fuelled vehicles. In particular, there were concerns with regard to extinguishment, training and proper fire-fighter outfits (SSE 7/WP.4 [12]).

Finally, in April 2022 and based on a proposal from China (MSC 104/15/19 [17]), the MSC agreed to include in its post-biennial agenda an output #193 on "Evaluation of adequacy of fire protection, detection and extinction arrangements in vehicle, special category and ro-ro spaces in order to reduce the fire risk of ships carrying new energy vehicles", assigning the SSE Sub-Committee as the associated organ (MSC 105/WP.1/Rev.1 [18]). In March 2023, the SSE Sub-Committee recalled that MSC105 had agreed to include, in its post-biennial agenda, the output #193, the output was included by MSC107 to the provisional agenda for SSE10 (SSE10 to be held in March 2024).

It should be noted that several initiatives addressing safe transportation of APVs in ro-ro spaces have been launched in parallel to the IMO development. In May 2022, EMSA issued a guidance for the safe carriage of Alternative Fuel Vehicles (AFVs) in ro-ro spaces of cargo and passenger ships [19]. Several classification societies are adapting their own rules to this challenge. In January 2023, Bureau Veritas issued an additional class notation, EVOC, related to charging of electric vehicles on board ro-ro passenger ships (NR467, Pt F, Ch 12, Sec 9 [20]).

4.2.3 Conclusion

By investigating and assessing several measures related to the fire safety of new energy vehicles (e.g., safe electrical connection, equipment and strategies for manual fire-fighting), the LASH FIRE project can feed the IMO output #193 on this topic.

5 Cost-effective Risk Control Options

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FSA is a structured and systematic methodology, aimed at enhancing maritime safety by using risk analysis and cost-effectiveness assessment. It is used as a tool to help in the evaluation of new IMO regulations for maritime safety, while achieving a trade-off between maritime safety and costs [1].

FSA consists of the following steps (Figure 2):

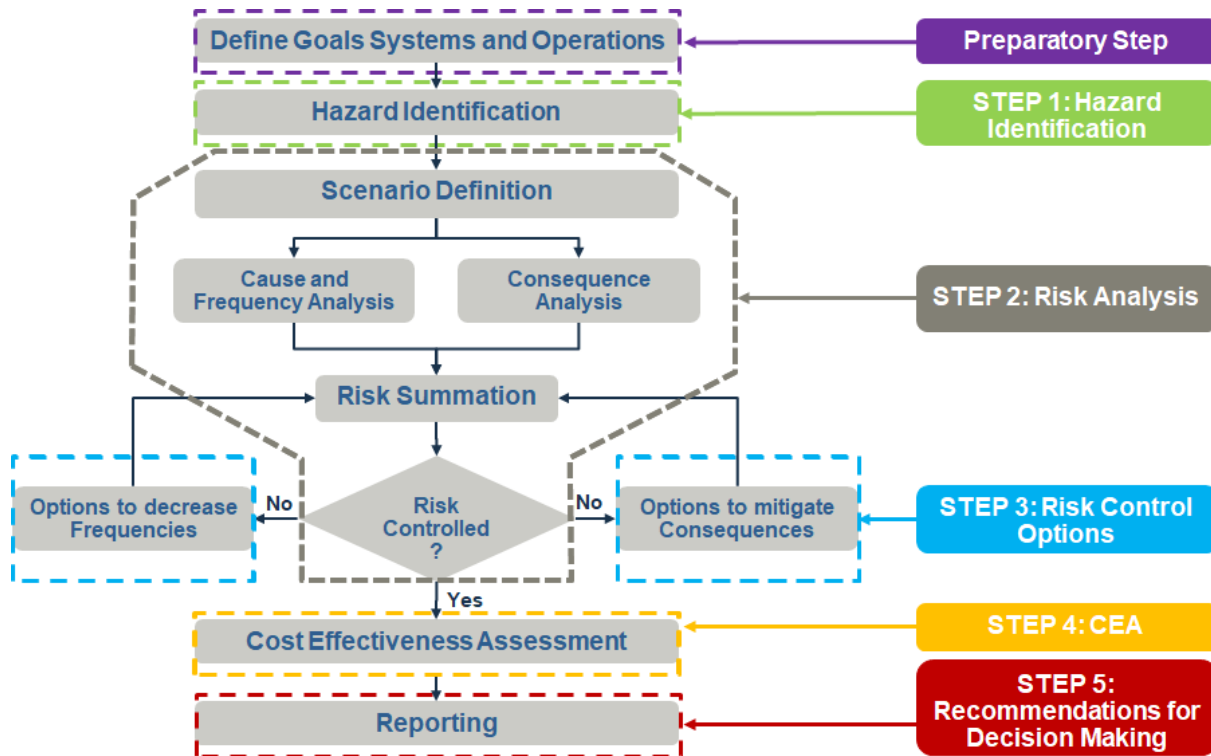


Figure 2. FSA flow chart.

All the above steps were addressed in LASH FIRE in order to provide a technical basis for future revisions of regulations by assessing cost-effectiveness of RCOs. The selection, definition, and assessments of the RCOs were summarized in the deliverable D04.6 “Cost-effectiveness assessment report” [21].

The results of the cost-effectiveness assessment were provided in deliverable D04.6 [21] and deliverable D04.7 “Cost-effectiveness assessment report: Uncertainty and sensitivity analysis report” [22].

An important feature of the RCOs for the end users are their maturity of the solutions and their readiness to be implemented on board ships. The Technology Readiness Level (TRL) is a good indicator for such a role. ANNEX A: Technology Readiness Level is provided the TRL of each RCO reached at the end of the LASH FIRE project.

A qualitative evaluation of RCO interdependencies is provided in ANNEX B: Interdependency matrix in the form of a matrix.

The relationship between the FSA steps and the LASH FIRE deliverables is provided in Table 1.

Table 1. FSA steps and LASH FIRE deliverables

FSA steps [1]	LASH FIRE deliverables
1 – Identification of hazards	D04.1 – Review of accident causes and hazard identification workshop report
2 – Risk analysis	D04.2 – Ro-ro space fire database and statistical analysis report D04.3 – Simulation tool for consequence quantification D04.4 – Holistic risk model D04.5 – Development of holistic risk model report
3 – Risk control options	D04.9 – Preliminary impact of solutions and related testing and demonstrations plan D04.6 – Cost-effectiveness assessment report (section 4, 5, 6)
4 – Cost-benefit assessment	D04.6 – Cost-effectiveness assessment report D04.7 – Cost-effectiveness assessment report: Uncertainty and sensitivity analysis report
5 – Recommendations for decision-making	D04.8 – Impact on regulations by new solutions and consolidation of new proposals for regulations

The following was concluded:

1. Ro-ro passenger ships - Newbuildings:

Thirteen RCOs were found cost-effective in terms of life safety, saving the cargo and the ship.

2. Ro-ro passenger ships - Existing ships:

Nine RCOs were found cost-effective in terms of life safety, saving the cargo and ship and two RCOs in saving the cargo and the ship.

3. Ro-ro cargo ships - Newbuildings:

No RCO was found cost-effective in terms of life safety but six RCOs were found cost-effective in saving the cargo and the ship.

4. Ro-ro cargo ships - Existing ships:

No RCO was found cost-effective in terms of life safety but two RCOs were found cost-effective in saving the cargo and the ship.

5. Vehicle carriers - Newbuildings:

No RCO was found cost-effective in terms of life safety but seven RCOs were found cost-effective in saving the cargo and the ship.

6. Vehicle carriers - Existing ships:

No RCO was found cost-effective in terms of life safety but two RCOs were found cost-effective in saving the cargo and the ship.

Table 2 and Table 3 summarize the final cost-effectiveness results for all RCOs.

Table 2. Cost-effective RCOs in terms of life safety. CRS = closed ro-ro space, ORS = open ro-ro space, WD = weather deck, NB = newbuildings, Ex = existing ships, Impr. = improved, localiz. = localization, activat. = activation, exting. = extinguishment

Ref	Designation	Cost-effective in terms of life safety?					
		Ro-pax		Ro-ro cargo		Vehicle carrier	
		NB	Ex	NB	Ex	NB	Ex
RCO 1	Impr. fire patrol. Impr. fire confirmation & localiz.	Yes	Yes	No	No	No	No
RCO 2	Impr. signage and markings for effective localiz.	Yes	Yes	No	No	No	No
RCO 3	Developed efficient first response	Yes	Yes	No	No	No	No
RCO 4	Developed manual firefighting for APVs	Yes	Yes	No	No	No	No
RCO 5	Alarm system interface prototype	Yes	Not assessed	No	Not assessed	No	Not assessed
RCO 6	Process [...] for efficient activation of exting.	Yes	Yes	No	No	No	No
RCO 7	Training module for efficient activat. of exting.	Yes	Yes	No	No	No	No
RCO 8	Safe electrical connection for reefers	Yes	Yes	No	No	Not assessed	Not assessed
RCO 9	Safe electrical connection of reefers and EVs	Yes	Yes	Not assessed	Not assessed	Not assessed	Not assessed
RCO 10	Fire detection on weather decks	No	No	No	No	Not assessed	Not assessed
RCO 11	Alternative fire detection in CRS & ORS	Yes	Not assessed	No	Not assessed	No	Not assessed
RCO 12	Visual system for fire confirmation and localiz.	Yes	Yes	No	No	No	No
RCO 13	Dry-pipe sprinkler system for VC	Not assessed	Not assessed	Not assessed	Not assessed	No	Not assessed
RCO 14	Remote.-control. fire monitor using water for WD	Yes	Note 1	No	No	Not assessed	Not assessed
RCO 15	Autonomous fire monitor using water for WD	Yes	Note 2	No	No	Not assessed	Not assessed
RCO 16	Guideline for fire ventilation in CRS	No	No	No	No	Not assessed	Not assessed
Note 1 Found cost-effective for the generic ship. Medium confidence in this result. Found not cost-effective for some weather deck arrangements. Further evaluation needed to conclude.							
Note 2 Found not cost-effective for the generic ship. Medium confidence in this result. Found cost-effective for some weather deck arrangements. Further evaluation needed to conclude.							

Table 3. Cost-effective RCOs in saving cargo, and in saving the ship. CRS = closed ro-ro space, ORS = open ro-ro space, WD = weather deck, NB = newbuildings, Ex = existing ships, Impr. = improved, localiz. = localization, activat. = activation, exting. = extinguishment

Ref	Designation	Cost-effective in saving cargo and ship?					
		Ro-pax		Ro-ro cargo		Vehicle carrier	
		NB	Ex	NB	Ex	NB	Ex
RCO 1	Impr. fire patrol. Impr. fire confirmation & localiz.	Yes	Yes	Yes	Yes	Yes	Note 4
RCO 2	Impr. signage and markings for effective localiz.	Yes	Yes	Note 3	No	Yes	Note 4
RCO 3	Developed efficient first response	Yes	Yes	Yes	Yes	Yes	Yes
RCO 4	Developed manual firefighting for APVs	Yes	Yes	Note 3	No	Yes	Note 4
RCO 5	Alarm system interface prototype	Yes	Not assessed	Yes	Not assessed	Yes	Not assessed
RCO 6	Process [...] for efficient activation of exting.	Yes	Yes	Yes	No	Yes	Yes
RCO 7	Training module for efficient activat. of exting.	Yes	Yes	Note 3	No	Yes	Note 4
RCO 8	Safe electrical connection for reefers	Yes	Yes	No	No	Not assessed	Not assessed
RCO 9	Safe electrical connection of reefers and EVs	Yes	Yes	Not assessed	Not assessed	Not assessed	Not assessed
RCO 10	Fire detection on weather decks	Note 2	No	No	No	Not assessed	Not assessed
RCO 11	Alternative fire detection in CRS & ORS	Yes	Not assessed	No	Not assessed	No	Not assessed
RCO 12	Visual system for fire confirmation and localiz.	Yes	Yes	No	No	No	No
RCO 13	Dry-pipe sprinkler system for VC	Not assessed	Not assessed	Not assessed	Not assessed	No	Not assessed
RCO 14	Remote.-control. fire monitor using water for WD	Yes	Yes	Yes	No	Not assessed	Not assessed
RCO 15	Autonomous fire monitor using water for WD	Yes	Yes	Yes	No	Not assessed	Not assessed
RCO 16	Guideline for fire ventilation in CRS	No	No	No	No	Not assessed	Not assessed
Note 2 Found not cost-effective for the generic ship. Medium confidence in this result. Found cost-effective for some weather deck arrangements. Further evaluation needed to conclude.							
Note 3 Negative NCAF, low ΔRisk and low ΔCost-ΔBenefits for the generic ship. High confidence in these results. Found not cost-effective in some ship arrangements. Further evaluation needed to conclude.							
Note 4 Negative NCAF, low ΔRisk and low ΔCost-ΔBenefits for the generic ship. Medium confidence in these results. Further evaluation needed to conclude.							

In addition to the cost-effective RCOs, low-hanging fruits (i.e. measures directly recommendable, without the need of a quantitative cost-effectiveness assessment) were identified during the RCOs workshop (refer to deliverable D04.6 [21] for more details) and should be addressed as potential proposals for regulation amendments. The low-hanging fruits are listed in Table 4. A description of all Risk Control Measures (RCMs), including low-hanging fruits, can be found in deliverable D04.9 “Preliminary impact of solutions and related testing and demonstrations plan” [23] or in deliverable D04.10 “Consolidation of performance assessments and solutions’ impact on safety” [24].

Table 4. List of low-hanging fruits. NB = Newbuildings. Ex = Exiting ships

ID	Title of RCM	Ship types	Ro-ro space types	NB + Ex?
Pre5	Proposal for requirements of surface materials in ro-ro spaces, with reference to suitable test method and material property performance criteria	Ro-Pax, ro-Ro, VC	CRS, ORS, WD	NB + Ex
Ext5	Development of a relevant fire test standard for alternative fixed water-based fire-fighting systems intended for ro-ro spaces and special category spaces	Ro-Pax, Ro-Ro	CRS, ORS	NB
Cont9	Ship manoeuvring/operation to limit the effect of fire at least in critical areas	Ro-Pax, Ro-Ro, VC	CRS, ORS, WD	NB + Ex
Cont10	Safety distances between side and end openings and critical areas	Ro-Pax, Ro-Ro	ORS	NB + Ex
Cont11	Guidance on calculation of side openings in ro-ro spaces	Ro-Pax, Ro-Ro	CRS, ORS	NB

6 Regulatory review

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A regulatory review for the 20 D&D actions was already conducted and summarized in deliverable D05.6 “Ship integration requirements” [25] and in the various D&D deliverables, as starting point of the action developments.

This section provides a more detailed review of the existing regulations in order to assess the compatibility of the cost-effective RCOs and low-hanging fruits with the existing regulations, and to identify any potential conflicting regulations or barriers to their implementation. This supports the development of new proposals in Chapter 7.

In general, the regulatory review performed in the present section takes into account:

- Relevant IMO Conventions and Codes into force, including:
 - SOLAS – International Convention of the Safety of Life at Sea, especially SOLAS Chapter II-2/20;
 - ISM Code – International management code for the safe operation of ships and for pollution prevention;
 - STCW Code – Seafarers’ Training, Certification and Watchkeeping.
- IMO Circular 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;
- Planned amendments to SOLAS Chapter II-2, FSS Code and MSC.1/Circ.1430 as described in SSE9/20 annexes 5 and 6².

6.1 RCO1: Improved fire patrol. Improved fire confirmation & localization

RCO1 is providing recommendations regarding the role, tasks, conditions of performance/equipment for the fire patrol member and the runner, as well as the communication between the bridge and them.

The fire patrol member is in charge of ensuring that there are no issues on board from the security/safety side via periodic safety routes, whereas the runner is in charge of confirming or disconfirming the existence of a fire after a fire detection. Often the role of the fire patrol and the role of the runner will be held by same person. Therefore, RCO1 provides the same recommendations for the fire patrol member and the runner, as far as practicable.

6.1.1 Requirement for fire patrols

SOLAS Ch. II-2 Reg. 7.8 requires “efficient fire patrols” to be organized onboard passenger ships carrying more than 36 passengers. More specifically, SOLAS Ch. II-2 Reg. 20.4.3.1 requires efficient fire patrols in any special category space.

According to the cost-effectiveness assessment conducted in LASH FIRE, RCO1 is cost-effective for new and existing ships of both ro-ro passenger and ro-ro cargo ships [21]. It would therefore also be advisable to conduct fire patrols in ro-ro cargo ships. This could be achieved by extending the scope of SOLAS Ch. II-2 Reg. 7.8 to all ro-ro spaces and ro-ro ships (excepted for vehicle carriers, where the

² It shall be noted that the regulatory review was done while the conclusions of MSC107 were not reported yet.

fire patrols were deemed not practicable). This can be further developed as an amendment proposal to SOLAS Ch. II-2 Reg. 20.4.

6.1.2 Definition of the role and tasks of fire patrols and the runner

In the IMO regulations, the tasks of the fire patrols are not explicitly described and must be developed in the onboard procedures by shipping companies. IMO Circular MSC.1/Circ.1615 paragraph 1.7.1 further specifies some items to be checked during a fire patrol in ro-ro spaces on new and existing ro-ro passenger ships.

The role of the runner, as developed in RCO1, is not yet defined in the regulatory framework. It is however a cost-effective measure and should therefore be included in the regulations.

SOLAS Ch. II-2 Reg. 16.1 requires the provision of fire safety operation booklets. Reg. 16.2 describes the contents of such booklets:

“2.1 The required fire safety operational booklet shall contain the necessary information and instructions for the safe operation of the ship and cargo handling operations in relation to fire safety. The booklet shall include information concerning the crew’s responsibilities for the general fire safety of the ship while loading and discharging cargo and while underway. Necessary fire safety precautions for handling general cargoes shall be explained.”

It presents a good medium for the introduction of the role of the runner (incl. tasks, equipment etc.) as described in RCO1. Apart from the superordinate specifications of Reg. 16.2.1, the content of the fire safety booklet is not specified in any more detail. It is therefore up to the shipping companies, to compose this document according to their own standards and procedures.

Furthermore, the ISM Code requires that any company operating a ship sets up a safety management system with identified persons in charge of the relevant duties and procedure to report incidents, prepare for and respond to emergency situations. The fire patrols are to be included in this safety management system, and the runner should be included as well.

Lastly, RCO1 emphasizes the necessity of standardized language and terminology in fire patrols’ and runner’s tasks (especially when communicating to the bridge).

Based on the above discussion, amendment proposals to SOLAS Ch. II-2 Reg. 16 can be further developed.

6.1.3 Requirement for equipment

SOLAS Ch. II-2 Reg.7.8.3 requires *“two-way portable radiotelephone apparatus”* for fire patrols. This regulation could be extended to all ro-ro ships, and to equip the runners with mandatory push-to-talk buttons on the radiotelephone devices and a measure for minimum coverage of the cargo areas to reduce the number of potential blind spots and radio shadows.

IMO Circular MSC.1/Circ.1615 paragraph 1.7.2 recommends the use of *“thermal imaging devices”* during a fire patrol in ro-ro spaces on new and existing ro-ro passenger ships. This recommendation can be required for all ro-ro ships to equip the runners.

Based on the above discussion, amendment proposals to SOLAS Ch. II-2 Reg. 20 can be further developed.

6.1.4 Requirement for training and familiarization

SOLAS Ch. II-2 Reg. 15 requires crew members to:

- *“Receive instructions on fire safety on board the ship.”*
- *“Receive instructions on their assigned duties.”*

Furthermore, *“parties responsible for fire-extinguishing shall be organized. These parties shall have the capability to complete their duties at all times while the ship is in service.”*

According to Reg. 15.2.2.1, *“Crew members shall be trained to be familiar with the arrangements of the ship as well as the location and operation of any fire-fighting systems and appliances that they may be called upon to use.”*

SOLAS requires a training manual to be provided in each crew mess room and recreation room or each crew cabin.

SOLAS Ch. II-2 Reg. 15.2.3.4 defines: the training manual shall explain – among other things:

“.2 general instructions on fire-fighting activities and fire-fighting procedures including procedures for notification of a fire and use of manually operated call points.”

According to SOLAS Ch. III Reg. 19 – *Emergency training and drills*, which is applicable for all ship types, crew members are required to participate in an onboard fire drill at least every month. The contents of such fire drills are described in Reg. 19.3.5.2:

“.1 reporting to stations and preparing for the duties described in the muster list required by regulation 8.

.2 starting of a fire pump, using at least the two required jets of water to show that the system is in proper working order;

.3 checking of fireman's outfit and other personal rescue equipment;

.4 checking of relevant communication equipment;

.5 checking the operation of watertight doors, fire doors, fire dampers and main inlets and outlets of ventilation systems in the drill area; and

.6 checking the necessary arrangements for subsequent abandoning of the ship.”

More specifically, SOLAS Ch. II-2 Reg. 7.8.1 requires the members of the fire patrol to be *“trained to be familiar with the arrangements of the ship as well as the location and operation of any equipment he may be called upon to use.”*

In order to familiarize with their tasks, all fire patrol members should receive an awareness training of fire hazards in ro-ro spaces.

In order to familiarize with their tasks and the ship, the tasks of the runner could be incorporated in the regular onboard fire drills. This enhances familiarization with the task itself, but also with the role and specific duties of the runner.

The regular onboard fire drills should also include the correct communication procedures to be used by both fire patrols and runners.

Based on the above discussion, amendment proposals to SOLAS Ch. II-2 Reg. 15 and Ch. III Reg. 19 can be further developed.

According to STCW Code Section A-VI/1, “all persons employed or engaged on a seagoing ship [...] shall receive approved familiarization training in personal survival techniques or receive sufficient information and instruction [...] to be able to: [...]”

1.2 know what to do if:

1.2.2 fire or smoke is detected, or

1.2.3 the fire or abandon ship alarm is sounded;

1.5 raise the alarm and have basic knowledge of the use of portable fire extinguishers; [...]”

Furthermore, “seafarers employed or engaged in any capacity on board ship on the business of that ship [...] shall, before being assigned to any shipboard duties:

2.1 receive appropriate approved basic training or instruction in:

2.1.2 fire prevention and fire fighting as set out in table A-VI/1-2 “Specification of minimum standard of competence in fire prevention and fire fighting”.”

This table contains a variety of aspects with regard to fire safety training, every seafarer has to undergo (not exclusive to seafarers engaged on ro-ro ships). The implementation and execution of fire patrols as recommended by RCO1, as well as fire confirmation and localization is not yet part of the minimum standard of competence. These aspects could be included by means of an amendment proposal to STCW Code Chapter V – *Standards regarding special training requirements for personnel on certain types of ships* by means of a new section regarding special training requirements for personnel on ro-ro ships.

6.2 RCO2: Improved signage and markings for effective wayfinding and localization

Within IMO corpus, requirements for marking and signage are generally included in the requirement or detailed standard of the concerned system or equipment. In addition, SOLAS Ch. II-2 Reg. 15 contains general requirements related to onboard instructions, including fire control plans. RCO2 includes marking and signage requirements related to the drencher system (including coherence of marking between the drencher system and the fixed fire alarm and fire detection system) and the video monitoring system.

Although these aspects are not explicitly covered yet, parts of them have been discussed in the scope of IMO work item “Review of SOLAS chapter II-2 and associated codes to minimize the incidence and consequences of fires on ro-ro spaces and special category spaces of new and existing ro-ro passenger ships”, resulting in:

Coherence of marking between the drencher system and the fixed fire alarm and fire detection system is currently addressed in:

- A recommendation for new ro-ro passenger ships in IMO Circular MSC.1/Circ.1615 paragraph 2.1.3, addressing coherence of marking between the drencher system and the fixed fire alarm and fire detection system
“In the design of the fire detection alarm system, it should be designed with a system interface which provides logical and unambiguous presentation of the information, to allow a quick and correct understanding and decision-making. In particular, the alarm system section numbering should coincide with the sections of other systems, such as fixed water-based fire-extinguishing system or television surveillance system, if available.”

- Planned amendments to SOLAS Ch. II-2 Reg. 20 requiring clearly visible signage for drencher section inside the ro-ro spaces of ro-ro passenger ships built after 1 January 2026 through a new paragraph SOLAS Ch. II-2 Reg. 20.7
“In passenger ships, vehicle, special category and ro-ro spaces, where fixed pressure water-spraying systems are fitted, shall be provided with suitable signage and marking on deckhead and bulkhead and on the vertical boundaries allowing easy identification of the sections of the fixed fire-extinguishing system. Suitable signage and markings shall be adapted to typical patterns of crew movement taking into consideration obstruction by cargo or fixed installations. Section number signs shall be of photoluminescent material. The section numbering indicated inside the space shall be same as section valve identification and section identification at the safety centre or continuously manned control station.”*

Amendment proposals will be developed to reflect RCO2 conclusions to the following IMO instruments:

- SOLAS Ch. II-2 Reg. 15, starting from the text currently in force, for general consistency of drencher zones marking and reference.
- SOLAS Ch. II-2 Reg. 20, starting from the existing draft text of this regulation, for marking and signage related to drencher zones - including coherence of marking between the drencher system and the fixed fire alarm and fire detection system - and video monitoring system. As a side note, it could alternatively be considered including requirements related to the coherence of marking between the drencher system and the fixed fire alarm and fire detection system within IMO Circular MSC.1/Circ.1430 paragraph 4.8, since this paragraph addresses interactions between the fixed fire alarm and fire detection system and the drencher system. The present proposal however opts for including all marking and signage requirements in SOLAS Ch. II-2 Reg. 20 because the planned new SOLAS Ch. II-2 Reg. 20.7 already starts addressing the matter and it is deemed more efficient to group such requirements as much as possible.

It should also be kept in mind that the planned amendments to SOLAS Ch. II-2 Reg. 20 are meant to apply to passenger ships only: Strictly following the conclusions of the LASH FIRE study could mean extending the application of the foreseen SOLAS Ch. II-2 Reg. 20.4 and SOLAS Ch. II-2 Reg. 20.7 to new ro-ro cargo ships and vehicle carriers.

6.3 RCO3: Developed efficient first response

There is no definition of the first response given in rules and regulations.

According to the cost-effectiveness assessment conducted in LASH FIRE, RCO3 is cost-effective for all ro-ro ships. It would therefore be advisable to include a definition of efficient first response into the regulatory framework. A suitable place would be the Fire Safety Operational Booklet as required by SOLAS Ch. II-2 Reg. 16.1. An amendment proposal can be developed to SOLAS Ch. II-2 Reg. 16.

In the IMO regulations, the tasks of the fire response are not explicitly described and must be developed in the onboard procedures by shipping companies. As per the ISM Code, the first response (maybe not under this terminology) is to be included in this safety management system of the shipping companies.

STCW Code Section A-VI/1 specifies the extent of training every seafarer must undergo before being assigned to his shipboard duties. Among other training aspects, seafarers shall receive training to “*be able to [...] know what to do if fire or smoke is detected*”.

Table A-VI/1-2 “*Specification of minimum standard of competence in fire prevention and fire fighting*” further specifies the areas, in which the seafarers have to demonstrate a minimum standard of competence (not exclusive to seafarers engaged on ro-ro ships). It is aspired to include first response techniques into the knowledge, seafarers are obliged to obtain. They could be included by means of an amendment proposal to STCW Code Chapter V – *Standards regarding special training requirements for personnel on certain types of ships* by means of a new section regarding special training requirements for personnel on ro-ro ships.

To facilitate the understanding and implementation of efficient first response measures, it would be recommended to also introduce a new IMO Model Course “Advanced training for ro-ro operations”. This IMO Model Course could be drafted based on the various LASH FIRE recommendations and guidelines (e.g., based on deliverable D06.7 “Evaluation and development of tactics, gear, equipment, and guidelines for effective first response” [26]).

6.4 RCO4: Developed manual fire-fighting for Alternatively Powered Vehicles

RCO4 is providing recommendations regarding the equipment, the training and the tactics of manual fire-fighting for Alternative Powered Vehicles.

6.4.1 Requirement for equipment

SOLAS Ch. II-2 Reg. 10.10 provides general requirements for fire-fighter outfits and FSS Code Ch. 3 provides more details about type approval and the pieces of personal protective equipment included in fire-fighter’s outfits. As per FSS Code Ch. 3, “*a fire fighter’s outfit consists of a set of personal equipment and a self-contained air-breathing apparatus*” and a set of personal equipment means:

- Water-resistant and heat-protective clothing;
- Non-conducting (rubber) boots;
- Rigid helmet;
- Electric safety lamp with 3 hours autonomy; and
- Axe (handle with high-voltage insulation).

In SSE 9/19/7, the Republic in Korea sought clarification on the applicable equipment standards for fire-fighter's outfits, as required by SOLAS Ch. II-2 Reg. 10 and the FSS Code, in an effort to ensure safe and effective fire-fighting by ship's crew in case of shipboard fire and facilitate global and uniform implementation. The SSE Sub-Committee highlighted a need for further technical discussion and instructed the FP Correspondence Group to further consider this document.

SOLAS Ch. II Reg. 10.2 provides technical specifications for the fire hoses and nozzles. In addition, as per SOLAS Ch. II Reg. 20.6.2, a number of portable equipment are required on board in order to allow manual fire-fighting in vehicle or ro-ro spaces: portable fire extinguishers, water fog-applicators and portable foam, with the provisions of the FSS Code Ch. 4. IMO Circular MSC.1/Circ.1615 paragraph 1.8.1 further recommends that “*the company should ensure [...] good access to any specialized fire-fighting equipment for alternatively powered vehicles.*”

SOLAS Ch. II Reg. 14 requires that fire-fighting systems and appliances shall be kept in proper working order, be regularly maintained and inspected. As guidelines, IMO MSC.1/Circ.1432, as amended by IMO MSC.1/Circ.1516, provides a maintenance and inspection plan for manual fire-fighting 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.

Amendment proposals will be developed to reflect RCO4 conclusions to the following IMO instruments:

- SOLAS Ch. II-2 Reg. 20 and FSS Code Ch. 3, for additional specifications to fire-fighter's outfits in case of manual fire-fighting for APVs;
- SOLAS Ch. II-2 Reg. 20, for additional specifications for fire-fighting tools;
- SOLAS Ch. II-2 Reg. 20, for general provision regarding maintenance and inspection of additional fire-fighting tools. SOLAS Ch. II Reg.14.2 is deemed adequate and sufficient for general provision regarding maintenance and provisions of fire-fighter's outfits. RCO4 provides no frequency of maintenance. Therefore, IMO MSC.1/Circ.1432 cannot be further developed; and
- About storage of equipment, SOLAS Ch. II Reg. 10.10.3 is deemed adequate and sufficient. Therefore, no amendment proposals will be developed.

6.4.2 Requirement for training

SOLAS Ch. II-2 Reg. 15 requires crew members to:

- *“Receive instructions on fire safety on board the ship.”*
- *“Receive instructions on their assigned duties.”*

Furthermore, *“parties responsible for fire-extinguishing shall be organized. These parties shall have the capability to complete their duties at all times while the ship is in service.”*

According to Reg. 15.2.2.1, *“Crew members shall be trained to be familiar with the arrangements of the ship as well as the location and operation of any fire-fighting systems and appliances that they may be called upon to use.”*

IMO Circular MSC.1/Circ.1615 paragraphs 1.8.1 and 3.2.1 further recommend that *“the company should ensure adequate training [...] for alternatively powered vehicles”* and *“relevant crew members should be trained on fire-fighting strategies and risks associated with alternatively powered vehicles such as battery or gas driven vehicles.”*

Special requirement for manual fire-fighting of APVs can be further developed as amendment proposals to SOLAS Ch. II-2 Reg. 15.

In addition to SOLAS, the STCW Convention specifies that all crew members shall receive appropriate approved basic training or instruction in fire prevention and fire-fighting. Table A-VI/1-2 of STCW Code Ch. VI Section A-VI/1 provides the specification of minimum standard of competence in fire prevention and fire-fighting (not exclusive to seafarers engaged on ro-ro ships), i.e., competence, knowledge, understanding and proficiency, methods for demonstrating competence, and criteria for evaluating competence.

For crew members designated to control fire-fighting operations, they shall have successfully completed advanced training in techniques for fighting fire, in accordance with the STCW Code. In particular, Ch. VI Section A-VI/3 and Table A-VI/3 provide the mandatory minimum standard of competence in advanced fire-fighting (not exclusive to seafarers engaged on ro-ro ships). However, current STCW requirements do not mention the specific risks associated with APVs or how a fire-fighting operation should be organized in case manual fire-fighting would be necessary. Regarding the specific requirements of manual fire-fighting for APV, a minimum standard of competence for APV manual fire-fighting has been developed as an amendment proposal of STCW Code Annex 1, Section A-V by means of a new section regarding special training requirements for personnel on ro-ro ships. It is shown in section 7.4.

Alternatively, manual fire-fighting for APVs could be added to the STCW mandatory minimum standard of competence in advanced fire-fighting (STCW Code Ch. VI Section A-VI/3 and Table A-

VI/3). It is then also advised to propose the amendment of IMO Model Course 2.03 “Advanced Fire Fighting” by a section on manual fire-fighting for Alternatively Powered Vehicles under Competence 1: *Control fire-fighting operations aboard ship*.

6.4.3 Requirements for tactics

Fire-fighting tactics are operations that are not specified by IMO regulations and are developed by shipping companies. IMO Circular MSC.1/Circ.1615 paragraph 1.8.1 recommends that *“the company should establish a fire-fighting plan that, in particular, [...] outlines the most appropriate fire-fighting techniques for such vehicles.”*

That being said, in any case, the IMO regulations require training for manual fire-fighting (see section above, section 6.4.2).

6.5 RCO5: Alarm system interface prototype

The topic of fire alarm interface readability and ergonomics has been discussed in the scope of IMO work item “Review of SOLAS chapter II-2 and associated codes to minimize the incidence and consequences of fires on ro-ro spaces and special category spaces of new and existing ro-ro passenger ships”, resulting in:

- Recommendations in IMO Circular MSC.1/Circ.1615 paragraphs 2.1.3 and 2.5 for “logical and unambiguous presentation of the information” and for alarm system design and integration.
- Planned amendments to SOLAS Ch. II-2 Reg. 20 and FSS Code making these recommendations mandatory for ro-ro passenger ships.

As a complement and since RCO5 provides more detailed recommendations in view of alarm system design, it is proposed in section 7.5 to develop an IMO Circular as a guideline on this topic.

It is to be noted additionally that the currently planned amendments by IMO to SOLAS and the FSS Code are meant to apply to ro-ro passenger ships only: Strictly following the conclusions of the LASH FIRE study would mean extending the application of the foreseen SOLAS Ch. II-2 Reg. 20.4.1.3 and FSS Code Ch. 9 paragraph 2.5.1.2 to new ro-ro cargo ships and vehicle carriers.

6.6 RCO6: Process for development of procedures and design for efficient activation of extinguishing system

In the IMO regulations, the requirements for fire drills are provided in SOLAS Ch. II-2 Reg. 15.2.2 and further details in Ch. III Reg. 19.3.5. In particular, Reg. 15.2.2.3 emphasizes the necessity of periodical drills *“to identify areas in need of improvement, to ensure competency in fire-fighting skills is maintained, and to ensure the operational readiness of the fire-fighting organization.”* Therefore, RCO6 can be seen as specific guidelines, in connection with the fire drills, to identify improvement potentials for procedures and systems for efficient activation of fixed fire-extinguishing in ro-ro spaces.

An amendment proposal can be developed in the form of an IMO Circular MSC.1/Circ.XXXX, as this medium is deemed more appropriate for guidelines.

6.7 RCO7: Training module for efficient activation of extinguishing system

RCO7 recommends the inclusion of training on the manual activation of the fixed fire-extinguishing systems, to familiarize all crew members with the process.

SOLAS Ch. III Reg. 19.3.2 requires at least one fire drill on board every month. The shipping company Safety Management System (SMS) will specify clear instructions and guidelines about how fire drills

shall be safely and efficiently carried out. However, in reality, and due to the daily operative on board the real activation of the fire-fighting systems is not part of the compulsory fire drills.

According to IMO Circular MSC.1/Circ.1430/Rev.2, manual activation of the deluge (or so-called drencher) systems is allowed, and every crew member should be aware of the procedure. But reality shows that the recommendation is not fully implemented throughout the shipping industry.

According to Chapter 5 of the FSS Code, Section 2.2.2 sets out that the controls of the carbon dioxide systems *“shall be located inside a release box clearly identified for the particular space. If the box containing the controls is to be locked, a key to the box shall be in a break-glass-type enclosure conspicuously located adjacent to the box”*. Reality shows that crew members do not have access to the CO₂ control room, which is considered as a protected space with locked access. They are not familiar with activation and the efficacy of the carbon dioxide (CO₂) as fire-fighting agent.

Hands-on activation of the fire extinguishing systems is not part of the Table A-VI/3 of the STCW Course *“Advanced Fire Fighting”* and correspondingly also not part of IMO Model course 2.03.

To familiarize the crew members with the activation of the different means of the fire extinguishing system, a training module was developed in RCO7. Training on manual activation of the fire extinguishing systems is recommended to be included in a new proposed STCW Code Section A-V/5 – *Mandatory minimum requirements for the training and qualification of masters, officers, ratings and other personnel on ro-ro ships* or alternatively in STCW Table A-VI/1-2.

To facilitate training for the efficient activation of fixed fire-fighting appliances, it would be recommended to also introduce a new IMO Model Course *“Advanced training for ro-ro operations”*. This IMO Model Course could be drafted based on the various LASH FIRE recommendations and guidelines.

6.8 RCO8: Safe electrical connection for reefers

It is to be noted that SOLAS Ch. II-1 Reg. 45 already includes general requirements regarding grounding or electrical insulation of electrical equipment and circuits (SOLAS Ch. II-1 Ch. 45.1.1). Quality of power supply is not covered in detail by SOLAS. However, it is to be noted that IACS UR E5 – *Voltage and frequency variations* addresses this topic and is applicable to all ships classed by Classification Societies, members of IACS. Therefore, it is not deemed necessary to include further requirements related to the quality of power supply into SOLAS.

At the moment, SOLAS does not require any specific equipment on electrical circuit outlets located in ro-ro or vehicle spaces. The issue of reefer electrical connection has however been taken into account in the scope of IMO work item *“Review of SOLAS chapter II-2 and associated codes to minimize the incidence and consequences of fires on ro-ro spaces and special category spaces of new and existing ro-ro passenger ships”*, resulting in a recommendation in IMO Circular MSC.1/Circ.1615 paragraph 1.5 stating that circuit breakers should be provided for each socket in ro-ro passenger ships ro-ro or vehicle spaces. This recommendation does not fully cover the scope of RCO8. Therefore amendment proposals will be developed in section 7.8.

It is proposed to include such amendments in SOLAS Ch. II-1 Reg. 45, which is dealing with *“Precautions against shock, fire and other hazards of electrical origin”*, which relates to the general architecture of the electrical system and already includes requirements about short-circuit and overload protection. Besides and although this goes beyond the scope of LASH FIRE study, it is understood that the notion of safe electrical connection may have a wider application than ro-ro ships, it may also be relevant for ships carrying reefer containers. In this perspective, it is deemed

more appropriate to include such requirements in SOLAS Ch. II-1 Reg. 45 than in SOLAS Ch. II-2 Reg. 20 which applies only to ro-ro ships.

6.9 RCO9: Safe electrical connection of reefers and electric vehicles (EVs)

SOLAS does not include any requirement specifically covering the charging equipment for electrical vehicles. It is therefore proposed in section 7.9 to include such amendments in SOLAS Ch. II-1 Reg. 45, based on the understanding that such equipment, although mainly foreseen for use in ro-ro spaces (on ro-ro passenger ships), may also need to be installed in other spaces and on ships other than ro-ro ships, e.g., for the recharging of onboard auxiliary vehicles such as forklifts, or passenger ships wishing to offer onboard recharging of small electrical vehicles such as bicycles or scooters. As a note, installation of charging equipment onboard space and therefore the intent to carry out electric vehicle charging in this space may require additional safety measures for the space itself, which may need to be further discussed.

6.10 RCO10: Fire detection on weather decks

In the current SOLAS, no fixed fire detection is required on weather decks. IMO Circular MSC.1/Circ.1615 recommends installing a fire detection system on weather decks for new ships.

Although, it could not be concluded that this RCO is cost-effective based on the assumptions of LASH FIRE, it is to be noted that this RCO is already covered by IMO planned amendments for new ro-ro passenger ships, through the introduction of SOLAS Ch. II-2 Reg. 4.1.4, requiring that a fixed fire detection and fire alarm system is provided for the area on the weather deck intended for the carriage of vehicles.

6.11 RCO11: Alternative fire detection in closed ro-ro spaces & open ro-ro spaces

Video monitoring as a decision-support system has been discussed in the scope of IMO work item “Review of SOLAS chapter II-2 and associated codes to minimize the incidence and consequences of fires on ro-ro spaces and special category spaces of new and existing ro-ro passenger ships”, resulting in:

- A recommendation in the IMO Circular MSC.1/Circ.1615 paragraph 2.3 to supplement smoke detectors with flame or heat detectors in open ro-ro spaces. This is not directly related to the linear heat detection solution investigated in RCO11 – except that this recommendation implies that heat detection may be relevant in open ro-ro spaces.
- Planned amendments to SOLAS Ch. II-2 reg. 20 and FSS Code requiring combined heat and smoke detectors in open and closed ro-ro spaces of new and existing passenger ships and allowing linear heat detectors for the purpose of heat detection. The outcomes of RCO11 provide some complements to the technical specification for the use of linear heat detectors, those are proposed as amendments to the foreseen FSS Code Ch. 9 in section 7.11.

As a note, the planned FSS Code amendments allow linear heat detectors tested according to EN 54-22.

6.12 RCO12: Visual system for fire confirmation and localization

Alternative fire detection systems have been discussed in the scope of IMO work item “Review of SOLAS chapter II-2 and associated codes to minimize the incidence and consequences of fires on ro-ro spaces and special category spaces of new and existing ro-ro passenger ships”, resulting in:

- A recommendation in the IMO Circular MSC.1/Circ.1615 paragraph 2.2 to provide effective television surveillance in ro-ro and special category spaces.

- Planned amendments to SOLAS Ch. II-2 reg. 20 requiring video monitoring in vehicle, special category and ro-ro spaces. RCO12 investigates video monitoring in ro-ro spaces and on weather decks, therefore the outcomes of RCO12 are proposed as amendments to the foreseen SOLAS Ch. II-2 Reg. 20.4.4 in section 7.12.

6.13 RCO13: Dry-pipe sprinkler system for vehicle carriers

This RCO was not found to be cost-effective and will not be considered further.

6.14 RCO14: Fixed remotely-controlled fire monitor system using water for weather decks

As outlined in D10.3 section 4, SOLAS currently does not require any fixed fire-extinguishing system on a weather deck intended for the carriage of vehicles. However, such systems have been considered in the scope of IMO work item “Review of SOLAS chapter II-2 and associated codes to minimize the incidence and consequences of fires on ro-ro spaces and special category spaces of new and existing ro-ro passenger ships”, resulting in:

- A recommendation in IMO Circular MSC.1/Circ.1615 paragraph 3.4 that a fixed fire-extinguishing system, e.g., water monitors, be provided on weather decks intended for the storage of vehicles on passenger ships. This recommendation does not include any detailed specification of this system.
- Planned amendments to SOLAS Ch. II-2 Reg. 20 and FSS Code, requiring the installation of water monitors on weather deck as specified in IMO FSS Code new section 7.2.5 on ro-ro passenger ships built after 1 January 2026. Water monitors are also required on existing ro-ro passenger ships as of 1 January 2028.

From a technical point of view, the planned amendments to SOLAS do actually cover the intent of RCO14 – although the option to use foam or additive is not explicitly stated, but remains open anyway. Therefore, no further amendment proposal will be drafted in the present report.

It is to be noted that the planned amendments to SOLAS are meant to apply to passenger ships only: Strictly following the conclusions of the LASH FIRE study would mean extending the application of the foreseen SOLAS Ch. II-2 Reg. 20.6.2 to new ro-ro cargo ships.

6.15 RCO15: Fixed autonomous fire monitor system using water for weather decks

As outlined in section 6.14 above, the current regulations do not require any fixed fire-extinguishing system on weather decks intended for the carriage of vehicles. Nevertheless, SOLAS and FSS Code amendments are planned to require fixed water-based fire-extinguishing systems covering the weather decks of new and existing ro-ro passenger ships.

Amendment proposals will be developed in section 7.15, starting from the existing draft text of SOLAS Ch. II-2 Reg. 20.6 and FSS Code Section 7.2.5 in order to require automatic activation and autonomous control of this system.

6.16 RCO16: Guideline for fire ventilation in closed ro-ro space

This RCO was not found to be cost-effective and will not be considered further.

6.17 Pre5: Proposal for requirements of surface materials in ro-ro spaces, with reference to suitable test method and material property performance criteria

Pre5 is not addressing the development of new composite materials but rather testing the fire properties of composite materials as per the test procedures of FTP Code Part 2 - Smoke and toxicity and Part 5 - Spread of Flame. The objective is to provide new knowledge on composite materials that

are, or may be, used as surfaces within ro-ro spaces. The results of the tests can be shared with the maritime community: to support the engineering analysis and evaluation of alternative design and arrangements (cf. SOLAS Ch. II Reg. 17) related to the use of combustibles materials for interior surface of ro-ro spaces, to feed a new output at IMO or to support a new revision of IMO Circular MSC.1/Circ.1574.

6.18 Ext5: Development of a relevant fire test standard for alternative fixed water-based fire-fighting systems intended for ro-ro spaces and special category spaces

Ext5 is proposing revised fire test procedures for performance-based (alternative) fixed water-based fire-fighting systems intended for ro-ro spaces and special category spaces. These fire test procedures should replace those in the Appendix of IMO Circular MSC.1/Circ.1430/Rev.2.

6.19 Cont9: Ship manoeuvring/operation to limit the effect of fire at least in critical areas

Cont9 is a containment related Risk Control Measure (RCM) aiming to provide guidance to the ship's Master and nautical officers to select the best ship manoeuvring/operation to limit the effect of fire at least in critical areas. It is verified and demonstrated by simulations during the project that changing the course to favourable direction can help avoid smoke spread to critical areas such as Life-Saving Appliances (LSA), embarkation areas, etc. It is recommended for operators to include manoeuvring related guidance in case of a fire, considering different fire locations, wind directions and evacuation areas in addition to the normal navigational / operational limits. The guidelines could include an overview sketch of those locations and possible manoeuvring options based on scenarios that are created specifically for the ship in question.

Cont9 related costs are identified within LASH FIRE as:

- i) Procedure establishment per operator;
- ii) Instructions development for each ship; and
- iii) Training.

As the Cont9 suggestions could be implemented in the existing procedure and training schemes, it is deemed to be a low-hanging fruit for ro-ro ships. These could be implemented within a one-year period by the operator.

SOLAS Ch. V provides the requirements regarding the safety of navigation. However, to the authors' knowledge, no regulation of Ch. V explicitly deals with the ship manoeuvring operations or procedures. This chapter mainly provides technical requirements regarding the onboard navigation systems. Therefore, no amendments of SOLAS regarding Cont9 is foreseen. Even so, an IMO Circular MSC.1/Circ.XXXX can be developed in order to provide generic guidelines and support the onboard decision-making (that shall be ship-specific).

According to the ISM Code, the operators are required to identify ship-specific emergency situations and set up procedures to prevent their occurrence. It is suggested for ro-ro ship operators to prepare such plans including scenarios based on different wind directions and fire locations specifying the best possible ship manoeuvring / operation to avoid spread of smoke at least in critical areas. Some drawbacks could be that the beneficial directions for different critical areas can be contradictory, and the application may not be possible during blackout.

Since these procedures are not directly mentioned in the ISM Code, no amendments will be provided for the ISM Code.

In the STCW Code, the competences of the nautical officers at operational and management level are described in Table A-II/1 and A-II/2 respectively. These tables separately consider manoeuvring in different navigational conditions and operations during fire. However, a consolidated aspect of manoeuvring during fire is not mentioned. This will be suggested as an amendment in section 7.19.

6.20 Cont10: Safety distances between side and end openings and critical areas

The calculation methodology proposed by Cont10 is not developed to the level of detail needed for systematic application in the regulatory framework. In addition, it is noted that the need for a scientific method to determine safety distances has been dropped by the IMO SSE Working Group.

As a consequence, it is proposed not to push forward the development of regulatory amendment proposal.

6.21 Cont11: Guidance on calculation of side openings in ro-ro spaces

Open ro-ro spaces shall be provided with permanent openings in the side plating or deckhead, or from above as per SOLAS Ch. II-2 Reg. 3.36. These permanent openings shall have a total area of at least 10 % of the total area of the space sides. The definition of an open ro-ro space is open for interpretation in some areas.

Firstly, SOLAS does not define what is included in the definition of “permanent openings”.

Secondly, a clear definition of “space sides” is missing in SOLAS which should include what is a side and how high structure should be allowed for a side to be considered open. One interpretation is that a side or gunwale structure is not allowed to be more than 150 cm if the side is to be interpreted as open or “completely exposed to weather”, as required in the definition of weather deck.

Thirdly, at present, there is no internationally accepted best practise for how to calculate the openness of an open ro-ro space. This can cause different interpretations by Flag Administrations and Recognized Organizations.

Calculation guidance was not developed to the level of detail needed for systematic application in the regulatory framework and was decided to not push forward. The same applies to permanent openings; no further details or consequences have been investigated in detail. However, when it comes the definition of a side, a suggestion was formed.

The proposal is based on that a space side in the definition of an open ro-ro space is referring to the long sides, not including the deck or deckhead, nor the short ends, of a ro-ro space. The calculation of “total area of at least 10 % of the total area of the space sides” shall thus be based on the area of the long sides of the ro-ro space.

A guidance that the side should only consider the area of the long sides of open ro-ro and vehicle spaces is a good attempt in way of rules and design consolidation. However, with the same definition of a side for the definition of weather deck, and if allowing a maximum height of 150 cm for the sides to be considered “completely exposing the deck to weather”, may lead to reduced design flexibility. Some arrangements which are naturally considered as weather decks would then be categorized as closed ro-ro spaces. An example of a commonly used arrangement is a ro-ro deck exposed to the weather from above but with high sides (due to funnel casing etc.) and closed forward and/or aft (other ro-ro space, ramp). While clarifying the definition of a side and arguing for a concise definition of a “side”, it was therefore suggested to also make an amendment to the definition of weather deck in SOLAS Ch. II-2 Reg. 3.50. This definition suggests that there are more than two sides to a space/deck and seems to also include the ends of the space/deck. Instead of using inconsistent

meanings of the term “side” it was therefore suggested to clarify this by writing out that either the space sides OR ends need to be fully exposed to weather.

6.22 Conclusion of regulatory review

Table 5 provides the conclusion of the regulatory review and summarizes which RCO should be push to proposal for regulatory amendment.

Table 5. Conclusion of regulatory review

	Drafting of proposal?	Comments
RCO1	Yes	
RCO2	Yes	
RCO3	Yes	
RCO4	Yes	
RCO5	Yes	
RCO6	Yes	
RCO7	Yes	
RCO8	Yes	
RCO9	Yes	
RCO10	No	Already covered by planned SOLAS amendments, as detailed in SSE 9/20 Annex 5. RCO not cost-effective for other cases.
RCO11	Yes	
RCO12	Yes	
RCO13	No	RCO not cost-effective.
RCO14	No	Already covered by planned SOLAS amendments, as detailed in SSE 9/20 Annex 5 and 6.
RCO15	Yes	
RCO16	No	RCO not cost-effective.
Pre5	Yes	
Ext5	Yes	
Cont9	Yes	
Cont10	No	RCO not mature enough.
Cont11	Yes	

7 Recommendations for decision-making

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This section provides the draft text for recommendations for decision-making, i.e., proposals for IMO regulation amendments, in a way to be presentable at IMO.

Note 1: It should be noted that the application scope (passenger or cargo ship, new or existing ship) and application dates are left to the final text that may be submitted to IMO.

Note 2: It should be noted that the following proposals for regulations were developed while the conclusions of MSC107 were not yet reported. Therefore, they were based on text from the SSE Sub-Committee and, due to time constraint, were not updated based on potential revisions from MSC107.

Note 3: The proposals for amendment per RCO cannot be proposed in combination without having checked the interdependency matrix in ANNEX B: Interdependency matrix and having re-done the quantitative assessment of the combination of RCOs (when needed).

Note 4: In the following, it was decided to draft the different proposals based on the planned SOLAS amendments, as detailed in SSE 9/20 Annex 5 and 6. It is a liberty taken by LASH FIRE, even though those planned amendments were not considered in the risk and cost-effectiveness assessment. The reader should be aware of this limitation when using the following proposals.

7.1 RCO1: Improved Fire patrol. Improved fire confirmation & localization

7.1.1 SOLAS Ch. II-2 Reg. 20.4

This amendment proposal is based on SOLAS Ch. II-2 as planned to be amended as per SSE 9/20 Annex 5.

The existing section 4.3 is amended, as follows, the new section 4.4 is added after the existing section 4.3 and the subsequent paragraphs are renumbered accordingly:

4.3 Special category spaces

~~4.3.1 An efficient fire patrol system shall be maintained in special category spaces.~~

~~4.3.2~~ Manually operated call points shall be spaced so that no part of the space is more than 20 m from a manually operated call point, and one shall be placed close to each exit from such spaces.

4.4 Fire patrols

4.4.1 An efficient fire patrol system shall be maintained in vehicle and ro-ro spaces.

4.4.2 Each member of the fire patrol shall be provided with:

.1 a two-way portable radiotelephone apparatus with push to talk button;

.2 a flashlight; and

.3 a portable thermal imaging device suitable for screening, detection of hot areas and overheating electrical equipment upon suspicion, and to confirm fire.

4.4.3 Not less than the 85% of the vehicle and ro-ro space areas, fully loaded with cargo, shall have radio coverage.

4.45 Video monitoring

7.1.2 SOLAS Ch. II-2 Reg. 15

The following new section 4 is added after the existing section 3 (Additional requirements for passenger ships):

4 Additional requirements for ro-ro ships

4.1 The training manual shall provide general awareness of fire hazards in vehicle and ro-ro spaces.

4.2 The training manual shall explain procedures for fire confirmation and localization in vehicle and ro-ro spaces.

7.1.3 SOLAS Ch. II-2 Reg. 16

The following new section 4 is added after the existing section 3 (Additional requirements for tankers):

4 Additional requirements for ro-ro ships

The fire safety operational booklet referred to in paragraph 2 shall include provisions for fire confirmation and localization in vehicle and ro-ro spaces.

7.1.4 SOLAS Ch. III Reg. 19.3.5

The new paragraphs 3.5.4 and 3.5.5 are added after the existing paragraph 3.5.3:

3.5.4 The use of IMO Standard Marine Communication Phrases* shall be practiced during the fire drills.

3.5.5 In vehicle and ro-ro spaces, each fire drill shall include manual fire confirmation and localization activities.

*Refer to IMO Standard Marine Communication Phrases (resolution A.918(22)).

7.1.5 STCW Code Ch. V

The following new section A-V/5 is added after the existing section A-V/4 (Mandatory minimum requirements for the training and qualifications of masters and deck officers on ships operating in polar waters):

Section A-V/5

Mandatory minimum requirements for the training and qualification of masters, officers, ratings and other personnel on ro-ro ships

Standard of competence

1 Every candidate for certification in basic training for ro-ro ships shall be required to:

- .1** demonstrate the competence to undertake the tasks, duties and responsibilities listed in column 1 of table A-V/5-1; and
- .2** provide evidence of having achieved:
 - .1** the minimum knowledge, understanding and proficiency listed in column 2 of table A-V/5-1; and
 - .2** the required standard of competence in accordance with the methods for demonstrating competence and the criteria for evaluating competence tabulated in columns 3 and 4 of table A-V/5-1.

Table A-V/5-1

Specification of minimum standard of competence in basic training for ro-ro ships

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
Minimize the risk of fire and maintain a state of readiness to respond to emergency situations involving fire	Organization of effective fire patrols: .1 identification of cargo with highest potential fire hazards .2 critical zones to be inspected by fire patrol .3 potential fire hazards to look out for Localization and confirmation of a fire: .1 localization and approaching of a potential fire in a safe way .2 manual confirmation of existence of fire .3 emergency communication according to IMO Standard Marine Communication Phrases .4 decision on appropriate first response techniques	Assessment of evidence obtained from approved instruction or attendance at an approved course	Initial actions on becoming aware of an emergency conform with accepted practices and procedures Action taken on identifying and confirming fire is appropriate to the indicated emergency and complies with established procedures

7.2 RCO2: Improved signage and markings for effective wayfinding and localization

7.2.1 SOLAS Ch. II-2 Reg. 15

The following new paragraphs 2.3.5, 2.4.3 and 2.4.4 are added after the existing paragraphs 2.3.4 and 2.4.2:

2.3 Training manuals

[...]

2.3.5 For ro-ro ships where fixed pressure water-spraying systems are fitted in ro-ro or vehicle spaces, the training manual shall include fixed pressure water-spraying system section and deck numbering.

2.4 Fire control plans

[...]

2.4.3 For ro-ro ships where fixed pressure water-spraying systems are fitted in ro-ro or vehicle spaces, the fire control plan shall include fixed pressure water-spraying system section and deck numbering.

2.4.4 In general, decks shall be numbered in a simple and straightforward way by means of numbers or letters, and these references should be used throughout all onboard instructions and markings without mixing them with deck or system specific names or numbers.

7.2.2 SOLAS Ch. II-2 Reg. 20.4.4.1

This amendment proposal is based on SOLAS Ch. II-2 as planned to be amended as per SSE 9/20 Annex 5.

The existing paragraph 4.4.1 is amended, as follows:

4.4.1 For passenger ships, an effective video monitoring system shall be arranged in vehicle, special category and ro-ro spaces for continuous monitoring of these spaces. The system shall be provided with immediate playback capability to allow for quick identification of fire location, as far as practicable, and shall allow for instant identification of which drencher zones are visible from each camera. Cameras shall be installed to cover the whole space, high enough to see over cargo and vehicles after loading.

7.2.3 SOLAS Ch. II-2 Reg. 20.7

This amendment proposal is based on SOLAS Ch. II-2 as planned to be amended as per SSE 9/20 Annex 5.

The existing paragraph 7 is amended, as follows:

7 Decision-making

In passenger ships, vehicle, special category and ro-ro spaces, where fixed pressure water-spraying systems are fitted, shall be provided with suitable easily identifiable signage and markings⁵ on deckhead and bulkhead and on the vertical boundaries allowing easy identification of the sections of the fixed fire-extinguishing system. Suitable signage and markings shall be adapted to typical patterns of crew movement and fire patrol patterns, taking into consideration obstruction by cargo or fixed installations. Fire patrols should be able to visually confirm what section they are in from any position along the patrol route without moving more than 3 m along their route. Section number signs shall be of photoluminescent material.* The section numbering indicated inside the space shall

be same as section valve identification and section identification at the safety centre or continuously manned control station.

[§]Refer to ISO 24409-01:2020: Ships and marine technology — Design, location and use of shipboard safety signs, fire control plan signs, safety notices and safety markings — Part 1: Design principles.

*Refer to chapter 11 of the FSS Code for the evaluation and testing of photoluminescent material.

7.3 RCO3: Developed efficient first response

7.3.1 SOLAS Ch. II-2 Reg. 16

The following new section 4 is added after the existing section 3 (Additional requirements for tankers):

4 Additional requirements for ro-ro ships

The fire safety operational booklet referred to in paragraph 2 shall include provisions for early response to fire occurring in vehicle and ro-ro spaces and shall include how to raise the fire alarm, how to use portable fire extinguishers and more advanced procedures for crew members who are designated for early response activity to fire occurring in vehicle and ro-ro spaces.

7.3.2 STCW Code Ch. V

The following new section A-V/5 is added after the existing section A-V/4 (Mandatory minimum requirements for the training and qualifications of masters and deck officers on ships operating in polar waters):

Section A-V/5

Mandatory minimum requirements for the training and qualification of masters, officers, ratings and other personnel on ro-ro ships

Standard of competence

1 Every candidate for certification in basic training for ro-ro ships shall be required to:

.1 demonstrate the competence to undertake the tasks, duties and responsibilities listed in column 1 of table A-V/5-1; and

.2 provide evidence of having achieved:

.1 the minimum knowledge, understanding and proficiency listed in column 2 of table A-V/5-1; and

.2 the required standard of competence in accordance with the methods for demonstrating competence and the criteria for evaluating competence tabulated in columns 3 and 4 of table A-V/5-1.

Table A-V/5-1

Specification of minimum standard of competence in basic training for ro-ro ships

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
<p>Apply effective first response techniques in the event of a fire alarm</p>	<p>First actions after fire detection:</p> <ul style="list-style-type: none"> .1 raising the alarm .2 use of standard communication phrases .3 self protection <p>First response techniques:</p> <ul style="list-style-type: none"> .1 use of portable heat camera .2 use of different types of portable fire extinguishers .3 basic fire-fighting skills <p>General safety awareness:</p> <ul style="list-style-type: none"> .1 mental and physical preparedness for efficient first response .2 familiarization with vessel, access ways and limitations, marking of drencher zones etc. 	<p>Assessment of evidence obtained from approved instruction or during attendance at an approved course, including practical demonstration in spaces which provide truly realistic training conditions</p>	<p>The timing and sequence of individual actions are appropriate to the prevailing circumstances and conditions</p> <p>First response to a fire is achieved using appropriate procedures, techniques and fire-fighting agents</p>

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
	.3 familiarity with available means of fire-fighting, personal protection equipment		

7.4 RCO4: Developed manual fire-fighting for Alternatively Powered Vehicles

7.4.1 SOLAS Ch. II-2 Reg. 15

The following new section 4 is added after the existing section 3 (Additional requirements for passenger ships):

4 Additional requirements for ro-ro ships

Relevant crew members shall be trained to be familiar with fire-fighting activities and risks associated with new energy vehicles such as battery or gas driven vehicles.

7.4.2 SOLAS Ch. II-2 Reg. 20.6

This amendment proposal is based on SOLAS Ch. II-2 as planned to be amended as per SSE 9/20 Annex 5.

The following new section 6.4 is added after the existing section 6.3 (Portable fire extinguishers) – note: application dates to be agreed by IMO Member States:

6.4 Fire-extinguishing arrangements in vehicle and ro-ro spaces

(The requirements of this section shall apply to ships constructed on or after [1 January 2030]. Passenger ships and vehicle carriers constructed before [1 January 2030] shall comply with the requirements of this section not later than the first survey after [1 January 2032].)

6.4.1 Ships shall carry, in addition to the equipment and arrangements required in paragraphs 6.1, 6.2 and 6.3, at least:

- .1 one water mist lance;
- .2 one fire blanket; and
- .3 one boundary cooling device.

6.4.2 The water mist lance shall consist of a tube with a piercing nozzle which is capable of penetrating a vehicle and producing water mist inside the vehicle when connected to the fire main.

6.4.3 The fire blanket shall consist of a fire-retardant blanket, covering the whole vehicle, which can be used as a preventive measure, capable of mitigating fire spread to an adjacent vehicle, and during post extinguishment, capable of hindering re-ignition and containing gas emissions.

6.4.4 The boundary cooling device shall consist of a mobile pipe or rail of specifically oriented water spray nozzles which is capable of preventing fire spread from one car to adjacent vehicles when connected to the fire main.

6.4.5 Ships shall develop a maintenance plan for:

- .1 water mist lance;
- .2 fire blanket; and
- .3 boundary cooling device.

6.5 Fire-fighter's outfits

(The requirements of this section shall apply to ships constructed on or after [1 January 2030]. Passenger ships and vehicle carriers constructed before [1 January 2030] shall comply with the requirements of this section not later than the first survey after [1 January 2032].)

6.5.1 The additional personal equipment as regards as manual fire-fighting for new energy vehicles shall comply with section 2.3 of chapter 3 of the Fire Safety Systems Code.

6.5.2 Ships shall carry at least two sets of the additional personnel equipment.

6.5.3 The sets of additional personal equipment shall be kept ready for use in an easily accessible location that is permanently and clearly marked, together with the rest of the fire-fighter's outfits.

7.4.3 FSS Code Ch. 3

The following new section 2.3 is added after the existing section 2.2 (emergency escape breathing devices (EEBD)) – note: application dates to be agreed by IMO Member States:

2.3 Personal protection for ro-ro spaces and vehicle spaces

This section details the additional specification of personal protection equipment on ro-ro ships as regards as manual fire-fighting for new energy vehicles. The requirements of this section shall apply to ro-ro ships constructed on or after [1 January 2030]. Ro-ro passenger ships and vehicle carriers constructed before [1 January 2030] shall comply with the requirements of this section not later than the first survey after [1 January 2032].

2.3.1 Personal equipment

2.3.1.1 Personal equipment shall consist of the following:

- .1 flash hood to ensure that neck and head are protected;
- .2 long sleeved clothing under the protective clothing required in paragraph 2.1.1.1;
- .3 wristlets with a loop around the thumb to stop sleeves from going up, to reduce skin exposure;
- .4 pre-bent knees and elbows to improve mobility; and
- .5 knee pads to allow crawling on hot or hard surfaces.

2.3.1.2 The protective clothing required in paragraph 2.1.1.1 shall comply with EN 469:2020 level 2 (X2 Y2 Z2), or equivalent.

7.4.4 STCW Code Ch. V

The following new section A-V/5 is added after the existing section A-V/4 (Mandatory minimum requirements for the training and qualifications of masters and deck officers on ships operating in polar waters):

Section A-V/5

Mandatory minimum requirements for the training and qualification of masters, officers, ratings and other personnel on ro-ro ships

Standard of competence

1 Every candidate for certification in basic training for ro-ro ships shall be required to:

- .1 demonstrate the competence to undertake the tasks, duties and responsibilities listed in column 1 of table A-V/5-1; and
- .2 provide evidence of having achieved:

- .1 the minimum knowledge, understanding and proficiency listed in column 2 of table A-V/5-1; and
 - .2 the required standard of competence in accordance with the methods for demonstrating competence and the criteria for evaluating competence tabulated in columns 3 and 4 of table A-V/5-1.
2. Seafarers designated to control fire-fighting operations of new energy vehicle fire shall have successfully completed advanced training in techniques for fighting new energy vehicle fire, with particular emphasis on organization, tactics and command, and shall be required to demonstrate competence to undertake the tasks, duties and responsibilities listed in column 1 of table A-V/5-2.
3. The level of knowledge and understanding of the subjects listed in column 2 of table A-V/5-2 shall be sufficient for the effective control of fire-fighting operations of new energy vehicle fire on board ship.
4. Every candidate for certification of advanced fire-fighting of new energy vehicle fire shall be required to provide evidence of having achieved the required standard of competence, in accordance with the methods for demonstrating competence and the criteria for evaluating competence tabulated in columns 3 and 4 of table A-V/5-2.

Table A-V/5-1

Specification of minimum standard of competence in basic fire fighting of new energy vehicle fire for ro-ro ships

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
<p>Identify the hazards associated with carriage of new energy vehicles and charging of electric vehicles</p>	<p>Knowledge of the different types of new energy vehicles</p> <p>Ability to identify new energy vehicles, the location of the energy storage system, gas vent (if any) and establish cargo separation procedures</p> <p>Knowledge of possible consequences of overcharging, fast charging, charging damaged battery</p> <p>Knowledge of the procedures to charge on board electric cars, risks associated and possible mitigation actions</p>	<p>Assessment of evidence obtained from approved training and/or instruction</p>	<p>Quantitative Risk Assessment to estimate the likelihood of fire or thermal runaway when electric vehicles are loading on board</p>

Table A-V/5-2

Specification of minimum standard of competence in advanced fire fighting of new energy vehicle fire for ro-ro ships

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
Organize and control methods and equipment for fire-fighting operations of new energy vehicle fire on board ro-ro spaces	<p>Basic knowledge on suppression systems needed in case of fire-fighting operations of new energy vehicle fire on board ro-ro spaces</p> <p>Ability to perform fire-fighting technics and tactics regarding new energy vehicle fires</p>	Assessment of evidence obtained from approved training by practical demonstration, shipboard training drill or instruction	<p>Correct installation of cooling devices for the attenuation of radiant heat with the aim of producing a blockage effect</p> <p>Correct selection of the right manual fire-fighting tactic (defensive or offensive) depending on how the fire can be reached considering fire size and potential dangers</p>

7.5 RCO5: Alarm system interface prototype

7.5.1 FSS Code Ch. 9

This amendment proposal is based on FSS Code Ch. 9 as planned to be amended as per SSE 9/20 Annex 6.

The existing paragraph 2.5.1.2 is amended, as follows:

2.5.1.2 On ro-ro passenger ships constructed on or after 1 January 2026, alarm notifications shall follow a consistent alarm presentation scheme (wording, vocabulary, colour and position). Both the design of the panel and its integration on board shall take into account the guidelines developed by the Organization*. Alarms shall be immediately recognizable on the navigation bridge and shall not be compromised by noise or poor placing.

*Refer to the design guidelines for fixed fire detection and fire alarm panels and their integration on board (MSC.1/Circ.XXXX).

7.5.2 New MSC.1/Circ.XXXX: Design guidelines for fixed fire alarm detection and fire alarm panels and their integration on board

Add the following in Annex of MSC.1/Circ.XXXX:

(Note: The following text is extracted from the LASH FIRE guidelines for crew-centered fire safety design [27].)

ANNEX

DESIGN GUIDELINES FOR FIXED FIRE DETECTION AND FIRE ALARM PANELS AND THEIR INTEGRATION ON BOARD

1 General

1.1 The present guidelines contains design principles meant to outline how properties of the working environment relate to task performance. The principles are sorted into categories representing different levels of design consideration, reflecting the structure used throughout the guidance documentation.

1.2 These design principles are based on insights from fire management studies on ro-ro ships, and more principles may be relevant for other cases. The relevance of each principle may vary throughout the ship design project and all may not be applicable at once.

2 Application

These guidelines are intended to apply to new ro-ro ships.

3 Usability

- .1 Text-based information should be clear and informative.
- .2 Graphics should replace text when appropriate.
- .3 Graphics (e.g., GA) should contain only relevant information.
- .4 Safety systems should be easy to read and control.
- .5 A consistent naming practice should be applied in all systems and documents.
- .6 Clutter (e.g., paper handling) should be minimized.

.7 It should be possible to assess the source and validity of information, especially information that has been aggregated from different sources.

4 Layout & integration

- .1 There should be room for parallel activities.
- .2 Disturbances between work groups should be minimized.
- .3 The placement and layout of workstations should enable collaboration between work groups (e.g., evacuation and OOW).
- .4 Panels and controls should be placed in a way that promotes and efficient workflow.
- .5 Resources that must be used together should be placed together – consider integrating information and controls for different systems where it benefits efficiency and effectiveness.
- .6 It should be possible to quickly get an overview of all system statuses.

5 Collaboration

- .1 Information sharing with other parties (e.g., ECR and fire groups) should be supported.
- .2 Systems should provide information that is easy to communicate to others.
- .3 Events and developments in other working groups should be easy to monitor.
- .4 Work delegation should be supported, e.g., to relieve the fire chief.

7.6 RCO6: Process for development of procedures and design for efficient activation of extinguishing system

7.6.1 SOLAS Ch. III Reg. 19.3.5

The following new paragraph 3.5.4 is added after the existing paragraph 3.5.3:

3.5.4 The fire drills shall take into account the guidelines developed by the Organization*, as appropriate.

*Refer to guidelines for improving procedures and design for activation of fixed fire-extinguishing system in ro-ro spaces (MSC.1/Circ.XXXX).

7.6.2 New MSC.1/Circ.XXXX: Guidelines for improving procedures and design for activation of fixed fire-extinguishing system in ro-ro spaces

Add the following in Annex of MSC.1/Circ.XXXX:

(Note: The following text is extracted from the deliverable D07.9 “Development and implementation of design guidelines and procedures for extinguishing system activation” [28].)

ANNEX

GUIDELINES FOR IMPROVING PROCEDURES AND DESIGN FOR ACTIVATION OF FIXED FIRE-EXTINGUISHING SYSTEM IN RO-RO SPACES

1 Introduction

Successful management of fixed fire-extinguishing systems in fire situations in ro-ro ships requires both efficiency and thoroughness from the crew involved in the fire-fighting. Efficiency relates to the

swiftness of the activation process, and thoroughness relates to doing things in a right and safe way, e.g., following the established procedures and activating the extinguishing system in the right location of the ship.

1.1 Purpose

1.1.1 These guidelines present a Reflection, evaluation and change (REC) process designed to adapt and improve existing procedures and design relating to fixed fire-extinguishing systems management. The process should be carried out at the level of individual ships, preferably in collaboration with the onshore organisation, e.g., with participation from the Designated person ashore (DPA). This to ensure continuity across the process, from discovering improvement potentials during a fire drill, to implementing suggested changes in design or procedures.

1.1.2 A premise for the REC process is that there exists substantial tacit knowledge in the ship organization, through which ship crews shoulder risks associated with suboptimal designs and procedures. Such tacit knowledge is instrumental in coping with both routine work and for improvisation when faced with surprises. The purpose of the REC process is to make such tacit knowledge explicit through reflection, to evaluate needs for change, and to implement suggested/necessary changes (see Fig. 1).

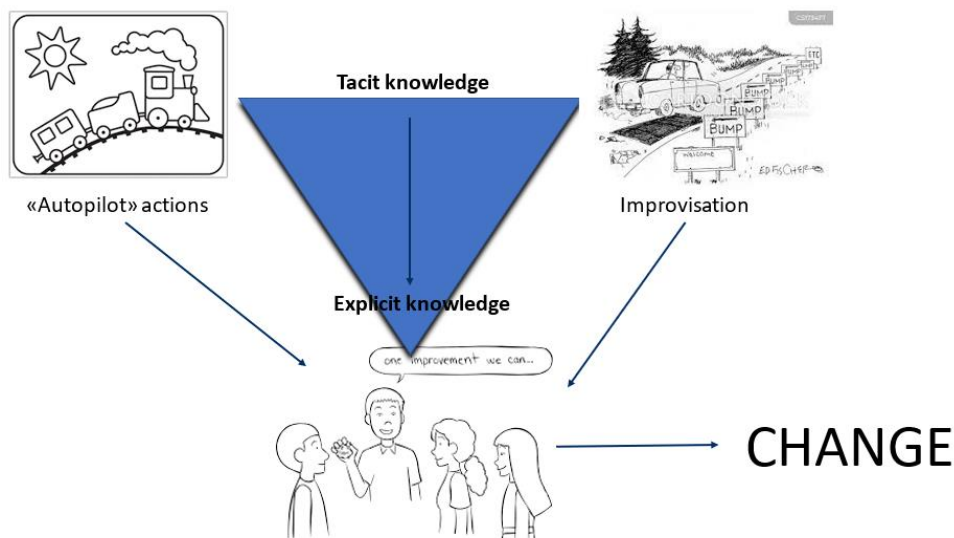


Fig. 1: REC process

1.1.3 The REC process should be run with a particular focus relating to fixed fire-extinguishing system activation, that should alternate from each time. Examples of foci could be decision-making and activation; communication; design of instructions materials; roles and responsibilities (coordination).

1.2 Intended recipients

The intended recipients of these guidelines are:

- .1 Those onboard the ship involved in fire management, the Master and the fire commander typically being 'super users'; and
- .2 The DPA, or other similar roles that can connect the crew with onshore organisational environments that can support with implementing changes.

2 Application

2.1 These guidelines are intended to apply to new and existing ro-ro ships, except existing ro-ro cargo ships.

2.2 The REC process should be carried out in connection with ordinary fire drills, although not all of them. It can be seen as an extended fire drill that is devoted not to rehearsing existing procedures and systems, but to identify improvement potentials for the same procedures and systems. There is no requirement with respect to the frequency of implementation, but since work practices and material environments on a ship is subject to continuous adaptation, it is recommended to implement the REC process no less than four times per year.

2.3 The REC process is estimated to extend a regular fire drill with approximately 1 ½ hours, in addition to time necessary for planning the extended fire drill (scenario).

3 How to conduct the Reflection, evaluation and change process

3.1 Pre-brief

3.1.1 A meeting is held before the fire drill, with everybody participating in the fire drill. The intention with this meeting is to prime everybody with a ‘critical’ mindset and to reflect collectively on their existing practices and experiences, searching for improvement potentials.

3.1.2 The pre-brief is focused on reflecting on and discussing a series of questions. The focus of the questions will change with the focus of the planned scenario. The common denominator is the heading, the context for the questions: “Based on your experience, and during the drill, try to notice...”. The framing of the pre-brief thus involves both looking back and looking forward. An example of questions that could be asked in a pre-brief when focus is on decision making and activation are provided in Textbox 1. For other foci, e.g., communication; design of instructions materials; roles and responsibilities (coordination), questions should be tailor made.

Based on your experience, and during the drill, try to notice...

- *Do you experience any difficulties or dilemmas?*
- *What could make this specific task difficult in a real emergency (dilemma/challenge), e.g.,*
 - *Making sense of the alarm (sensemaking)*
 - *Identifying correct drencher zone (sensemaking)*
 - *Looking up dangerous goods manifest (sensemaking)*
 - *Choice of extinguishing strategy (decision making)*
 - *Drencher activation steps (communication, know-how)*
 - *Activation instructions ‘poster’ (design)*
 - *Effect of water on dangerous goods (sensemaking)*
 - *Other ...*
- *Are there things you would have to do differently in a real fire emergency?*

Textbox 1. Leading questions for REC pre-brief. Questions may be adapted by users

The intention is to bring up experiences and knowledge that is seldom discussed explicitly, but merely coped with.

3.2 REC adapted-fire drill

After the pre-brief, the fire drill is run as planned. The crew should during the fire drill bear in mind the questions and discussions from the pre-brief. If useful, the questions could be printed and

brought during the fire drill. Notes can also be taken during the fire drill, although this is often not convenient for all participants.

3.3 De-brief

3.3.1 The debrief should start with discussing open question about learning points from the drill (Textbox 2):

- *What worked well?*
 - *How can we maintain and strengthen what went well?*
- *What did not work so well?*
 - *Is there anything we should have done differently?*
 - *If yes, which changes do that require in procedures and design?*

Textbox 2. Open questions for debrief

3.3.2 After the open questions session, proceed with more detailed questions (Textbox 3). The questions in this section should be related to the drill scenario and the activities undertaken during the fire drill. Hence, although many of the leading questions in Textbox 3 would be relevant in most fire drills, the questions must be adapted to the context.

.1 Localization of fire

- *Was it easy to make sense of the alarm?*
- *Was the information from alarm panel and other systems (e.g., CCTV) clear? What would be different in a real situation due to e.g., smoke?*
- *Was the runner sent in the right direction? How precise information was the runner able to gather?*

.2 Dangerous goods, information and handling

- *How was the process of looking up necessary information on dangerous goods? Easy? Cumbersome?*
- *Are there routines for checking dangerous goods when an alarm goes off? How efficient are they?*
- *Does the presence of dangerous goods cause any hesitation?*
- *Is the information about how to handle different types of dangerous goods clear and unambiguous?*
- *Do you plan so that unpleasant surprises with respect to dangerous goods cannot appear?*

.3 Fixed water-based fire-extinguishing system activation

- *What did you have to do to identify the correct drencher zone? Is it cumbersome?*
- *Are markings and numbering of drencher zones and pumps clear and unambiguous?*
- *Was the communication about drencher zone and pumps clear and unambiguous?*
- *Are there different locations from where drenchers could have been activated in this situation?*
- *Did you have any choice with respect to location from where you activate drenchers? (Are there organisational habits or actual/potential technical systems setup restricting the use of other locations)*
- *Was it obvious who should do the activation? Could there be alternatives regarding who undertakes the activation?*
- *Did you have any doubts at the moment of activation? Would you have any doubts if it was a real situation?*
- *Did you have the necessary information when activating the drenchers? (Both the person ordering it and the person performing the actual procedure)*
- *Are there any hands-on instructions for the drenchers? Did you make use of them?*
- *Are they well formulated? Unambiguous? Is there anything with the wording in the instruction that may lead to hesitation in a stressing situation?*
- *Are activation instructions available in all relevant locations from where activation is possible?*
- *Do the instructions say anything about who are allowed to activate the system, and in case, is it in line with the standing order or the general perception?*
- *Did the management of other fire-related equipment (e.g., fire dampers) cause any problems, delays, hesitation?*
- *How could we arrange for earlier activation the next time, or during a real fire?*

Textbox 3. Detailed questions for debrief. Note: these are only examples

3.3.3 A designated facilitator of the debrief session should be responsible for having the discussions and noting suggested changes, and bring this forward to the last stage.

3.4 Change

3.4.1 To close the loop of the REC process, a change initiative must be implemented. The authority required to implement a design or procedural change will vary from case to case and from company to company. Some changes will be possible for the crew to implement without conference with the onshore organisation, while others may necessitate involvement from the DPA or other onshore resources. This will typically also depend on the magnitude of the change, such as the costs and time needed, whether they are small (S), medium (M) or large (L). As part of the debrief documentation, this should be described, e.g., using a table like the one in Fig. 2.

Change	Description	S M L	Responsible	Done
Technical system		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/>
Procedures		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/>
Design		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/>
		<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		<input type="checkbox"/>

Fig. 2: Description of change suggestion, magnitude and responsible

3.4.2 This documentation should be kept for reference until a change has been implemented. It can also be useful as a reference in case a DPA or other relevant onshore representatives wish to explore transfer value of change suggestion to other ships.

7.7 RCO7: Training module for efficient activation of extinguishing system

7.7.1 STCW Code Chap. V

The following new section A-V/5 is added after the existing section A-V/4 (Mandatory minimum requirements for the training and qualifications of masters and deck officers on ships operating in polar waters):

Section A-V/5

Mandatory minimum requirements for the training and qualification of masters, officers, ratings and other personnel on ro-ro ships

Standard of competence

1 Every candidate for certification in basic training for ro-ro ships shall be required to:

- .1 demonstrate the competence to undertake the tasks, duties and responsibilities listed in column 1 of table A-V/5-1; and
- .2 provide evidence of having achieved:
 - .1 the minimum knowledge, understanding and proficiency listed in column 2 of table A-V/5-1; and

.2 the required standard of competence in accordance with the methods for demonstrating competence and the criteria for evaluating competence tabulated in columns 3 and 4 of table A-V/5-1.

Table A-V/5-1

Specification of minimum standard of competence in basic training for ro-ro ships

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
Fight and extinguish fires	<p>Theoretical knowledge on fixed fire-extinguishing systems:</p> <p>.1 procedures of fixed fire-extinguishing systems activation</p> <p>Practical knowledge on fixed fire-extinguishing systems:</p> <p>.1 fixed water-based fire-extinguishing system activation procedure and instructions</p> <p>.2 fixed gas fire extinguishing system activation procedure and instructions</p> <p>.3 actions to be taken in case of fixed fire-extinguishing systems failure</p>	Assessment of evidence obtained from approved instruction or attendance at an approved course	Action taken on fixed fire-extinguishing system activation is appropriate to the indicated emergency and complies with established procedures

7.7.2 IMO Model Course “Advanced training for ro-ro operations”

A new IMO Model Course “Advanced training for ro-ro operations” is recommended to be drafted from the guidelines developed in the LASH FIRE deliverable D07.9 “Development and implementation of design guidelines and procedures for extinguishing system activation” [28]:

ACTIVATION OF FIXED FIRE-EXTINGUISHING SYSTEMS

- 1. Target group:** Crew members (deck officers and able seaman) sailing on board ro-ro ships.
- 2. Goal of the training:** Effective activation of the fixed fire-fighting systems, including both rounds of activation with both water-based system (drencher) and gas system (CO₂).
- 3. Content and agenda:**

TRAINING PROGRAMME	
Training topics	hours
THEORY	
- Procedures for fixed fire-extinguishing systems activation (Theoretical part)	2
- End of the course. Q&A. Debriefing session	1
PRACTICAL	
- Drencher fire-extinguishing system activation procedure and instructions	1
- CO ₂ fire-extinguishing system activation procedure and instructions	1
- Actions to be taken in case of fixed fire-extinguishing system failure	2
TOTAL	7
SCHEDULE	
08:00-08:10	Safety introduction, introduction of course and participants
08:10-08:15	Background – rationale and objective of the course
08:15-08:45	Fixed fire-extinguishing systems – some challenges and historic events
08:45-09:00	<i>Coffee break</i>
09:00-09:30	Discussions in groups and plenum
09:30-10:00	Reflective practice and learning: introduction to the learning framework of Schön
10:00-10:15	<i>Coffee break. Donning of PPE</i>
10:15-11:15	Drencher fire-extinguishing system activation procedure and instructions
11:15-12:15	CO ₂ fire-extinguishing system activation procedure and instructions
12:15-13:00	<i>Lunch on fireground</i>
13:00-15:00	Actions to be taken in case of fixed fire-extinguishing system failure
15:00-16:00	End of the course. Q&A. Debriefing session

4. Learning objective

At the end of the exercise, each trainee team should be able to efficiently activate the fixed fire-extinguishing system (drencher or CO₂) on board.

5. Safety briefing

Safety briefing by chief trainer of the dos and don'ts during the practical task demonstration. Correct use of PPE.

6. Sequence/script for both drencher and CO₂ system

- 6 hands-on trainees on the training ground (i.e., container)
- 2 OOW/Master trainees on emergency simulator. They will be communicated with trainees on the training ground by means of UHF radio. Use of CCTV system
- Ensure that the system has electrical connection
- A car will be placed inside the container with a fire inside the cabin
- DG Magnesium (Mg). CLASS 4.3 IMDG "*Substances which, in contact with water, emit flammable gases*" will be placed inside the vehicle. No information in the cargo manifest
- Forced ventilation should be stopped
- Head counter
- Check section/zone affected for CO₂
- Activation of fire pump (water pressure)
- Selection of valves
- Trigger fixed fire-extinguishing system
- Confirmation with OOW/Master
- Monitoring temperature
- Has system been effective? If not consider manual fire-fighting. NOTE: it will be considered that drencher will be not effective due to presence of DG

7. Assessment

Discusses the below listed checks of the Fixed fire-extinguishing system.

	PRACTICAL TASK - ASSESSMENT	PERFORMED	NOT PERFORMED
1	Trainee has received the confirmation/presence of a fire		
2	Trainee has checked that first response has not been successful or possible		
3	Presence of personnel in the area. Head count		
4	Trainee confirms the areas where the system has to be discharged		
5	Controls and distribution valves are checked before discharge		
6	Warning alarms (audible/visual)		
7	Forced ventilation is stopped		
8	All doors and openings are locked		
9	Identification of DGs		
10	Release the system		
11	Confirmation that the system has been triggered		
12	Temperature check		
13	Confirmation that the system has been effective		

8. Debriefing

The trainer then debriefs the trainee on the discussed checks made by the trainee (positives and negatives).

7.8 RCO8: Safe electrical connection for reefers

7.8.1 SOLAS Ch. II-1 Reg. 45

The following new paragraph 6.3 is added after the existing paragraph 6.2:

6.3 [In cargo spaces where stowage of reefer container unit, reefer trailer unit or electrical vehicle is foreseen] [In ro-ro or vehicles spaces of passenger ships], a separate final circuit is to be provided for each socket outlet, which is to be provided with a circuit breaker capable of being controlled from the continuously manned central control station. The insulation level, temperature, power consumption and individual phase voltage shall be monitored and recorded and any anomaly on these values shall trigger an alarm at the continuously manned central control station.

7.9 RCO9: Safe electrical connection of reefers and electric vehicles (EVs)

7.9.1 SOLAS Ch. II-1 Reg. 45

Add the following sentence at the end of the paragraph 6.3 proposed above:

Where charging of electric vehicle is foreseen, the insulation level, temperature, power consumption and individual phase voltage shall be monitored and recorded both upstream and downstream the charging station.

7.10 RCO10: Fire detection on weather decks

No proposal for regulation.

7.11 RCO11: Alternative fire detection in closed ro-ro spaces & open ro-ro spaces

7.11.1 FSS Code Ch. 9

This amendment proposal is based on FSS Code Ch 9 as planned to be amended as per SSE 9/20 Annex 6.

The existing paragraphs 2.4.2.2 is amended, as follows, and paragraphs 2.4.3.3 and 2.4.3.4 are added after existing paragraph 2.4.3.2:

2.4.2.2.2 Sensor cables of the linear heat detection system shall be so installed as to pass through any zone delimited by longitudinal and transversal stiffeners below the deckhead. ~~Distance between two sensor cables of the linear heat detection system shall not be more than 9.0 m, while distance between such cables and bulkheads shall not be more than 4.5 m.~~

[...]

2.4.3.3 Sensor cables of the linear heat detection system shall not interfere with the operation of hoistable decks or ramps.

2.4.3.4 Sensor cables of the linear heat detection system shall be fixed at regular intervals in line with Table 9.2. In addition, when cables are not laid on top of horizontal cable trays or supports, metallic cable clips or saddles shall be provided at regular distances not exceeding 2.0 m.

Table 9.2 – Spacing of fixing points for cables not carried in pipes

External diameter of cables		Non-armoured or unbraided cables [mm]	Armoured or braided cables [mm]
Exceeding [mm]	Not exceeding [mm]		
-	8	200	250
8	13	250	300
13	20	300	350
20	30	350	400
30	-	400	450

7.12 RCO12: Visual system for fire confirmation and localization

7.12.1 SOLAS Ch. II-2 Reg. 20.4.4

This amendment proposal is based on SOLAS Ch. II-2 as planned to be amended as per SSE 9/20 Annex 5.

The existing section 4.4 is amended, as follows – note: application dates to be agreed by IMO Member States:

4.4 Video monitoring

The requirements of paragraphs 4.4.1 and 4.4.2 apply to ships constructed on or after 1 January 2026. Passenger ships with vehicle, special category or ro-ro spaces constructed before 1 January 2026 shall comply with the requirements of paragraphs 4.4.1 and 4.4.2 not later than the first survey after 1 January 2028.

4.4.1 For passenger ships, an effective video monitoring system shall be arranged in vehicle, special category and ro-ro spaces and in areas on the weather deck intended for the carriage of vehicles for continuous monitoring of these spaces. The system may use regular video cameras together with video analytics or thermal imaging. The system shall be provided with immediate playback capability to allow for quick identification of fire location, as far as practicable. Cameras shall be installed to cover the whole space, high enough to see over cargo and vehicles after loading.

4.4.2 The videos recorded by this monitoring system shall be available for replay at a continuously manned control station or at the safety centre for at least seven days for installation on ro-ro passenger ships constructed on or after 1 January 2026 and 24 hours for existing ro-ro passenger ships constructed before 1 January 2026 and the correspondence between any one video camera and the section of the fixed water-based fire-extinguishing system it is covering shall be clearly displayed close to the video monitor. Continuous monitoring of the video image by the crew is not required.

7.13 RCO13: Dry-pipe sprinkler system for vehicle carriers

No proposal for regulation.

7.14 RCO14: Fixed remotely-controlled fire monitor system using water for weather decks

7.14.1 SOLAS Ch. II-2 Reg. 20.6

This amendment proposal is based on SOLAS Ch. II-2 as planned to be amended as per SSE 9/20 Annex 5.

The existing paragraphs 6.1, 6.2.1 and 6.2.2 are amended, as follows – note: application dates to be agreed by IMO Member States:

6.1 Fixed fire-extinguishing systems

(The requirements of paragraphs 6.1.1 and 6.1.2 shall apply to ships constructed on or after 1 July 2014. Ships constructed before 1 July 2014 shall comply with the previously applicable requirements of paragraphs 6.1.1 and 6.1.2. The requirements of paragraph 6.2 shall apply to ro-ro ~~passenger~~ ships constructed on or after 1 January 2026. Passenger ships with vehicle, special category or ro-ro spaces constructed before 1 January 2026 shall comply with the requirements of paragraph 6.2.3 not later than the first survey after 1 January 2028.)

6.2 Fixed water-based fire-extinguishing on weather decks intended for carriage of vehicles

6.2.1 ~~In passenger ships, a~~ fixed water-based fire-extinguishing system based on monitor(s) shall be installed in order to cover weather decks intended for the carriage of vehicles. The monitor(s) shall comply with the provisions of the Fire Safety Systems Code.

6.2.2 ~~In passenger ships, d~~Drainage shall be provided where a fixed water-based fire-extinguishing system is installed to cover weather decks intended for carriage of vehicles. The system shall be sized to remove no less than 125% of the combined capacity of both the monitor(s) and the required number of fire hose nozzles.

7.15 RCO15: Fixed autonomous fire monitor system using water for weather decks

7.15.1 SOLAS Ch. II-2 Reg. 20.6

This amendment proposal is based on SOLAS Ch. II-2 as planned to be amended as per SSE 9/20 Annex 5.

The existing paragraphs 6.1, 6.2.1, 6.2.2 and 6.2.3 are amended, as follows – note: application dates to be agreed by IMO Member States:

6.1 Fixed fire-extinguishing systems

(The requirements of paragraphs 6.1.1 and 6.1.2 shall apply to ships constructed on or after 1 July 2014. Ships constructed before 1 July 2014 shall comply with the previously applicable requirements of paragraphs 6.1.1 and 6.1.2. The requirements of paragraph 6.2 shall apply to ro-ro ~~passenger~~ ships constructed on or after 1 January 2026. Passenger ships with vehicle, special category or ro-ro spaces constructed before 1 January 2026 shall comply with the requirements of paragraph 6.2.3 not later than the first survey after 1 January 2028.)

6.2 Fixed water-based fire-extinguishing on weather decks intended for carriage of vehicles

6.2.1 ~~In passenger ships, a~~ fixed water-based fire-extinguishing system based on monitor(s) shall be installed in order to cover weather decks intended for the carriage of vehicles. ~~The system shall have both automatic and manual release capabilities.~~ The monitor(s) shall comply with the provisions of the Fire Safety Systems Code.

6.2.2 ~~In passenger ships, d~~Drainage shall be provided where a fixed water-based fire-extinguishing system is installed to cover weather decks intended for carriage of vehicles. The system shall be sized to remove no less than 125% of the combined capacity of both the monitor(s) and the required number of fire hose nozzles.

6.2.3 For passenger ships built before 1 January 2026, a fixed water-based fire-extinguishing system based on monitor(s) shall be installed in order to protect areas on weather decks intended for the carriage of vehicles. Monitors shall be located in positions which ensure unobstructed protection of vehicles in the area on the weather deck intended for carriage for vehicles, as far as practicable. Monitors shall be capable of automatic activation upon detection by two separate fire detectors and the operation mode of the fire monitors shall be adapted to the number of fires detected. Operation of monitors shall be ensured by safe access ways or remote control not to be impaired by a fire in the area protected by that monitor. Capacity of each monitor shall be at least 1,250 L/min. The Administration may permit lower flow rates when the required rate is not practical given the size and arrangement of the ship. The Administration may also permit alternative arrangements for ships that have already installed a fixed water-based fire-extinguishing system based on monitor(s) prior to 1 January 2026.

7.15.2 FSS Code Ch. 7

This amendment proposal is based on FSS Code Ch. 7 as planned to be amended as per SSE 9/20 Annex 6.

The existing paragraph 2.5 is amended, as follows, and the new paragraph 2.5.7 and the new section 2.5.8 are added after the existing section 2.5.6 – note: application dates to be agreed by IMO Member States:

2.5 Fixed water-based fire-extinguishing on ro-ro passenger ships' weather decks intended for the carriage of vehicles

This chapter details the specification of fixed water-based fire-extinguishing on ro-ro passenger ships having weather decks intended for the carriage of vehicles as required by chapter II-2 of the convention. The requirements of this chapter shall apply to ro-ro passenger ships constructed on or after 1 January 2026.

Add the following paragraphs 2.5.7 – Fixed fire detection and fire alarm system and 2.5.8 – Automatic activation.

2.5.7 The fixed fire detection and fire alarm system shall be capable of identifying the position of the fire.

2.5.8 – Automatic activation

2.5.8.1 The monitors shall be automatically activated upon fire detection by two independent fire detectors. The delay between fire detection and water discharge shall not exceed 60 seconds.

2.5.8.2 At least two fire monitor systems shall be operable simultaneously and be capable of operating independently of each other. The systems should be positioned on opposing sides of the weather deck (either 90° or 180° of each other).

2.5.8.3 The system shall be capable of operating regardless of the number of fires detected. The system shall be capable of managing at least four fires detected simultaneously. In the event of more than four simultaneous fires detected on the weather deck, the fire monitor system shall be programmed so as to effectively spray the entire protected part of the weather deck in an oscillating pattern.

2.5.8.4 Once the fixed fire detection and fire alarm system stops detecting fire, the monitors shall keep oscillating the area for at least five minutes before automatically shutting off the flow.

2.5.8.5 It shall be possible to manually stop the monitors at any time. The system shall remain ready to automatically reactivate upon fire detection at all times.

2.5.8.6 A warning notice shall be displayed outside each entry point to the weather deck stating the type of medium used and the possibility of automatic release.

7.16 RCO16: Guideline for fire ventilation in closed ro-ro space

No proposal for regulation.

7.17 Pre5: Proposal for requirements of surface materials in ro-ro spaces, with reference to suitable test method and material property performance criteria

7.17.1 MSC.1/Circ.1574

The test results of FTP Code Part 2 - Smoke and toxicity and Part 5 - Spread of flame of surface materials measured in fire tests and that can support the revision of IMO Circular MSC.1/Circ.1574 are documented in annexes B and C of deliverable D08.14 "Fire risk assessment and establishment of requirements [material property performance and test method for evaluation] for combustible surfaces in ro-ro spaces" [29].

7.18 Ext5: Development of a relevant fire test standard for alternative fixed water-based fire-fighting systems intended for ro-ro spaces and special category spaces

7.18.1 MSC.1/Circ.1430

The revision of the fire test procedures in the Appendix of IMO Circular MSC.1/Circ.1430/Rev.2 is documented in deliverable D10.5 "Updated test standard for alternative fixed fire-fighting systems" [30].

7.19 Cont9: Ship manoeuvring/operation to limit the effect of fire at least in critical areas

7.19.1 New MSC.1/Circ.XXXX: Guidelines for ship manoeuvring in case of fire in ro-ro spaces
Add the following in Annex of MSC.1/Circ.XXXX:

(Note: The following text is extracted from the deliverable D11.4 "Description of development and assessment of safe ro-ro space openings" [31].)

ANNEX

GUIDELINES FOR SHIP MANOEUVRING IN CASE OF FIRE IN RO-RO SPACES

1 Purpose

The purpose of these guidelines is to provide general ship manoeuvring recommendations in case of fire in ro-ro spaces, in order to avoid smoke spread to critical areas of the ships, such as assembly stations, life-saving appliances (LSA) stowage areas or embarkation routes on open deck, and enhance safe evacuation of the ship.

2 Application

These guidelines are intended to apply to ro-ro ships.

3 Prerequisites

3.1 Safety of navigation shall always be the priority (i.e., to avoid collision, grounding, contact, etc.) in comparison to ship manoeuvring in case of fire.

3.2 The guidelines for ship manoeuvring in case of fire can be used only if the following conditions are satisfied:

- .1 the ship is manoeuvrable, i.e., no blackout;
- .2 the change of the ship's course does not endanger safe evacuation in rough seas; and
- .3 wind speed and direction are favourable to support the desired outcome after manoeuvring. Very low-speed wind will not be efficient in pushing the smoke away.

4. Manoeuvring recommendations in case of a fire near side openings of ro-ro spaces

4.1 Identify the side of the ship (port side or starboard side) from where evacuation can be done, and take measures to ventilate smoke away from the critical areas on that side. It is recommended to select the side of the ship that is located furthest away from the fire.

4.2 Try to manoeuvre the ship to such direction that the critical areas on the selected side has the least impact from fire products (smoke, radiant heat flux etc.).

4.2.1 The least impact can be achieved in most situations if the selected side is manoeuvred to face the wind perpendicular to it (portside wind or starboard side wind).

4.2.2 If manoeuvring the ship as mentioned above is not possible, then the following recommendations need to be explored for choosing a suitable direction for apparent wind:

- .1 if the fire is located aft from the critical areas, then the suitable apparent wind is most likely headwind; or
- .2 if the fire is located forward from the critical areas, then the suitable apparent wind is most likely tailwind.

4.3 Note that there can be smoke or stray smoke in the critical areas even after manoeuvring as per recommendations. However, its impact would be less than the other side of the ship nearest to the fire.

5. Manoeuvring recommendations in case of a fire near an end opening of ro-ro space

5.1 After a fire has been confirmed onboard, assess if any smoke can be observed outside. If yes, locate the opening(s) where the smoke is coming from.

5.2 If necessary, ventilate the smoke away from any critical areas such as assembly stations, LSA stowage areas and embarkation routes on open deck by manoeuvring the ship if possible.

5.3 Recommendations for choosing a suitable direction for apparent wind:

- .1 if the end opening of ro-ro space producing the smoke is located aft from the critical areas to be protected, suitable apparent wind is most likely from headwind to sidewind;
- .2 if the end opening of ro-ro space producing the smoke is located forward from the critical areas to be protected, suitable apparent wind is most likely from tailwind to sidewind; and
- .3 the best wind direction will push the smoke directly away from the ship, and the smoke will not travel across any parts of the ship.

5.4 Note that having a strong sidewind can cause the smoke recirculation back to the ship on the leeward side due to pressure differences.

5.5 Note that if the end opening is protected from the wind by large structures such as casing, smoke ventilation will not be as effective.

5.6 It is recommended to prioritize protecting those critical areas which are located furthest away from the fire. Those which are closest to the fire will more likely become unavailable due to the heat from the fire.

6. It is recommended that every ship develop ship-specific drawing including location of openings in ro-ro spaces, critical areas (assembly stations, LSA stowage areas or embarkation routes on open deck, as minimum) and ship heading.

7.19.2 STCW Code Ch. II

The existing Table A-II/1 and Table A-II/2 are amended, as follows:

Table A-II/1

Specification of minimum standard of competence for officers in charge of a navigational watch on ships of 500 gross tonnage or more

Function: Navigation at the operational level

Column 1 Competence	Column 2 Knowledge, understanding and proficiency	Column 3 Methods for demonstrating competence	Column 4 Criteria for evaluating competence
[...]	[...]	[...]	[...]
Manoeuvre the ship	<p><i>Ship manoeuvring and handling</i></p> <p>Knowledge of:</p> <p>.1 the effects of deadweight, draught, trim, speed and under-keel clearance on turning circles and stopping distances</p> <p>.2 the effects of wind and current on ship handling</p> <p>.3 manoeuvres and procedures in case of fire in ro-ro spaces and under various conditions of wind for avoiding smoke spread to critical areas</p> <p>.34 manoeuvres and procedures for the rescue of person overboard</p> <p>.45 squat, shallow-water and similar effects</p>	<p>Examination and assessment of evidence obtained from one or more of the following:</p> <p>.1 approved in-service experience</p> <p>.2 approved training ship experience</p> <p>.3 approved simulator training, where appropriate</p> <p>.4 approved training on a manned scale ship model, where appropriate</p>	<p>Safe operating limits of ship propulsion, steering and power systems are not exceeded in normal manoeuvres</p> <p>Adjustments made to the ship’s course and speed to maintain safety of navigation</p>

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
	56 proper procedures for anchoring and mooring		
[...]	[...]	[...]	[...]

Tab A-II/2

Specification of minimum standard of competence for masters and chief mates on ships of 500 gross tonnage or more

Function: Navigation at the management level

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluation competence
[...]	[...]	[...]	[...]
Manoeuvre and handle a ship in all conditions	Manoeuvring and handling a ship in all conditions, including: .1 manoeuvres when approaching pilot stations and embarking or disembarking pilots, with due regard to weather, tide, headreach and stopping distances .2 handling ship in rivers, estuaries and restricted waters, having regard to the effects of current, wind and restricted water on helm response .3 application of constant-rate- of-turn techniques .4 manoeuvring in shallow water, including the reduction in under-keel clearance caused by squat, rolling and pitching	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved simulator training where appropriate .3 approved manned scale ship model, where appropriate	All decisions concerning berthing and anchoring are based on a proper assessment of the ship’s manoeuvring and engine characteristics and the forces to be expected while berthed alongside or lying at anchor While under way, a full assessment is made of possible effects of shallow and restricted waters, ice, banks, tidal conditions, passing ships and own ship’s bow and stern wave so that the ship can be safely manoeuvred under various conditions of loading and weather

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluation competence
	<p>.5 interaction between passing ships and between own ship and nearby banks (canal effect)</p> <p>.6 berthing and unberthing under various conditions of wind, tide and current with and without tugs</p> <p>.7 ship and tug interaction</p> <p>.8 use of propulsion and manoeuvring systems</p> <p>.9 choice of anchorage; anchoring with one or two anchors in limited anchorages and factors involved in determining the length of anchor cable to be used</p> <p>.10 dragging anchor; clearing fouled anchors</p> <p>.11 dry-docking, both with and without damage</p> <p>.12 management and handling of ships in heavy weather, including assisting a ship or aircraft in distress; towing operations; means of keeping an unmanageable ship</p>		

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluation competence
	<p>out of trough of the sea, lessening drift and use of oil</p> <p>.13 precautions in manoeuvring to launch rescue boats or survival craft in bad weather</p> <p>.14 methods of taking on board survivors from rescue boats and survival craft</p> <p>.15 ability to determine the manoeuvring and propulsion characteristics of common types of ships, with special reference to stopping distances and turning circles at various draughts and speeds</p> <p>.16 importance of navigating at reduced speed to avoid damage caused by own ship's bow wave and stern wave</p> <p>.17 practical measures to be taken when navigating in or near ice or in conditions of ice accumulation on board</p> <p>.18 use of, and manoeuvring in and near, traffic separation schemes and in vessel traffic service (VTS) areas</p>		

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluation competence
	.19 manoeuvring during fire in ro-ro space and under various conditions of wind for avoiding smoke spread to critical areas		
[...]	[...]	[...]	[...]

7.20 Cont10: Safety distances between side and end openings and critical areas

No proposal for regulation.

7.21 Cont11: Guidance on calculation of side openings in ro-ro spaces

7.21.1 SOLAS Ch. II-2 Reg. 3

Add the following in SOLAS II-2/35:

The existing paragraphs 3.35, 3.36 and 3.50 are amended, as follows:

35 *Open ro-ro spaces* are those ro-ro spaces that are either open at both ends or have an opening at one end, and are provided with adequate natural ventilation effective over their 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**.

[...]

36 *Open vehicle spaces* are those vehicle spaces either open at both ends, or have an opening at one end and are provided with adequate natural ventilation effective over their 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**.

[...]

50 *Weather deck* is a deck which is completely exposed to the weather from above and from at least two sides or ends.

[...]

[...]

**Space sides refer to the port and starboard side platings of the space

8 Conclusion

Main author of the chapter: Eric De Carvalho, BV

Fourteen cost-effective RCOs and five low-hanging fruits were reviewed regarding their regulatory compatibility. Then, based on the final recommendations from the D&D WPs, more than twenty proposals for regulations were developed in the form of amendments to the various IMO instruments, i.e.:

- SOLAS Ch. II-1 Reg. 45 – *Precautions against Shock, Fire and Other Hazards of Electrical Origin*;
- SOLAS Ch. II-2, in particular, Reg. 15 – *Instructions, On-Board Training and Drills*, Reg. 16 – *Operations* and Reg. 20 – *Protection of Vehicle, Special Category and Ro-Ro Spaces*;
- FSS Code;
- STCW Code; or
- IMO Circulars.

The regulatory proposals were developed in a way to be directly used by the IMO stakeholders (following the instructions provided in the IMO Circular MSC.1/Circ.1500/Rev.2) and submitted to the relevant IMO bodies. As far as possible, the recent amendments drafted by IMO stakeholders were considered.

The work presented in this deliverable is the final step of the FSA conducted in LASH FIRE. This deliverable is the summary of task T04.9 ‘*Development of new proposals for regulations*’ and contributes to the strategic objective:

“To provide a **recognized technical basis** for the revision of international **IMO regulations**, which greatly **enhances fire prevention** and **ensures independent management of fires** on ro-ro ships in current and **future** fire safety challenges”;

and to the specific objective 3:

“LASH FIRE will provide a **technical basis** for future revisions of regulations by **assessing risk reduction and economic properties of solutions**”.

Beyond the LASH FIRE project, potential ways forward would be that the proposals are submitted through an INF paper to the relevant IMO bodies or be used by any IMO working group in order to feed an output related to fire safety in ro-ro spaces. This should rely on the IMO stakeholders, up to their decisions and depending on the agenda items of the Organization. The proposals may be also used by Classification Societies or Insurance Companies for the development of their own rules.

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11 ANNEXES

11.1 ANNEX A: Technology Readiness Level

Table 6. Technology Readiness Level of RCOS and low-hanging fruits. CRS = closed ro-ro space, ORS = open ro-ro space, WD = weather deck, NB = newbuildings, Ex = existing ships

ID	Title	Ship types	Ro-ro space types	NB, Ex	TRL	Time to market
RCO1	Improved Fire patrol. Improved fire confirmation & localization	Ro-Pax, Ro-Ro, VC	CRS, ORS, WD	NB, Ex	5	Ready to be implemented.
RCO2	Improved signage and markings for effective wayfinding and localization	Ro-Pax, Ro-Ro, VC	CRS, ORS, WD	NB, Ex	5	Ready to be implemented.
RCO3	Developed efficient first response	Ro-Pax, Ro-Ro, VC	CRS, ORS, WD	NB, Ex	6	Ready to be implemented.
RCO4	Developed manual fire-fighting for Alternatively Powered Vehicles	Ro-Pax, Ro-Ro, VC	CRS, ORS, WD	NB, Ex	6	Ready to be implemented.
RCO5	Alarm system interface prototype	Ro-Pax, Ro-Ro, VC	CRS, ORS, WD	NB	6	24 months.
RCO6	Process for development of procedures and design for efficient activation of extinguishing system	Ro-Pax, Ro-Ro, VC	CRS, ORS	NB, Ex	6	Ready to be implemented.
RCO7	Training module for efficient activation of extinguishing system	Ro-Pax, Ro-Ro, VC	CRS, ORS	NB, Ex	5	Ready to be implemented.
RCO8	Safe electrical connection for reefers	Ro-Pax, Ro-Ro	CRS, ORS, WD	NB, Ex	6	9 months, components commercially available today.
RCO9	Safe electrical connection of reefers and electric vehicles (EVs)	Ro-Pax	CRS, ORS, WD	NB, Ex	6	9 months, components commercially available today.
RCO10	Fire detection on weather decks	Ro-Pax, Ro-Ro	WD	NB, Ex	7	Ready to be implemented.
RCO11	Alternative fire detection in closed ro-ro spaces & open ro-ro spaces	Ro-Pax, Ro-Ro, VC	CRS, ORS	NB	7	Ready to be implemented.
RCO12	Visual system for fire confirmation and localization	Ro-Pax, Ro-Ro, VC	CRS, ORS, WD	NB, Ex	7	Ready to be implemented.
RCO13	Dry-pipe sprinkler system for vehicle carriers	VC	CRS	NB	6	Ready to be implemented.
RCO14	Fixed remotely controlled fire monitor system using water for weather decks	Ro-Pax, Ro-Ro	WD	NB, Ex	6	Ready to be implemented.
RCO15	Fixed autonomous fire monitor system using water for weather decks	Ro-Pax, Ro-Ro	WD	NB, Ex	6	Ready to be implemented.
RCO16	Guideline for fire ventilation in closed ro-ro space	Ro-Pax, Ro-Ro	CRS	NB, Ex	4	Published. Ready for dissemination.
Pre5	Proposal for requirements of surface materials in ro-ro spaces, with reference to suitable test method and material property performance criteria	Ro-Pax, Ro-Ro, VC	CRS, ORS, WD	NB, Ex	N/A	TRL not applicable as no solution is being developed. However, several material systems (commercially available) were tested in lab, but just a few were applied on ro-ro ships (and cargo ships in general).
Ext5	Development of a relevant fire test standard for alternative fixed water-based fire-fighting systems intended for ro-ro spaces and special category spaces	Ro-Pax, Ro-Ro	CRS, ORS	NB	4	3 months, components commercially available today.
Cont9	Ship manoeuvring/operation to limit the effect of fire at least in critical areas	Ro-Pax, Ro-Ro, VC	CRS, ORS, WD	NB, Ex	6	Maybe one year, depending on ship operators. General recommendations for manoeuvring in case of fire have been given. Ship-specific guidelines shall be developed by operators.

ID	Title	Ship types	Ro-ro space types	NB, Ex	TRL	Time to market
Cont10	Safety distances between side and end openings and critical areas	Ro-Pax, Ro-Ro	ORS	NB, Ex	5	Several years. Defining proper safety distances requires further research and validation work and approval of regulators.
Cont11	Guidance on calculation of side openings in ro-ro spaces	Ro-Pax, Ro-Ro	CRS, ORS	NB	5	Published. Future use depending on ship operators.

Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

- TRL 1 –basic principles observed
- TRL 2 –technology concept formulated
- TRL 3 –experimental proof of concept
- TRL4 –technology validated in lab
- TRL 5 –technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6 –technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 –system prototype demonstration in operational environment
- TRL 8 –system complete and qualified
- TRL 9 –actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Reference: HORIZON 2020 – Work programme 2014-2015. General Annexes. G. Technology readiness levels (TRL).

11.2 ANNEX B: Interdependency matrix

The risk reduction provided by each RCO was estimated with the assumption that none of the other RCOs were implemented (i.e., each RCO was assessed independently). However, the risk reduction attributed to the implementation of a second RCO (in addition to the first one) may be reduced compared to if the second RCO was implemented on its own, especially if both are affecting the same hazards. This will lead to reduced cost-effectiveness of the second RCO, when considered together with the first one.

Where several RCOs are proposed to be implemented at the same time, the risk reduction effectiveness of such a combination should be assessed. For RCOs with strong dependency, a quantitative assessment of the combined effects should be conducted, while combinations of RCOs with weak dependencies could be quantitatively or qualitatively assessed.

A qualitative evaluation of interdependencies between all RCOs was performed, looking at the functional and computational dependencies of RCOs and respective impacts in the fire risk model. The results of this evaluation are presented in an interdependency matrix in Table 7.

The interdependency matrix lists the RCOs both vertically and horizontally. Reading horizontally, the table indicates in the first row any dependencies between RCO1 and each of the other proposed RCOs. For example, in this case the table states that if RCO1 is implemented first, RCO3, being strongly dependent on RCO1, needs to be re-evaluated before adopting it in conjunction with RCO1. On the other hand, RCO10 is not dependent on RCO1, and therefore the cost-effectiveness of RCO10 will not be affected by the combined adoption with RCO1. Furthermore, RCO2 is weakly dependent on RCO1, so a re-evaluation may or may not be necessary before a combined adoption of the two RCOs.

Table 7. Interdependency matrix

	Secondly implemented → Firstly implemented ↓	RCO1	RCO2	RCO3	RCO4	RCO5	RCO6	RCO7	RCO8	RCO9	RCO10	RCO11	RCO12	RCO13	RCO14	RCO15	RCO16
RCO1	Improved fire patrol. Improved fire confirmation & localization ¹		Weak	Strong	No	No	Weak	No	Weak	Weak	No	No	Weak	No	No	No	No
RCO2	Improved signage and markings for effective wayfinding and localization	Strong		Strong	No	Weak	Strong	No	No	No	No	No	Weak	No	No	No	Weak
RCO3	Developed efficient first response	Weak	Weak		Strong	Weak	Weak	No	No	No	No	No	Strong	Weak	No	No	No
RCO4	Developed manual firefighting for Alternatively Powered Vehicles	No	No	Weak		No	Weak	Weak	No	No	No	No	No	No	No	No	Weak
RCO5	Alarm system interface prototype	Weak	Weak	No	No		Strong	No	No	No	Strong	Strong	Strong	No	No	Weak ²	Weak
RCO6	Process for development of procedures and design for efficient activation of extinguishing system	No	Weak	No	Weak	No		Strong	No	No	No	No	No	No	No	No	No
RCO7	Training module for efficient activation of extinguishing system	No	Weak	No	Weak	No	Strong		No	No	No	No	No	No	No	No	No
RCO8	Safe electrical connection for reefers ¹	Weak	No	No	No	No	No	No			No	No	No		No	No	No
RCO9	Safe electrical connection of reefers and electric vehicles (EVs) ¹	Weak	No	No	No	No	No	No			No	No	No		No	No	No
RCO10	Fire detection on weather decks	Strong ²	No	Weak ²	No	Weak ²	No	No	No	No		No	Strong ²		Weak	Strong	No
RCO11	Alternative fire detection in closed ro-ro spaces & open ro-ro spaces	Weak	Weak	Weak	No	Weak	Weak	No	No	No	No		No	No	No	No	No
RCO12	Visual system for fire confirmation and localization	Strong	Strong	Weak	No	Weak	Weak	No	No	No	Strong	No		No	Weak	Weak	No
RCO13	Dry-pipe sprinkler system for vehicle carriers	Strong	No	Strong	Strong	No	Strong	Strong				No	Strong				
RCO14	Fixed remotely-controlled fire monitor system using water for weather decks	No	No	Weak ²	Weak ²	No	Strong ²	Strong ²	No	No	No	No	No				No
RCO15	Fixed autonomous fire monitor system using water for weather decks	Strong ²	No	Strong ²	Strong ²	Weak ²	No	No	No	No	Strong	No	Strong ²				No
RCO16	Guideline for fire ventilation in closed ro-ro space	No	Weak	No	Weak	Weak	No	No	No	No	No	No	No		No	No	

Notes:

¹ RCO1, RCO8 and RCO9 impact directly the fire ignition (i.e., preventive RCOs). If implemented first, the cost-effectiveness of the other RCOs (i.e., mitigating RCOs) shall be re-assessed.

² "Weak" or "Strong" only for weather decks. "No" for closed and open ro-ro spaces.