LASH FIRE

Legislative Safety Assessment for Safety Hazards of Fire
and Innovations in Ro-Ro Ship Environment

How to control fire risks related to ro-ro space openings

Tuula Hakkarainen
VTT Technical Research Centre of Finland Ltd

CFIS 2022 –Conference on Fire Safety at Sea
11.10.2022

Contents

- LASH FIRE project in brief
- Fire safety and ro-ro space openings
- Fire simulations
- Results
- Safety distances for ro-ro space openings
- Conclusions and further work

LASH FIRE project in brief

- "Legislative Assessment for Safety Hazards of Fire and Innovations in Ro-ro ship Environment"
- www.lashfire.eu
- Duration: September 2019 – August 2023 (48 months)
- Total budget: 13.5 M€; EU funding: 12.2 M€
- Consortium: 25 partners from 13 Member States of the EU

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814975

Strategic objective of LASH FIRE

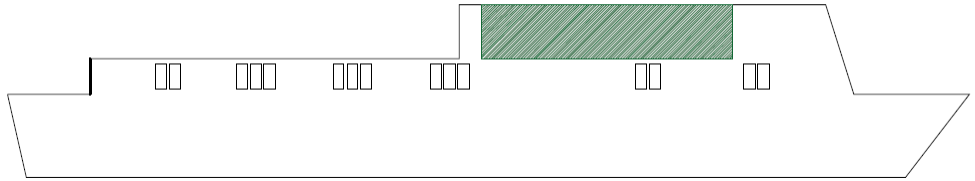
"To provide a **recognized technical basis** for the revision of international **IMO regulations**, which greatly **enhances fire prevention** and **ensures independent management of fires** on ro-ro ships in current and **future** fire safety challenges."

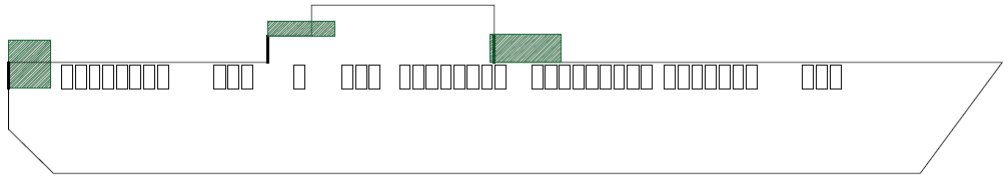
LASH FIRE WP11: Containment

- Objectives: Eliminate significant containment weaknesses, considering smoke, fire and heat integrity. This is achieved by four actions with the following goals:
  - (11-A) Develop and demonstrate artificial and new means for **fire integrity sub-division** of ro-ro spaces.
  - (11-B) Develop solutions and recommendations to ensure **safe evacuation** (in line with purpose of SRtP) and when evacuating at foreign port.
  - **(11-C) Develop ro-ro space openings design guidelines by assessment of the risks of smoke and heat transfer from ro-ro space openings to life-saving appliances, adjacent areas and ventilation inlets.**
  - (11-D) Determine the effects of **natural and mechanical ventilation** on fire development and evaluate current possibilities and new measures for smoke containment.

Fire safety and ro-ro space openings

- Pictures show typical ro-ro space geometries; locations of embarkation stations and life-saving appliances shown in green
- Open ro-ro spaces have been identified as a risk due to open end and side openings.
- Why not to ban openings?
  - Natural ventilation → Possibility to transport cargo that cannot be transported in closed ro-ro spaces
  - Full banning not cost-efficient (FIRESAFE II study)



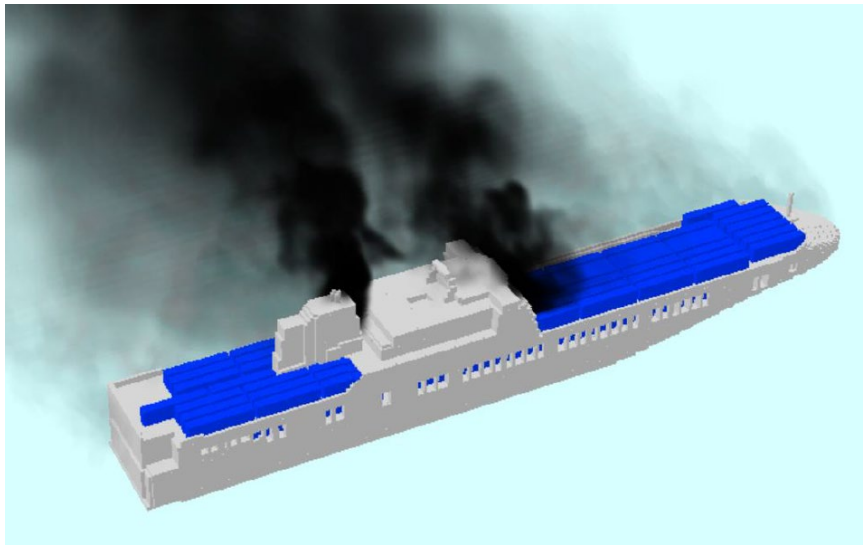


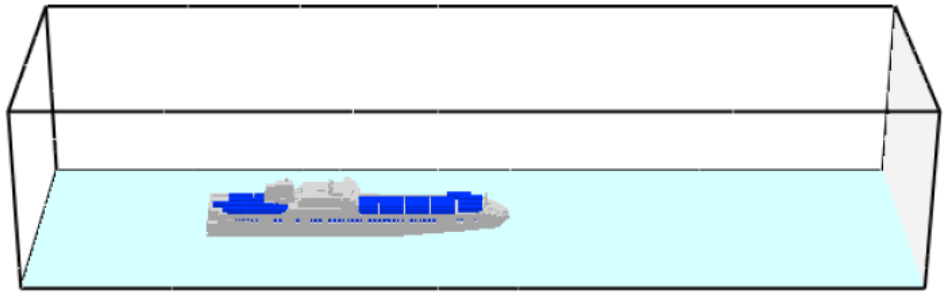
Fire simulations

- Simulations of fires in ro-ro spaces of two generic ships (ro-pax and ro-ro cargo) were performed using Fire Dynamics Simulator (FDS) software

- Heat and smoke transfer simulations in different wind conditions when there is a fire in an open ro-ro space

- Design fire: a Heavy Goods Vehicle, based on experimental data





Risk assessment

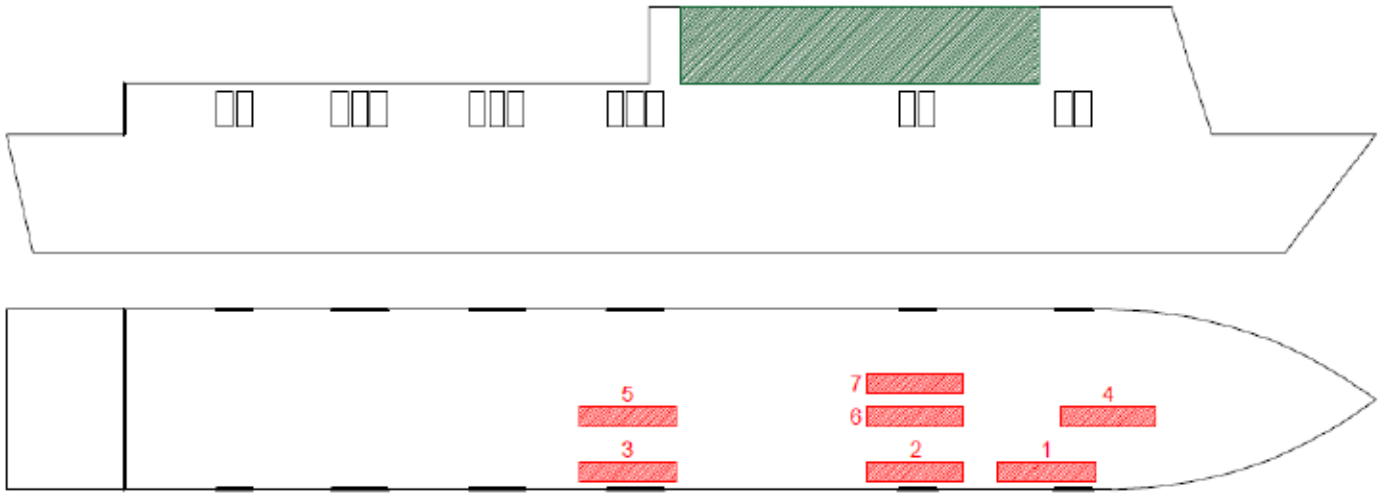
- Life safety performance criteria according to MSC.1/Circ.1552

Maximum air temperature	60ºC
Maximum radiant heat flux	2.5 kW/m^2
Minimum visibility	10 m; 5 m in spaces ≤ 100 m^2
Maximum CO concentration	1200 ppm (instantaneous exposure) 500 ppm (for 20 min cumulative exposure times)

- Critical heat flux for materials of life-saving appliances: 10 kW/m^2

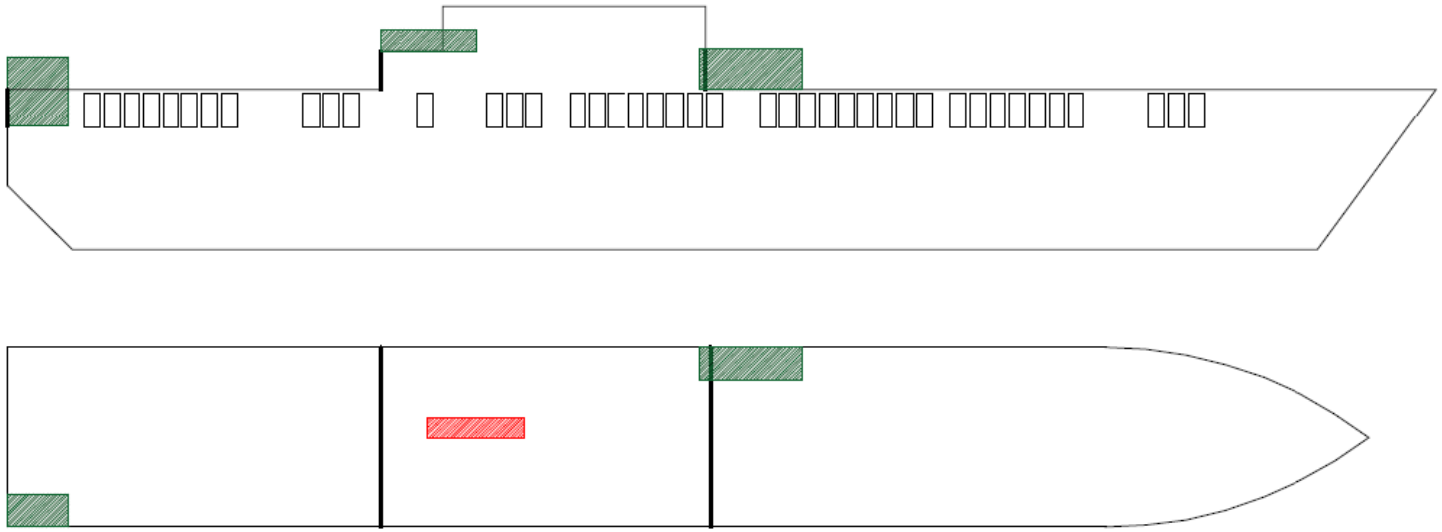
Simulation scenarios: ro-pax

Scenario	Wind	Fire location
1	No wind	2
2	Headwind	4
3	Headwind	2
4	Tailwind	5
5	Portside	7
6	Headwind	1
7	Tailwind	3
8	No wind	6

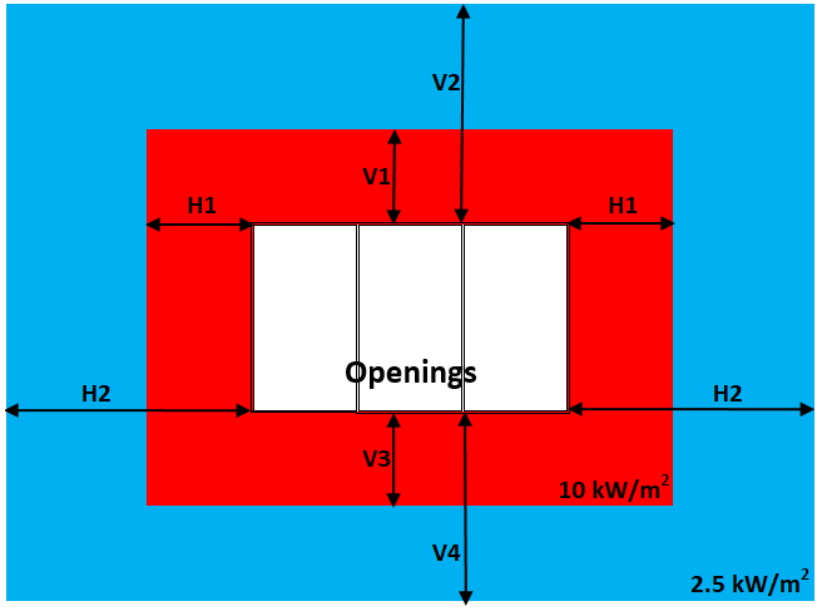


Simulation scenarios: ro-ro cargo

Scenario	Wind
9	Headwind
10	Tailwind
11	Portside
12	Starboard side
13	No wind



Results: ro-pax



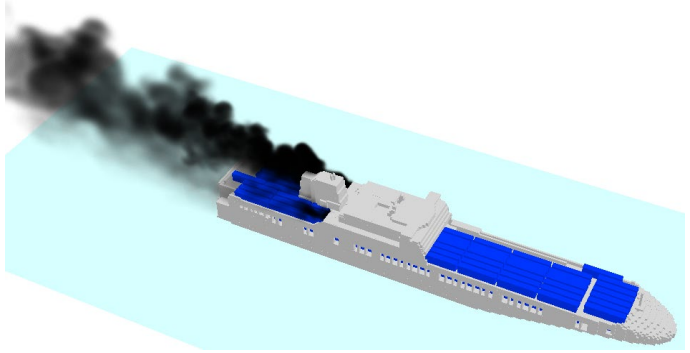
Red area: no LSAs
Blue area: only LSAs not involving passengers

Wind	Distance to < 2.5 kW/m² (m)			Distance to < 10 kW/m² (m)		
Headwind	**H2 = 7.5**	V2 = 9.1	V4 = 1.6	**H1 = 1.5**	V1 = 3.1	V3 = 0
Tailwind	H2 = 3.4	V2 = 4.2	V4 = 0.5	H1 = 0.4	V1 = 0.6	V3 = 0
Portside / Starboard side	H2 = 0	V2 = 0	V4 = 0	H1 = 0	V1 = 0	V3 = 0
No wind	H2 = 2.1	**V2 = 14.3**	**V4 = 2.0**	H1 = 0.5	**V1 = 5.4**	V3 = 0

Results: ro-ro cargo

Scenario	Wind	Distance to < 2.5 kW/m²	Distance to < 10 kW/m²
9	Headwind	26.6 m*	16.6 m*
10	Tailwind	14.2 m	6.0 m
11	Portside	9.6 m	5.4 m
12	Starboard side	15.2 m	9.4 m
13	No wind	14.4 m	9.8 m

* Instantaneous value downwind due to a shed eddy.



t = 10 min, scenario 9

t = 10 min, scenario 12

Safety distances for ro-ro space openings

- Implementing safety distances between the ro-ro space openings and critical areas seems to be an effective way to ensure safety of such spaces.
- In newbuilds, the safety distances could be implemented by means of novel ship designs. For existing ships, the safety distances could be established by either closing some openings or by fitting some of the openings with suitable closure devices.
- NB! The obtained simulation results are dependent on the assumptions made about the ship's geometry, the size of the fire, environmental conditions, and operational procedures.
  - Plausible / possible worst-case scenario?

Safety distances for ro-ro space openings

- Proposal: Safety distance based on radiant heat flux
- On the basis of FIRE SAFE II project:

Horizontal safety distance	FIRESAFE II
For < 2.5 kW/m^2	13 m
For < 5 kW/m^2	8 m

A [13 m] safety distance between LSA embarkation stations and weather deck/ro-ro space aft openings;
An [8 m] safety distance between stowed LSAs (including survival craft, not embarked onboard) and weather deck/ro-ro space aft openings

Conclusions and further work

- Ship design can be made safer by implementing a safe area around openings based on safety distances.
- The definition of proper safety distances is challenging, requiring further research work.
- In the future, it might be possible to use either prescriptive values defined in IMO regulations or ship-specific values based on alternative, performance-based design.
- The alternative approaches for defining suitable safety distances could be either analytical calculation tools or advanced computational methods (such as CFD models). NB! Such tools need to be well validated and approved.

Conclusions and further work

- LASH FIRE efforts to advance in making analytical formulas for defining safety distances:
  - An analytical formula for safety distance based on radiant heat flux
    - Input needed: heat release rate of a vehicle in fire, geometrical and environmental inputs
    - Calculations: radiant heat flux, flame height, and velocity in a plume
  - A linear relationship between the assumed fire size and the resulting safe distance around openings
    - Only fire size as an input
    - Safe distances as an output without intermediate calculations
  - A parametric study on the combined effect of different fire sizes with different opening widths
    - It was demonstrated that the size of the openings has a considerable effect on the radiant heat flux around the openings.

LASH FIRE

Legislative Safety Assessment for Safety Hazards of Fire and Innovations in Ro-Ro Ship Environment

www.lashfire.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814975