SUPER-LNG overview and risk assessment at LNG ports

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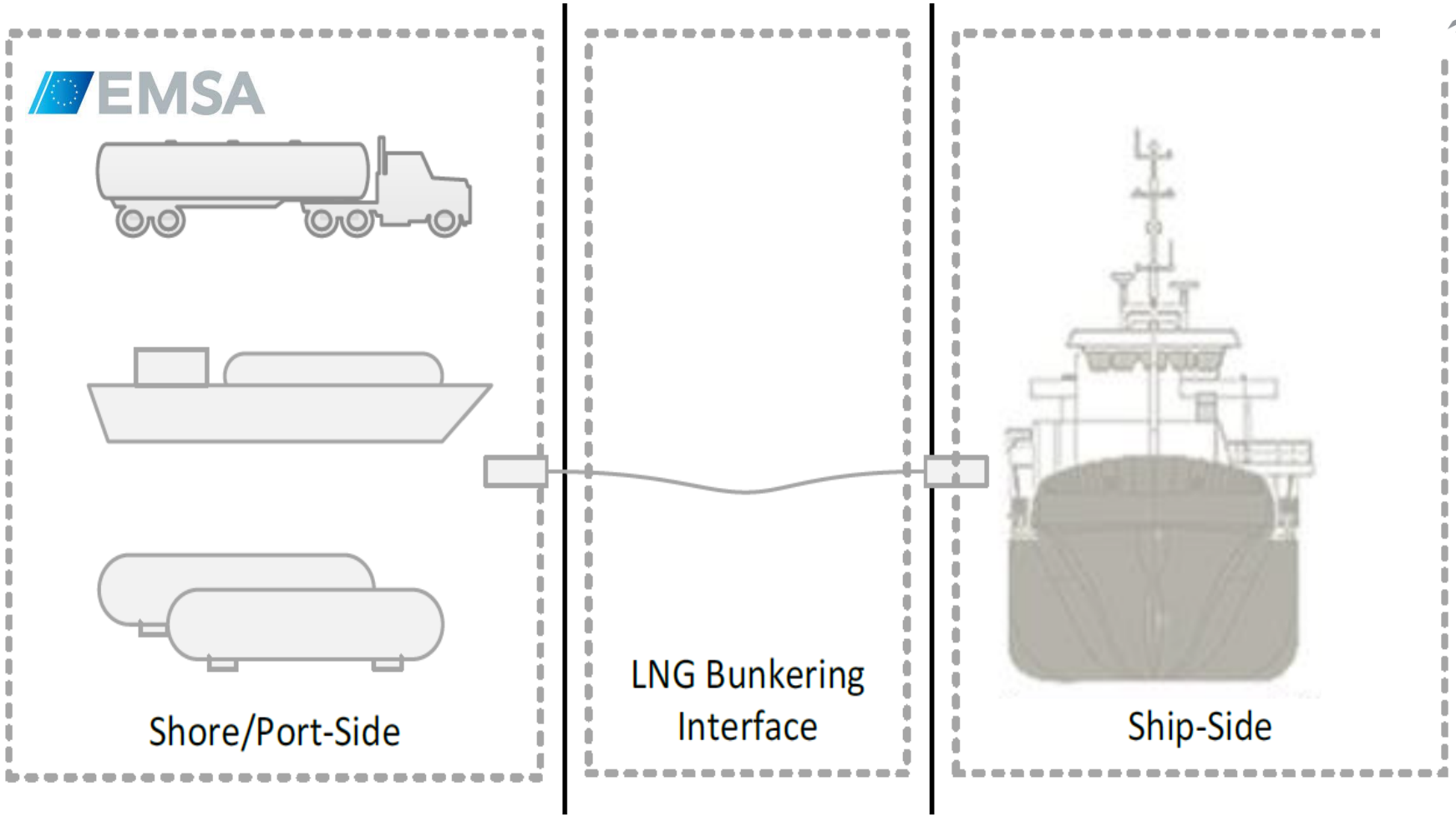
SUPER LNG PLUS WORKSHOP

Outline

- Introduction
- Regulatory framework – Gap Analysis
- Network of experts
- Safety Guidelines for LNG bunkering
- Risk assessment
- Guidelines for emergency planning
- Training courses
- Conclusions

Ship to Shore LNG Bunkering



Ref: http://www.emsa.europa.eu/

Overview of Regulations

High level Regulations
- International
- European Union

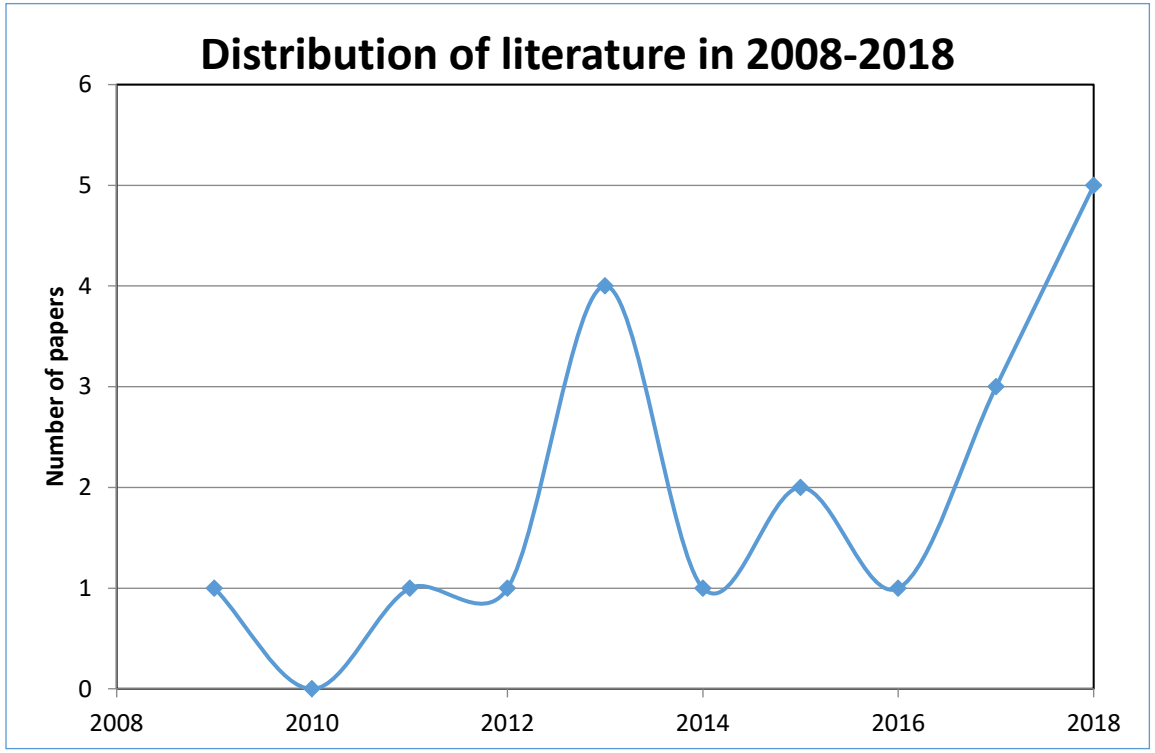
Standards
- ISO Standards
- CEN Standards
- NFPA Standards

Class Regulations
- IACS
- Classifications

Guidelines
- SGMF
- SIGTTO
- OCIMF
- OGP

Port Regulations

Literature Data



RESEARCH AREAS

- LNG bunkering operations (7 docs)
- Small scale LNG facilities (2 docs)
- LNG at ports combined with the supply network (2 docs)
- Consequence assessment of LNG releases at ports (3 docs)
- Risk assessment for LNG storage and bunkering at ports (5 docs)

Comparative Analysis

Tanks: SEVESO III, EN 1473, NFPA 59A

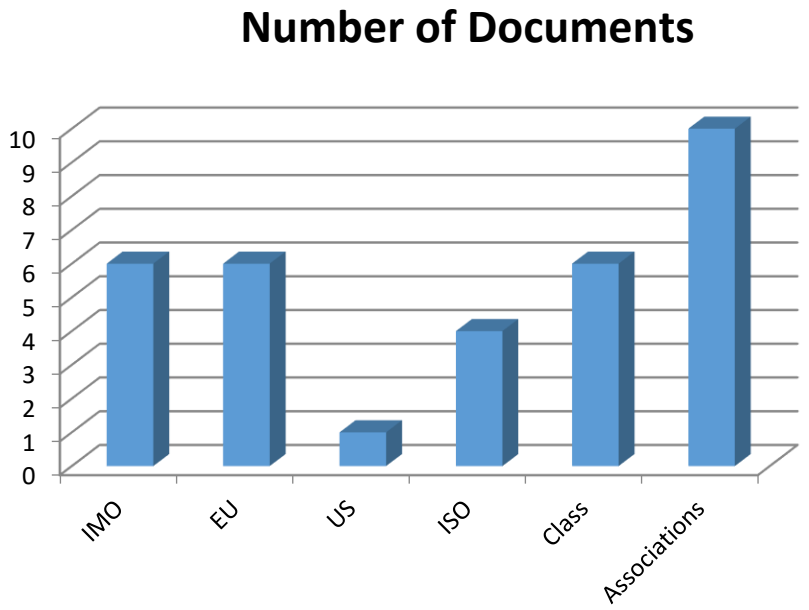
Truck-vehicle: ADR, ISO 20421-2

Bunker ship: IGC code, ISO 20519, ISO 28460

Bunkering: ISO 20519, ISO 18683,
ISO 16901, ISO 28460, SEVESO III

Receiving ship: IGF code

Risk assessment: SEVESO III, ISO 18683, NFPA 59A,
ISO 16901, ISO 20519, EN1473,

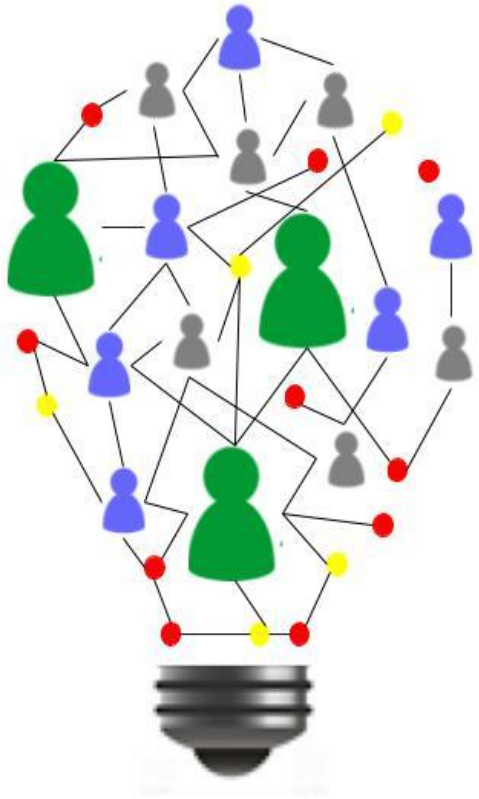


Identified Gaps

- Lack of harmonization of LNG safety regulations both at sea and on the land, for all LNG operations at ports namely, ship-fuelling, bunkering and LNG land facilities
- Lack of harmonization for LNG safety regulations within various countries across the world
- Lack of knowledge for estimating safety and hazardous zones during storage and bunkering of LNG, under various conditions

Network of experts in the area of safety, security and training of LNG port authorities

- 11 members of the network from the following organisations:
  - NCSR “DEMOKRITOS”
  - University of Bologna
  - Jozef Stefan Institute
  - Piraeus Port Authority
  - Southern Adriatic Sea Ports Authority
  - National Fire Brigade, Italy
  - Ecole des Mines d'Alès
  - NTNU Norway
  - GAZIL Hellas
  - National Technical University of Athens
  - University of the Aegean



SUPER-LNG Guidelines

- Guidelines for Safety Reporting
- Guidelines for Evaluation of Safety Reporting
- Guidelines for Emergency Planning

Guidelines for Safety Reporting

- ✓ Guidelines are based on requirements of SEVESO III, ISO 18683, ISO 20517

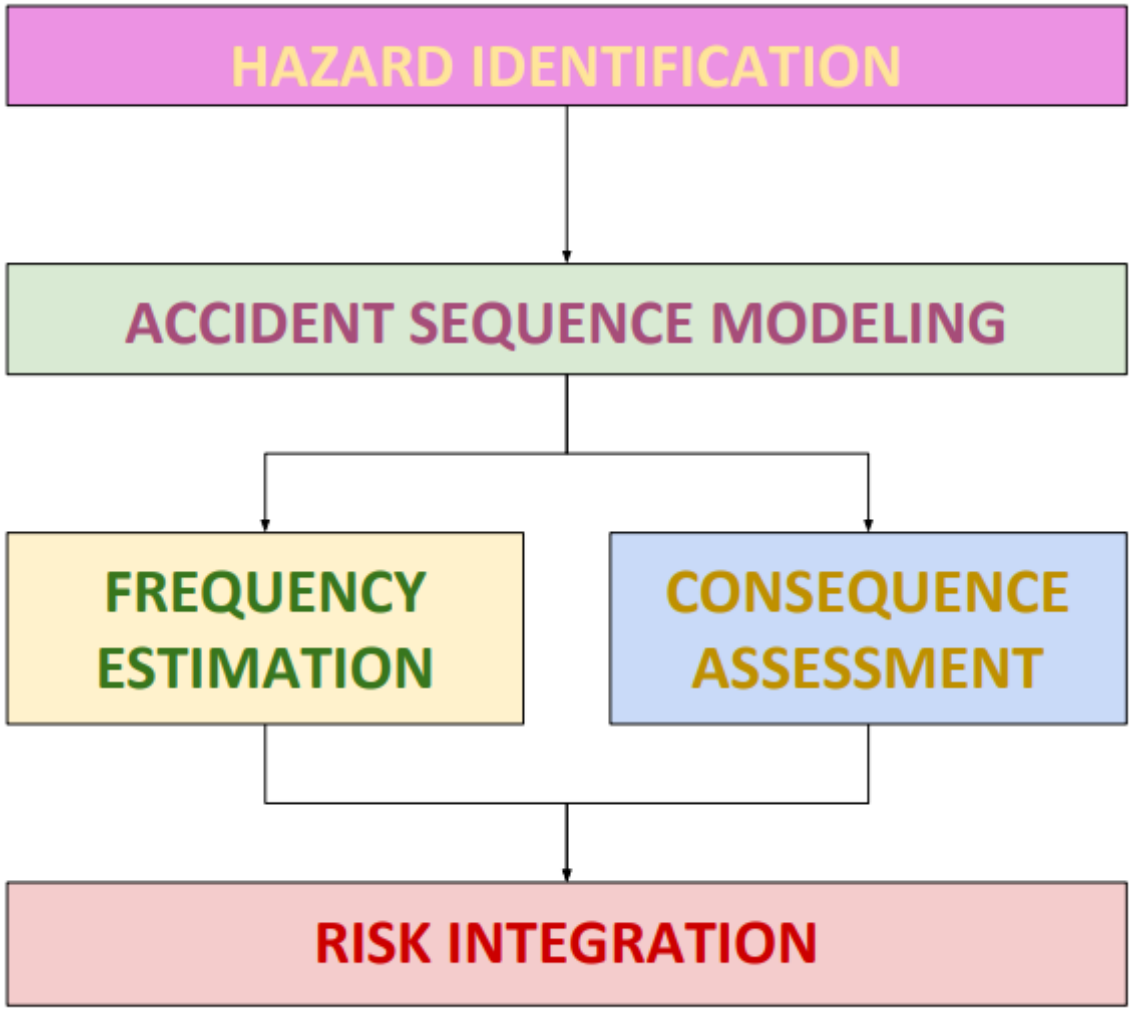
Description of the Establishment and Environment

Hazard Identification and Risk assessment

Safety Management System

Major Accident Prevention Policy

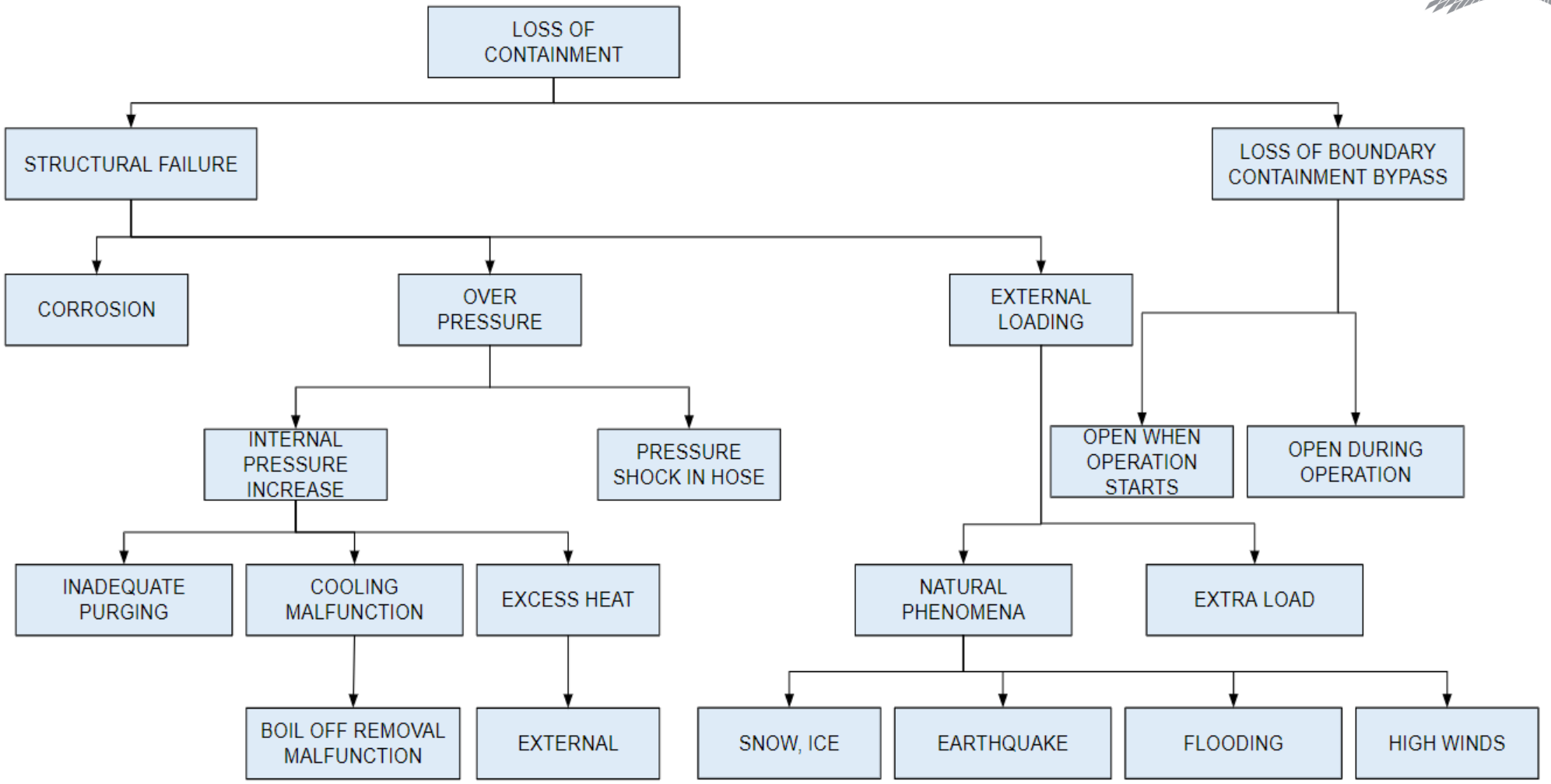
Major Steps for QRA



Hazard Identification in Ports Handling LNG

- Use of check lists from previous analyses or study of LNG accidents, for initiating event identification
- Examples of accident databases (ARIA, MARS)

MLD for loading/unloading arm area



Initiating Event in a Port Handling LNG

✓ LNG storage tank

- Boiloff removal malfunction, during unloading or storage
- Excess external heat in storage tank area
- Level rise beyond safety height, or overfilling
- Continuation of unloading beyond lower safety level

✓ Loading arm section

- Excess external heat in jetty area
- Water hammer in loading arm, due to inadvertent valve closure
- Inadequate cooling of loading arm
- High winds during loading-unloading

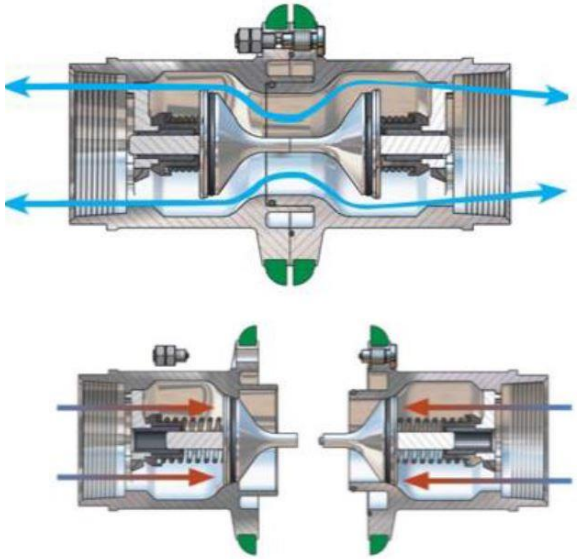
✓ Truck

- Excess external heat
- Level rise beyond safety height
- Extra load on hose

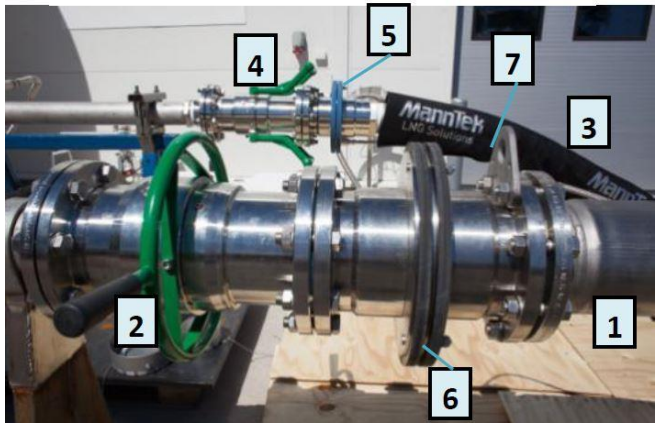
Safety Systems

SAFETY SYSTEMS FOR INITIATING EVENT: Level rise beyond safety limit

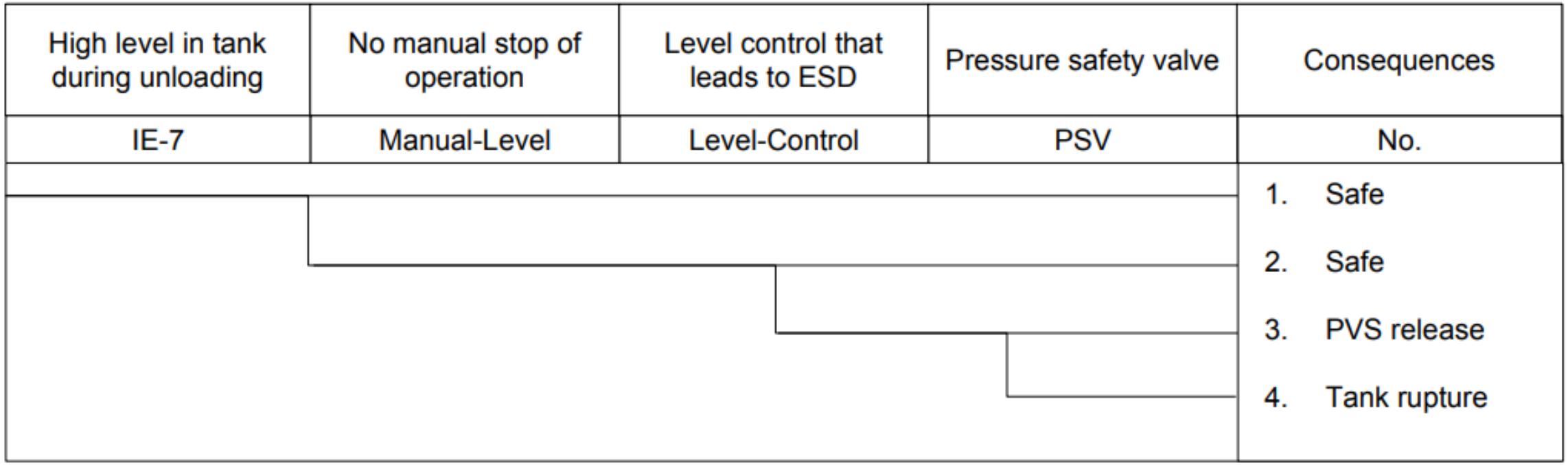
- Manual stop of Loading
- Emergency Shutdown System (ESD)
- Pressure Safety Valves (PSV)



1. **LNG bunkering line**
2. Main Quick-Connect/ Dry Disconnect coupling (QC/DC)
3. Vapour return line
4. Return QC/DC
5. ERC main line
6. ERC Vapour Return
7. Pad-eye for LNG bunkering hose crane handling



Accident Sequence Modeling



FAULT TREES
HUMAN PRFORMANCE ANALYSIS

Plant Damage States

Definition

- A plant damage state uniquely characterizes the installation-dependent conditions of release of the hazardous substance.

Damage States

LNG Storage Tank
- Tank rupture owing to overpressure, overfilling
- Pipe failure- tank to pump

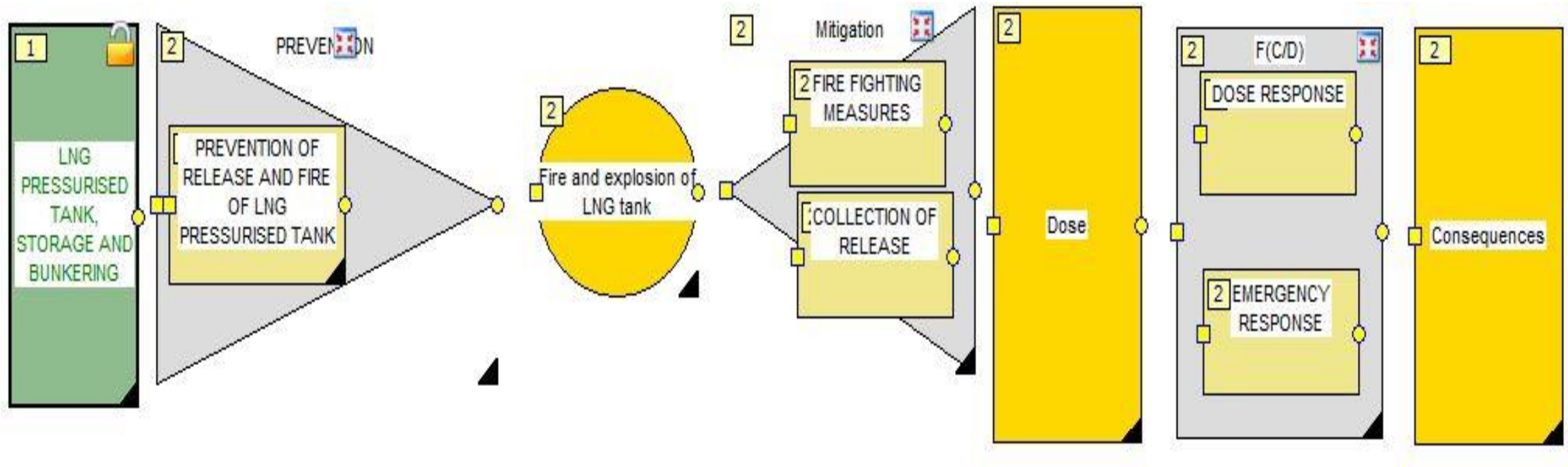
Loading arm- Unloading section
- Pipe rupture
- Hose rupture

Truck
- Truck rupture

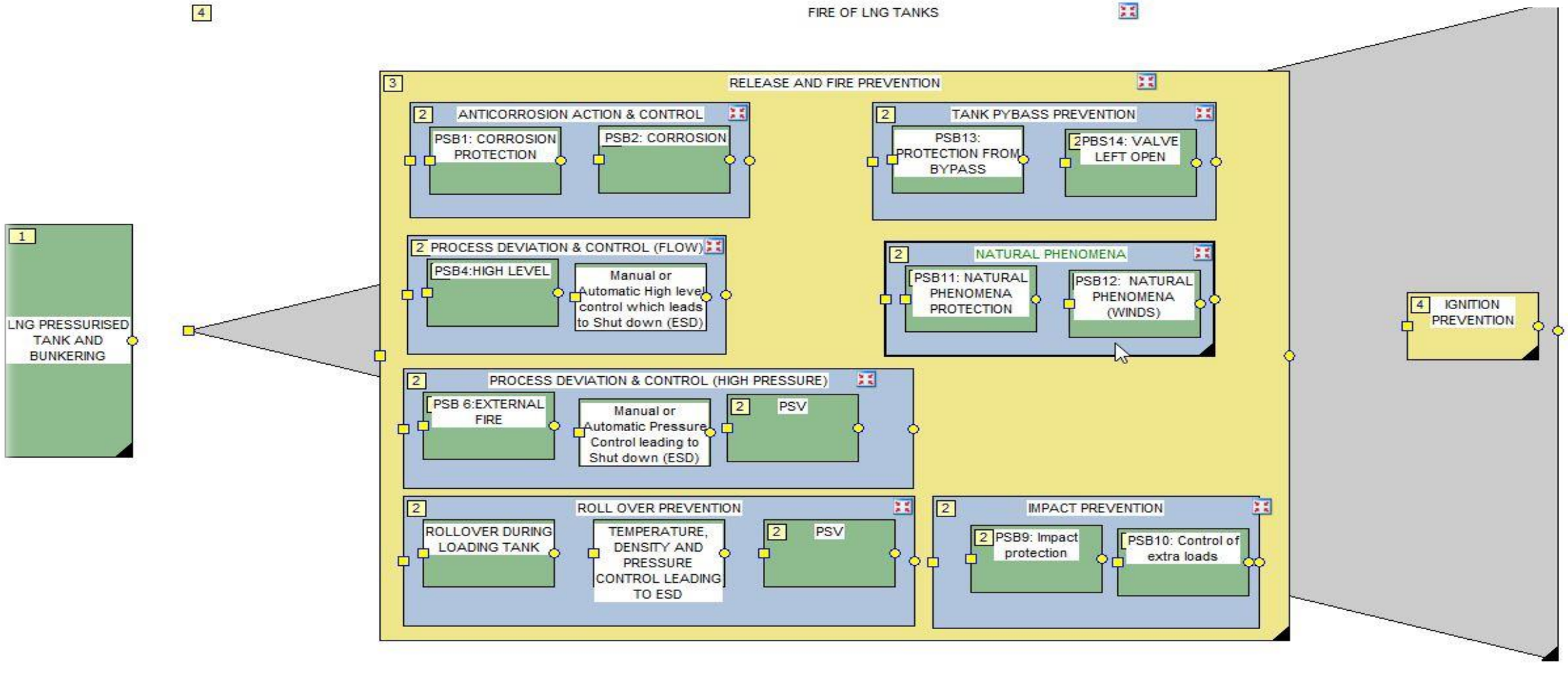
Buffer Ship
- Buffer ship rupture

Fuelled Ship
- Tank rupture owing to overpressure, overfilling

General Bowtie for LNG Pressurised Tank



Left Hand Side of the Bowtie



Frequency Assessment of Damage States

Guidance on Data and Parameter Assessment

- ✓Estimate frequencies of the initiating events, component unavailability, probabilities of human actions
- ✓Data Gathering and parameter value assessment

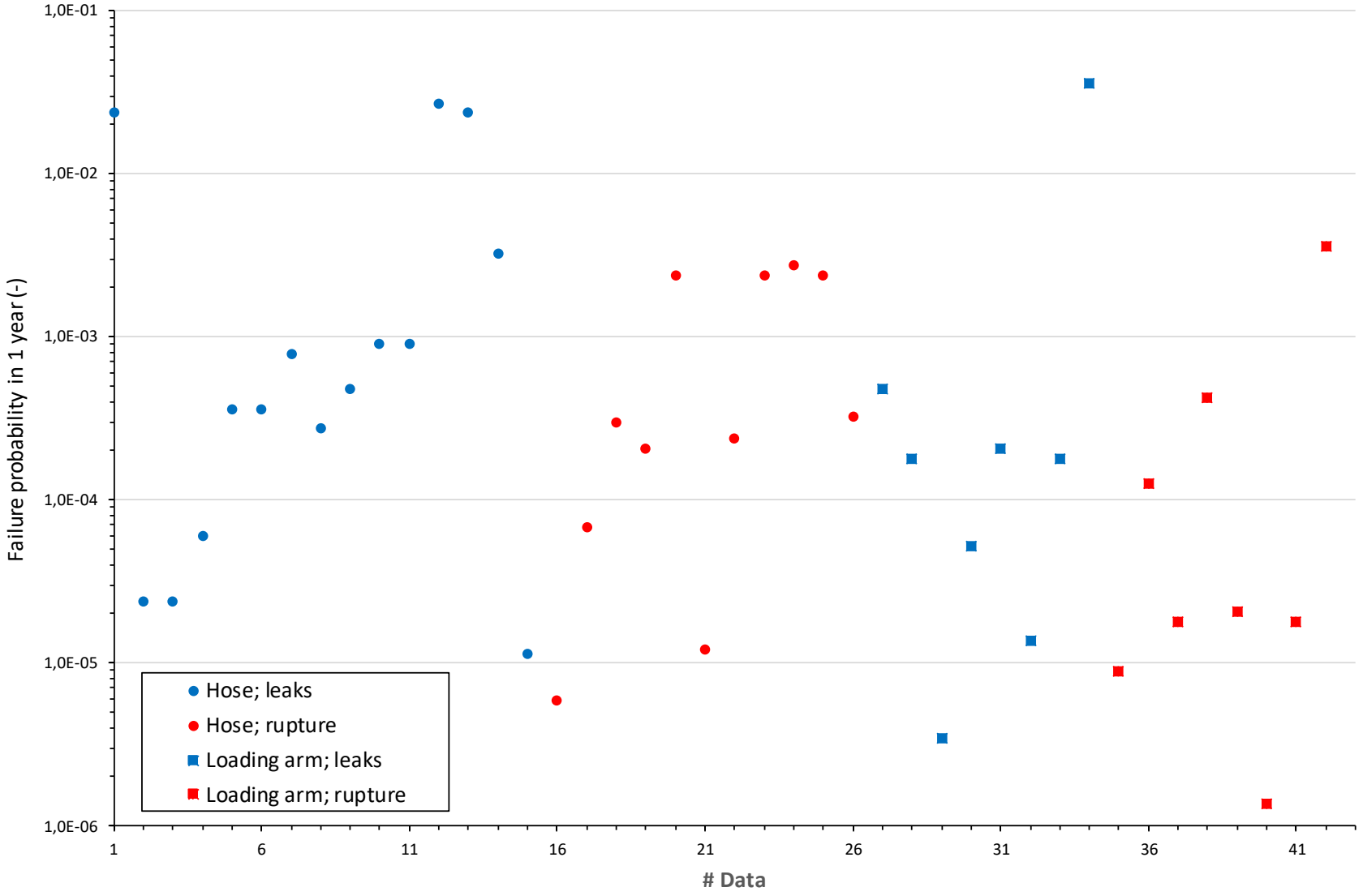
Guidance on Accident Sequence and Plant damage State Quantification

- ✓Calculate frequency of occurrence of accident sequences and Damage states using the event trees of the logic model.

Frequency of Plant Damage States

	Plant Damage State	Frequency (events per year)
1	Tank Rupture (at port) owing to overpressure (1000 m^3)	$1.55\ 10^{-5}$
2	Overfilling of LNG tank (1000 m^3)	$1.55\ 10^{-7}$
3	Pipe break between LNG tanks and pumps	$1.0\ 10^{-5}$
4	BLEVE of tank (1000 m^3)	$1.16\ 10^{-7}$
5	Loading arm rupture (750 m^3/h)	$1.54\ 10^{-5}$
6	Rupture of loading arm during fuelled ship bunkering (250 m^3/h)	$7.0x10^{-4}$
7	Rupture of (un)loading hose during (un)loading of truck ship (60 m^3/h)	$4.0x10^{-4}$
8	Rupture of pipe (port tank to truck) (60 m^3/h)	$1.0\ 10^{-5}$
9	Truck Rupture owing to overpressure (60 m^3)	$5.0\ 10^{-7}$
10	BLEVE of truck (60 m^3)	$5.8x10^{-7}$
11	Rupture of hose between bunker ship and fuelled ship (750 m^3/h)	$4.0x10^{-4}$
12	Tank Rupture of LNG bunker ship (3000 m^3)	$5.00\ 10^{-6}$

Uncertainty of hose and loading arm rupture



Consequence Analysis

Pool fire

Jet fire

Fireball

Consequence assessment means to evaluate the spatial and temporal distribution of:

- Pressure and impulse after explosion
- Heat radiation after fire
- Fragments after explosion
- Concentration if no ignition (dispersion analysis)

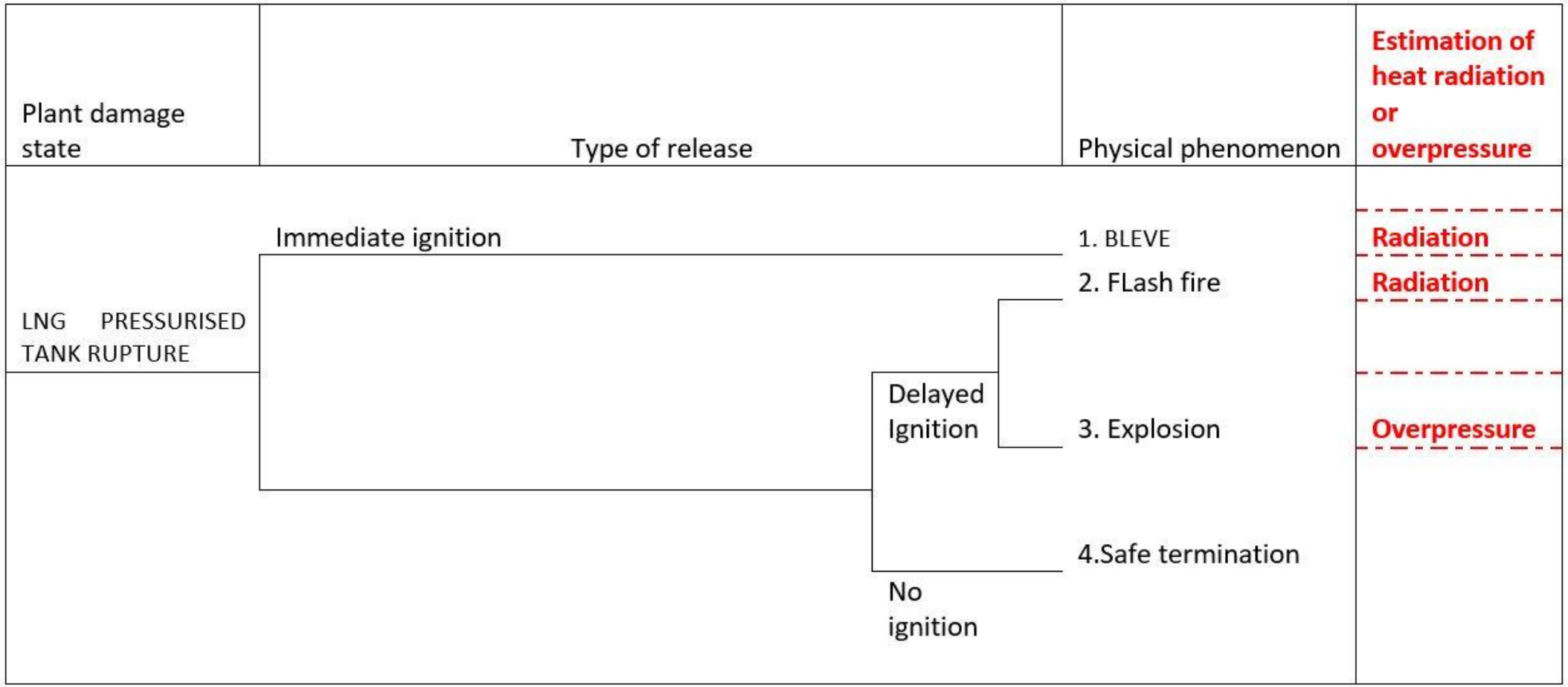
Environmental pollution is not taken into account (non-acute accident)

Deaths
Burn Deaths from Flash Fire
Burn Deaths from Pool Burning
Deaths from Lung Haemorrhage
Deaths from Impact
Deaths from Toxic Release

Injuries
Eardrum Ruptures
Injuries from Impact
Injuries from Flying Fragments
Injuries from Toxic Release

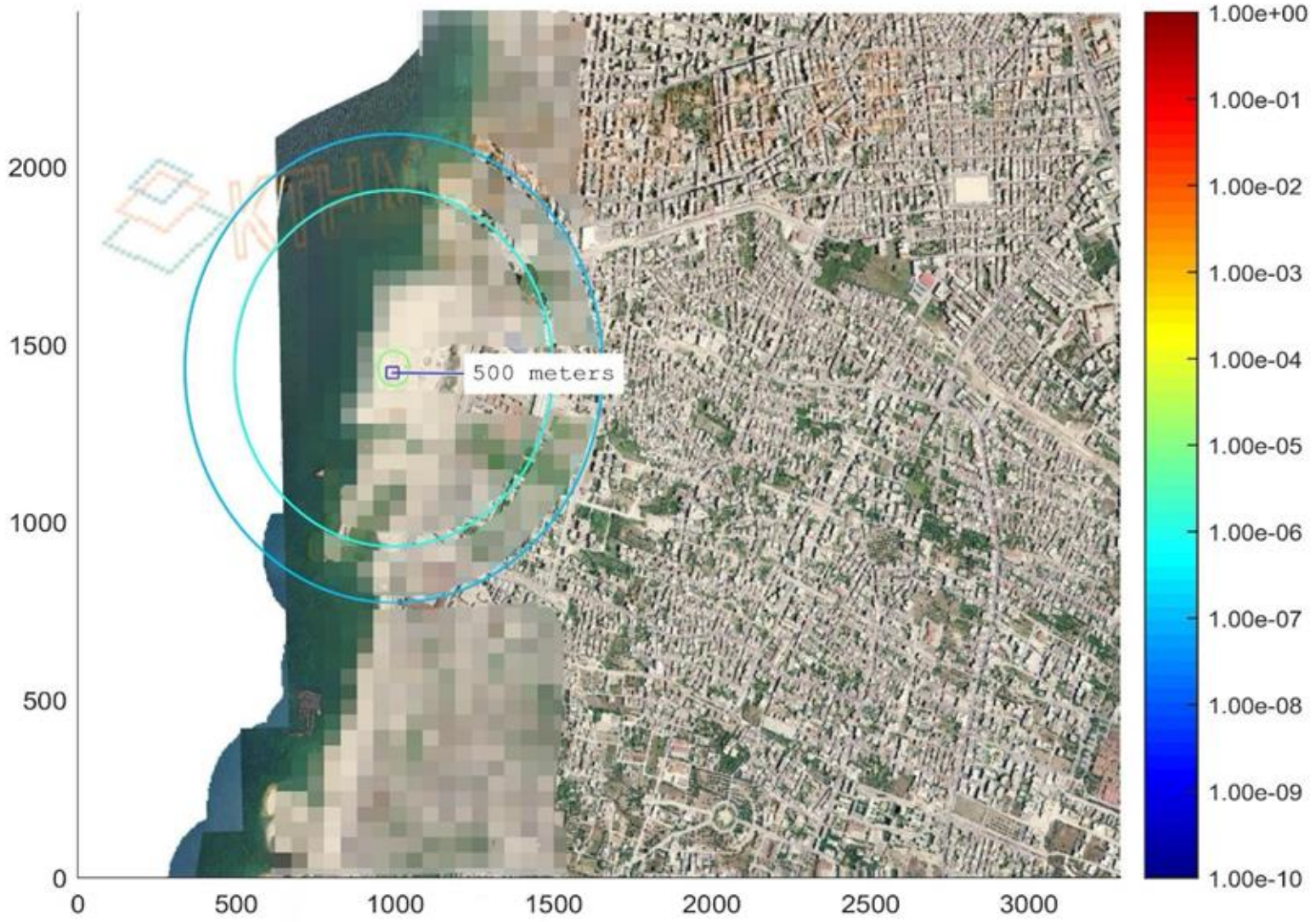
Damage
Structural Damage
Glass Breakage
Damage Due to Fire

Consequence Analysis



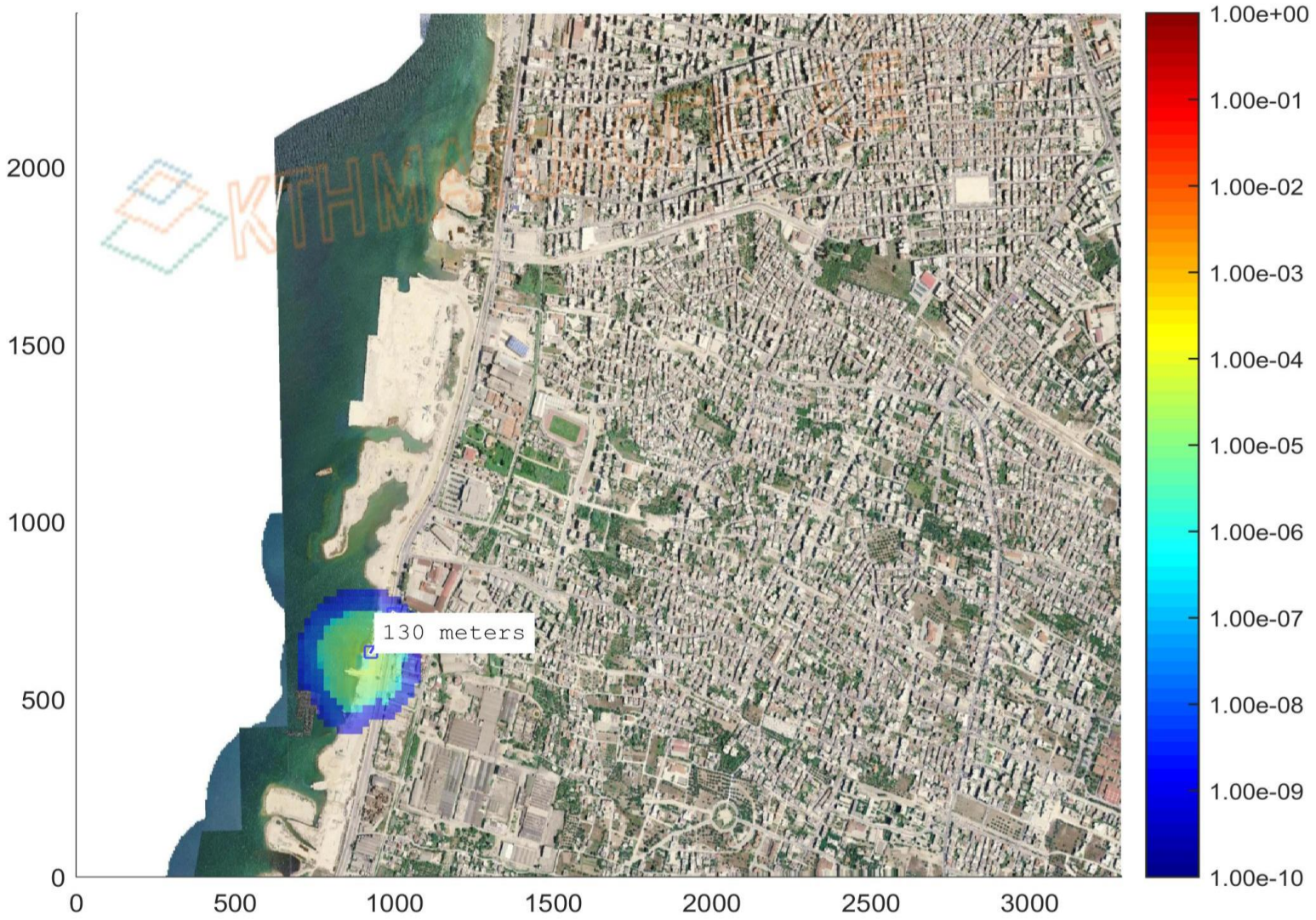
Total Individual Risk Contours

Total Unconditional iso-risk contours (10^{-7}, 10^{-6}, 10^{-5}/y) for LNG storage plant at port



Total Individual Risk Contours STS bunkering

10^{-5}, 10^{-6} /y



Total Individual Risk Contours TTS bunkering

10^{-4}, 10^{-7} /y

Guidelines for Emergency Planning

Internal Emergency plan

- Key personnel and respective tasks
- Measures for emergency plan
- Measures to protect people in the establishment
- Alarm system and communication with external authorities
- Training exercises
- Response strategies for LNG clouds (foam, water curtains), pool, flash and jet fire (foam, dry powder)

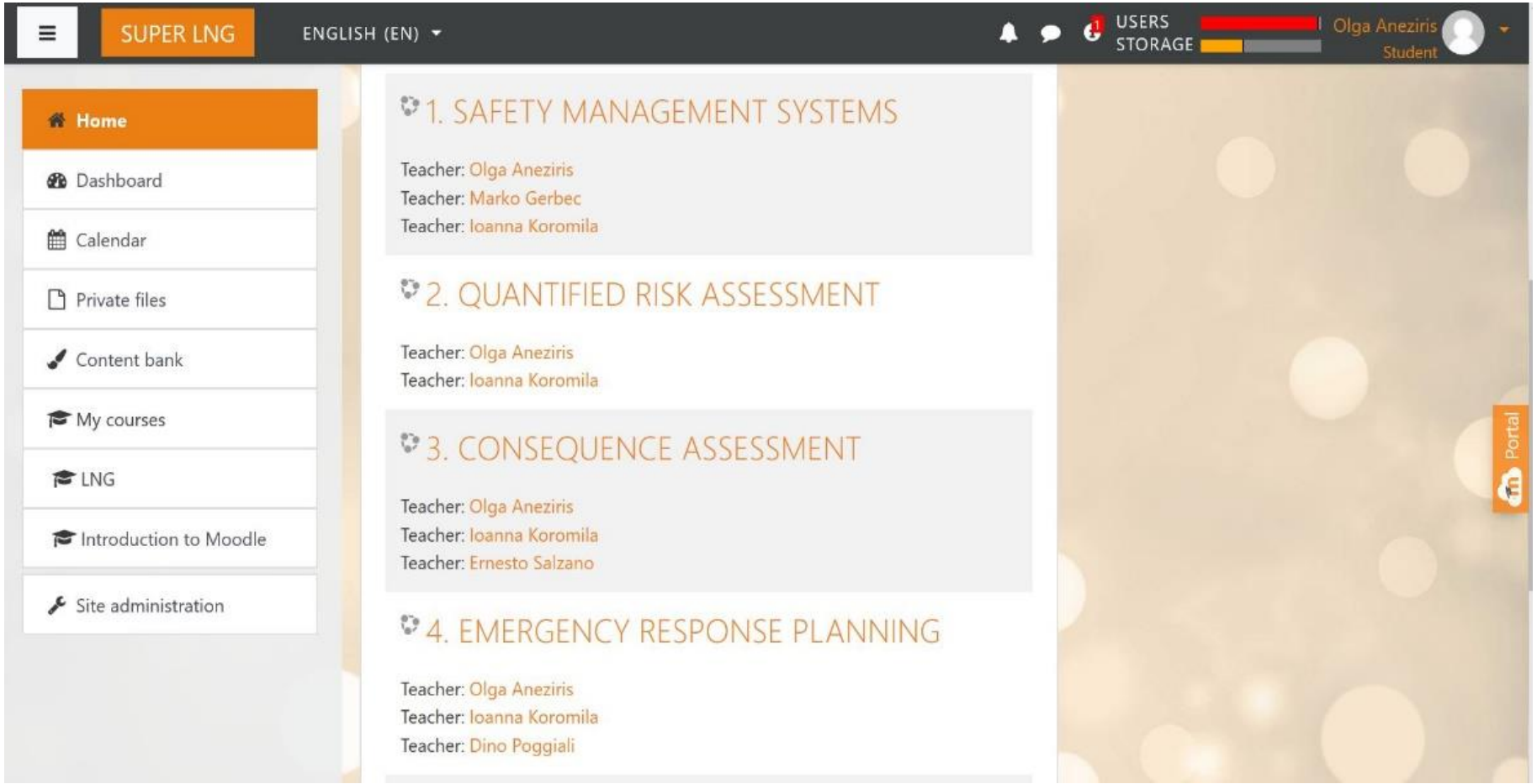
External Emergency plan

- Specific accidental scenarios (LNG spills, overfilling, rollover) and safety zones
- Population information
- Exercises and training

Training and educational structure for LNG safety at ports

- Training courses and material
- Training events and webinars

https://lngsafetyandsecurity.moodle.school



Conclusions

- Review on legislation, standards and guidelines regardin LNG at ports
- Literature review on scientific papers for safety at ports storing LNG
- Identified Gaps regarding legislation and scientific knowledge
- Main Deliverables
  - Expert Network establishment for LNG maritime activities
  - Guidelines for Safety Reporting and Evaluation of Safety Reporting
  - Guidelines for Emergency Planning
  - Training and educational framework - courses

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Thank you for your attention
Any Questions?

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