DNV·GL

LNG Terminal Risk Assessment

LNG Shipping Symposium

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OCTOBER 2014

Risks

Accident with LNG

Sea – to – road

Access to capital

Security of supply

OPEX

More regulations

CAPEX

Short-term financial expectation

Opportunities

Technology leadership

1st mover advantage

Societal wealth

OPEX

brand

alliances

Business model

Commercial niches

Small Import Terminal

Risk Assessment and Risk Management

small scale LNG in the big picture

Operation

Commissioning

Construction

Design

Feasibility

Strategy

Perspectives & roles

- Policy maker
- Governments
- Port authorities
- Ship owner
- Ship operator
- LNG bunker supplier
- O&G Majors
- ...

Developements

- Regulations
- Infrastructure
- Business
- Port
- Permitting processes
- Technologies
- ...

Tomorrow's infrastructure

Tomorrow's markets

Today's infrastructure development

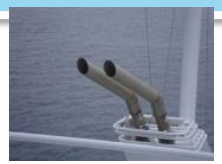
Import & large scale storage

Intermediate distribution

Intermediate storage

Bunker / Break Bulk

Marine fuel / other markets



Enablers for LNG bunkering to develop in ports

LNG availability, for example the nearby presence of an import terminal

Reliable & safe logistical concepts

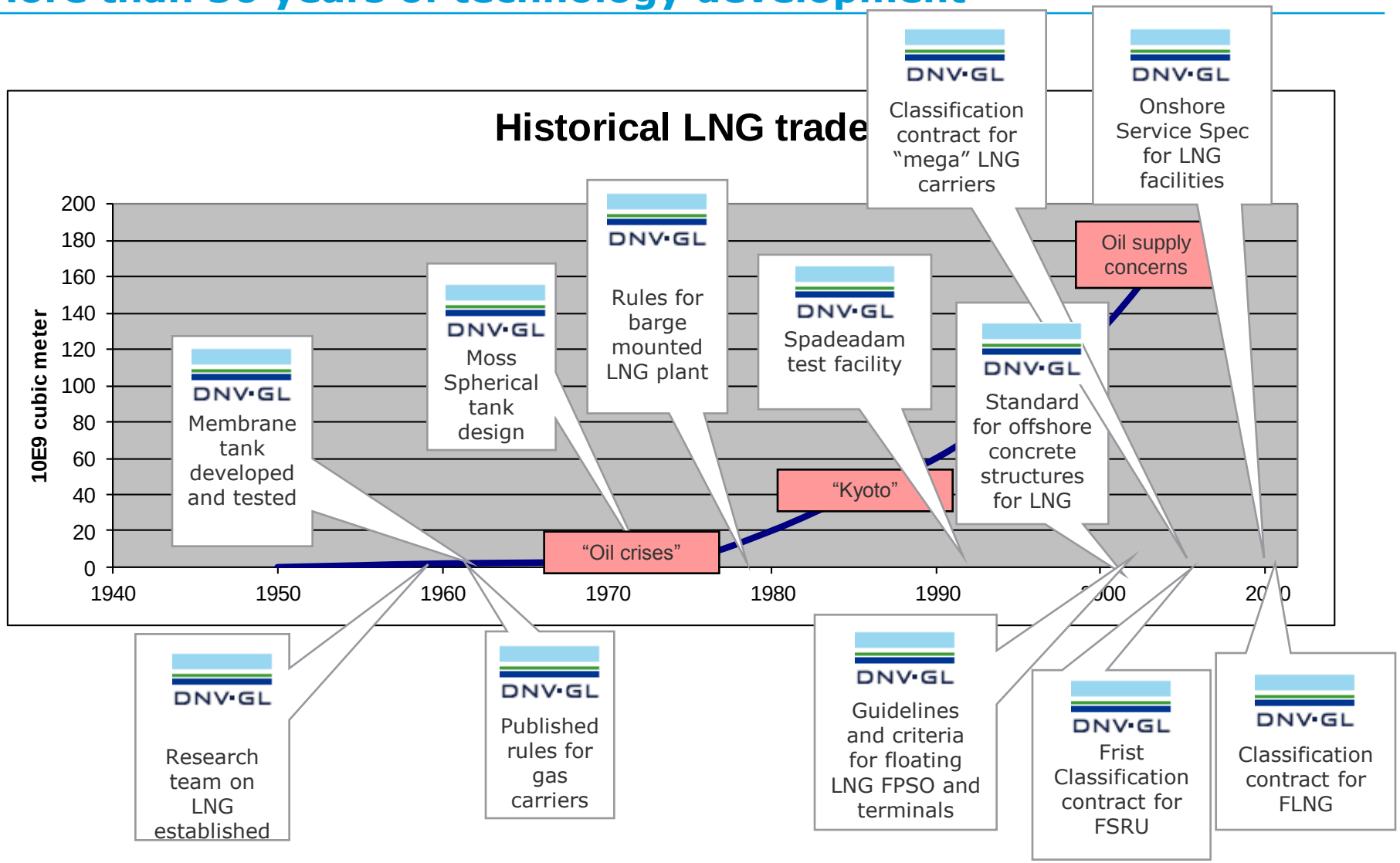
Legal certainty, established legislation and regulatory framework

Favorable investment climate & taxation regime

Necessary competences, knowledge & skills

Public acceptance

More than 50 years of technology development



LNG distribution needs to take a step

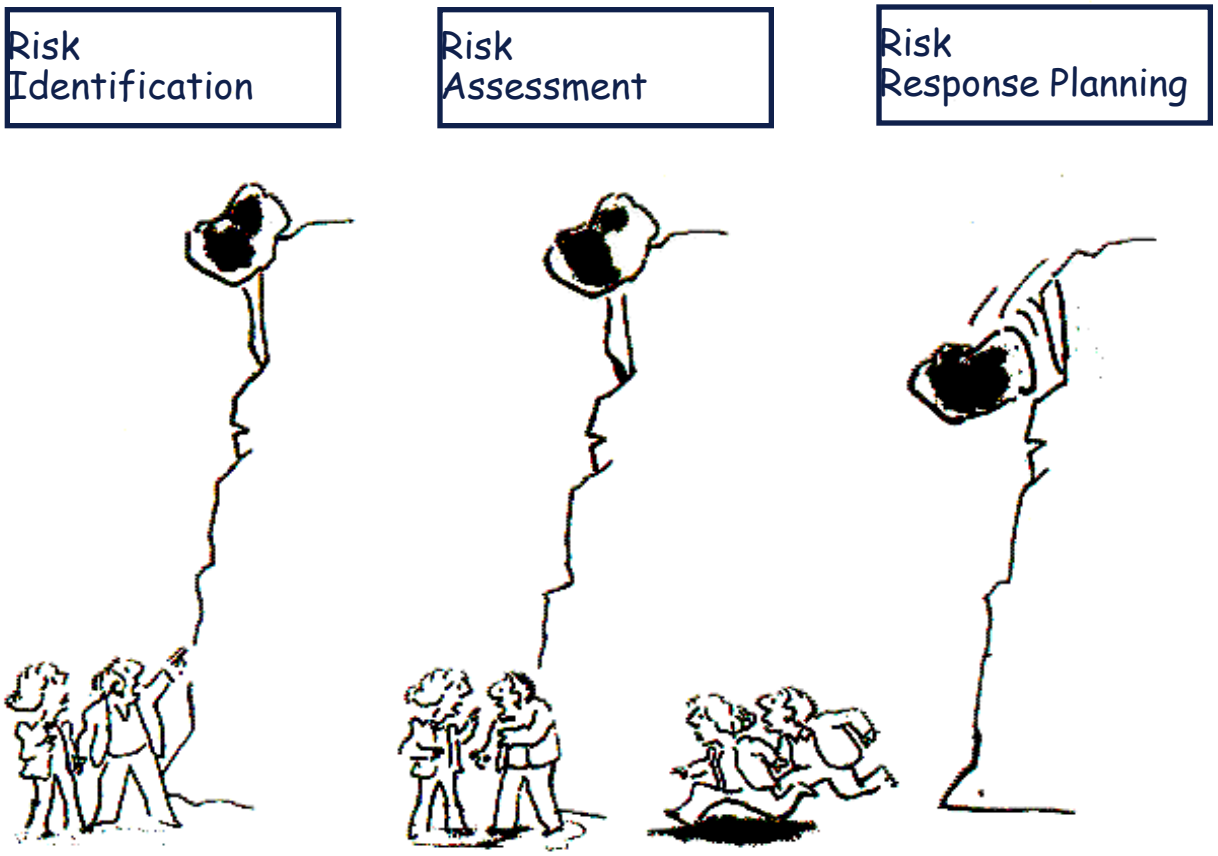
Decision support framework for major accident risk management

Significance to Decision Making Progress

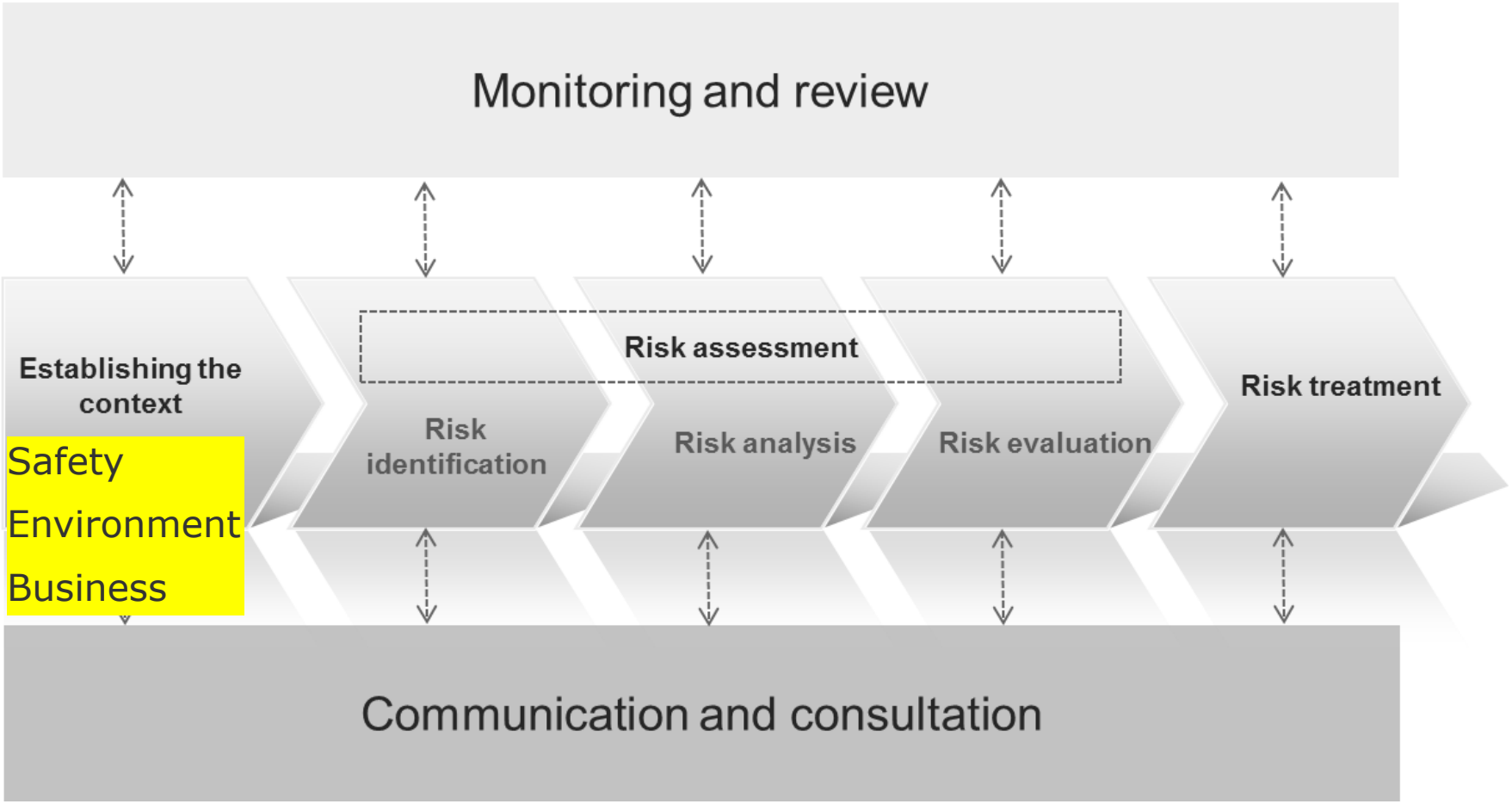
MEANS OF CALIBRATION		DECISION CONTEXT TYPE
Codes and Standards Verification	A	Nothing new or unusual Well understood risks Established practice No major stakeholder implications
Per Review Benchmarking	B	Lifecycle implications Some risk trade-offs/transfers Some uncertainty or deviation from standard or best practice Significant economic implications
Internal Stakeholder Consultation External Stakeholder Consultation	C	Very novel or challenging Strong stakeholder views and perceptions Significant risk trade-offs or risk transfer Large uncertainties Perceived lowering of safety standards

Source: OGP draft 116901

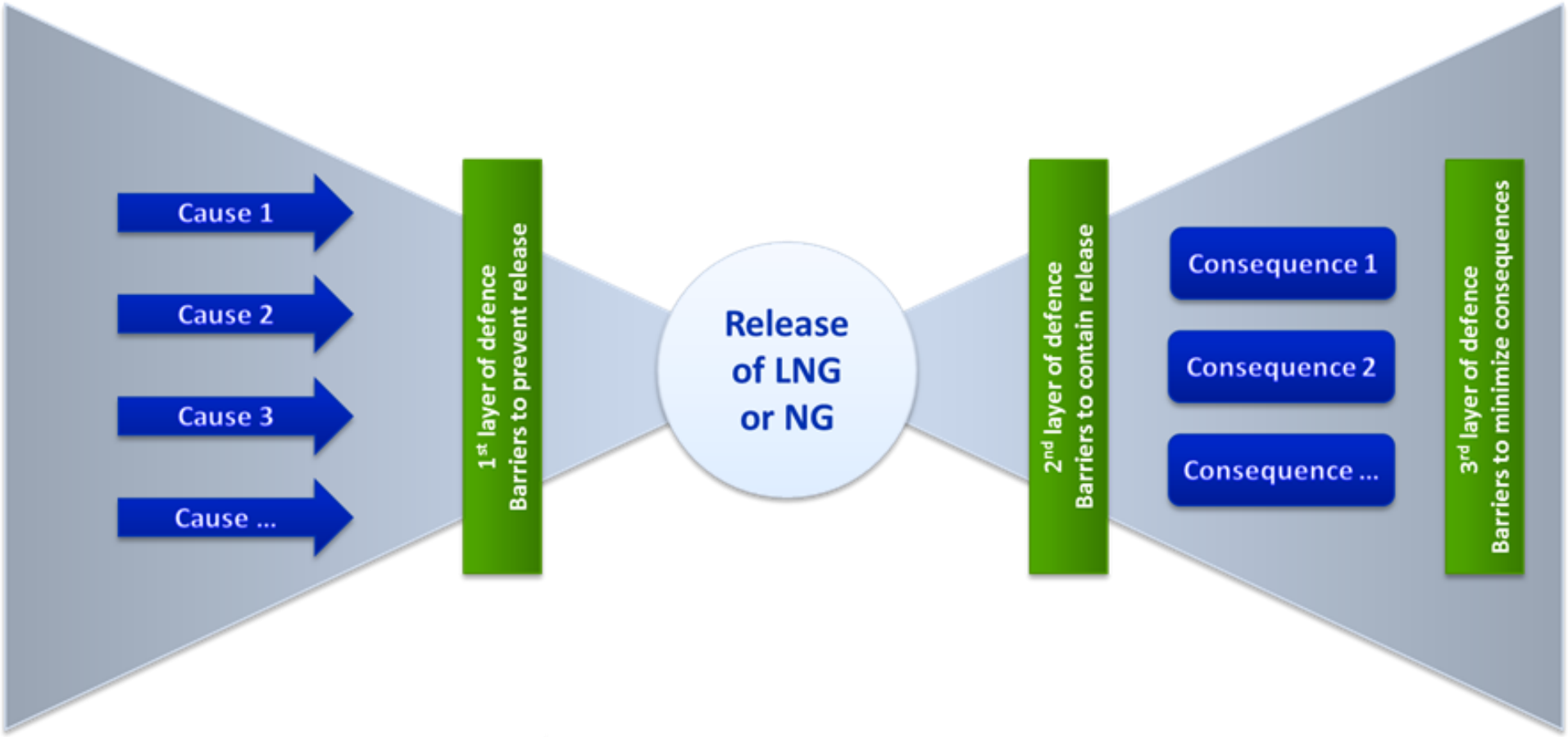
Risk assessment – no rocket science



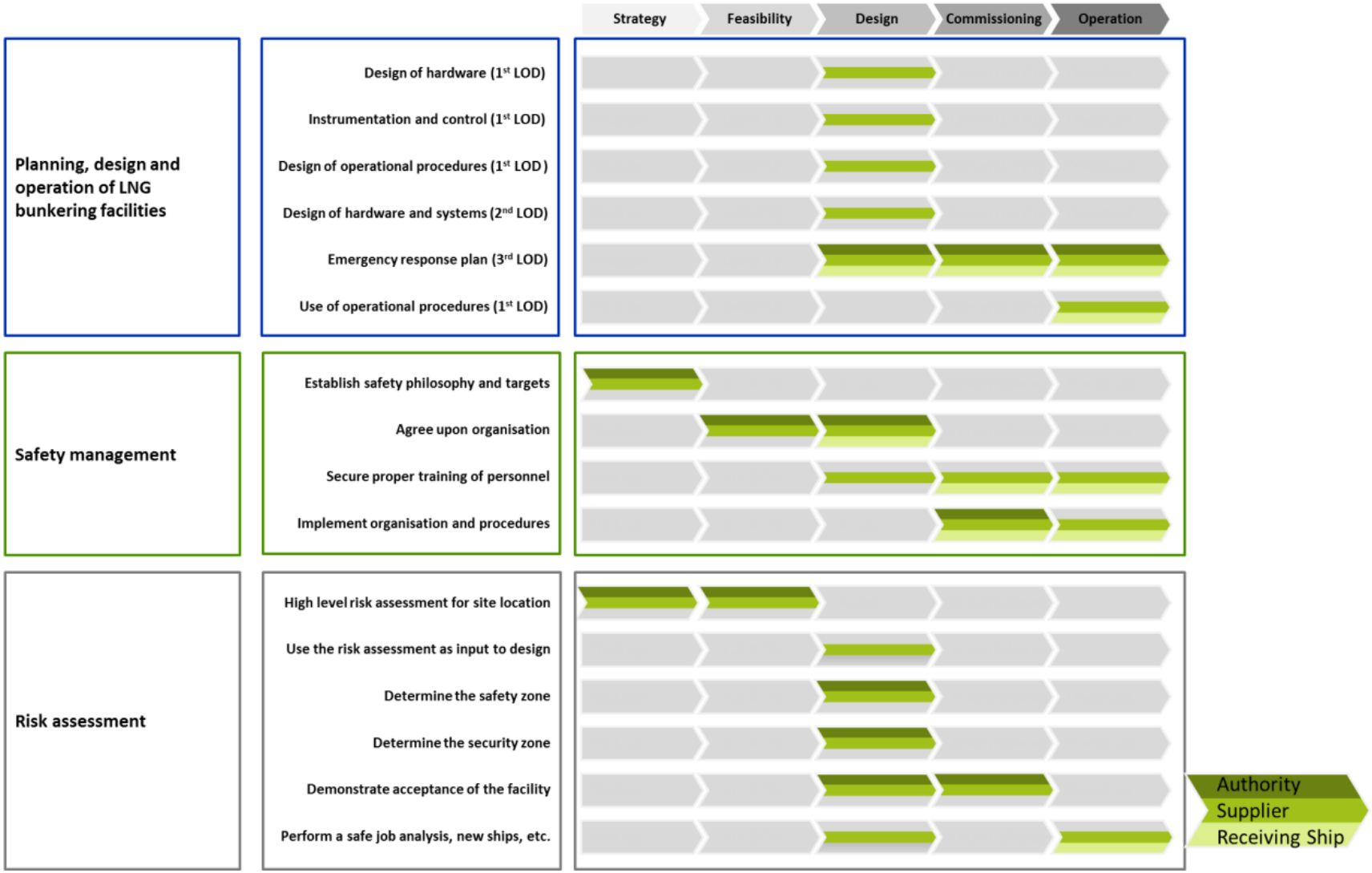
ISO 31000 Risk management process



RP: Structure for introducing barriers



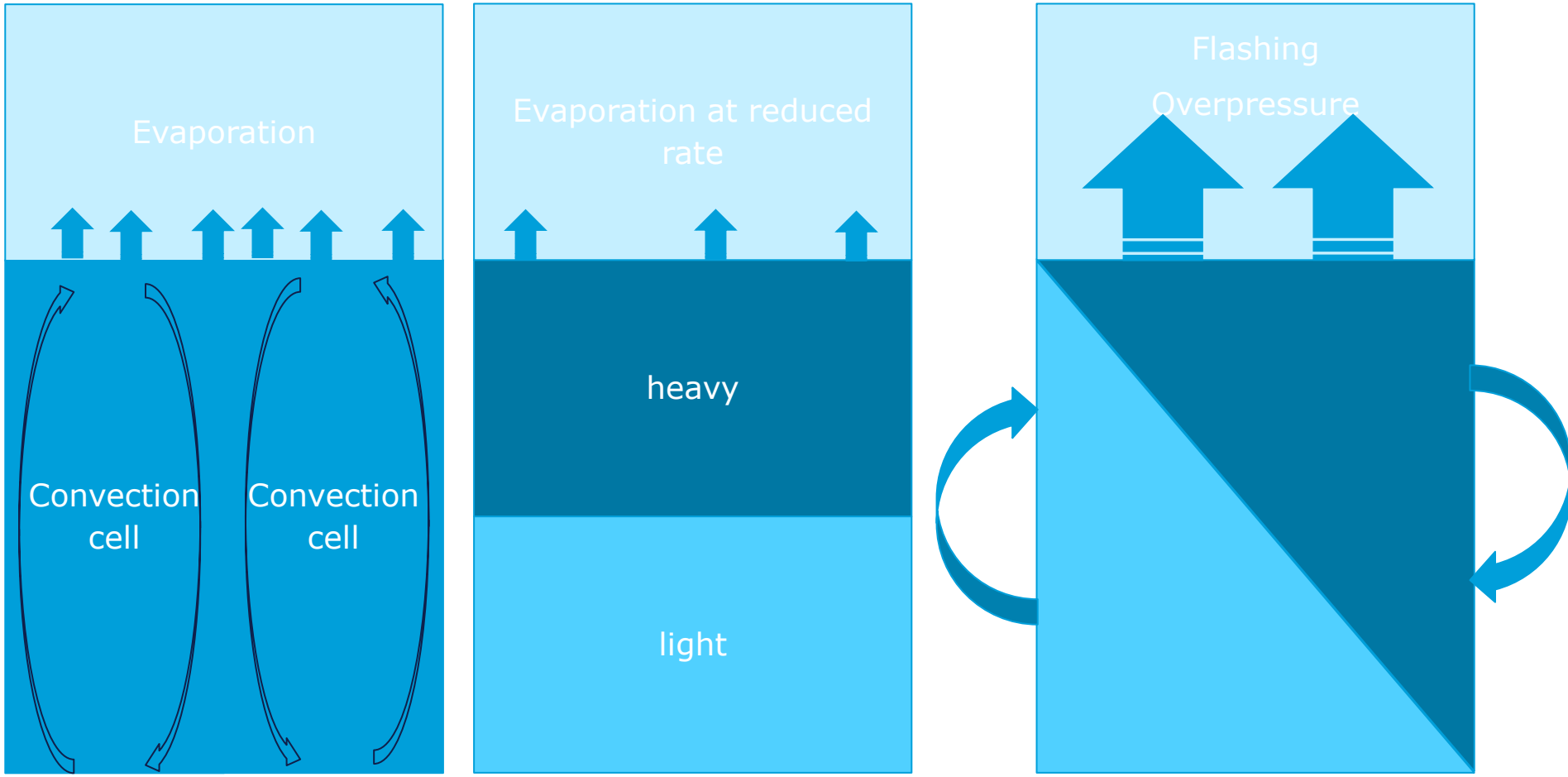
The RP: overall process description



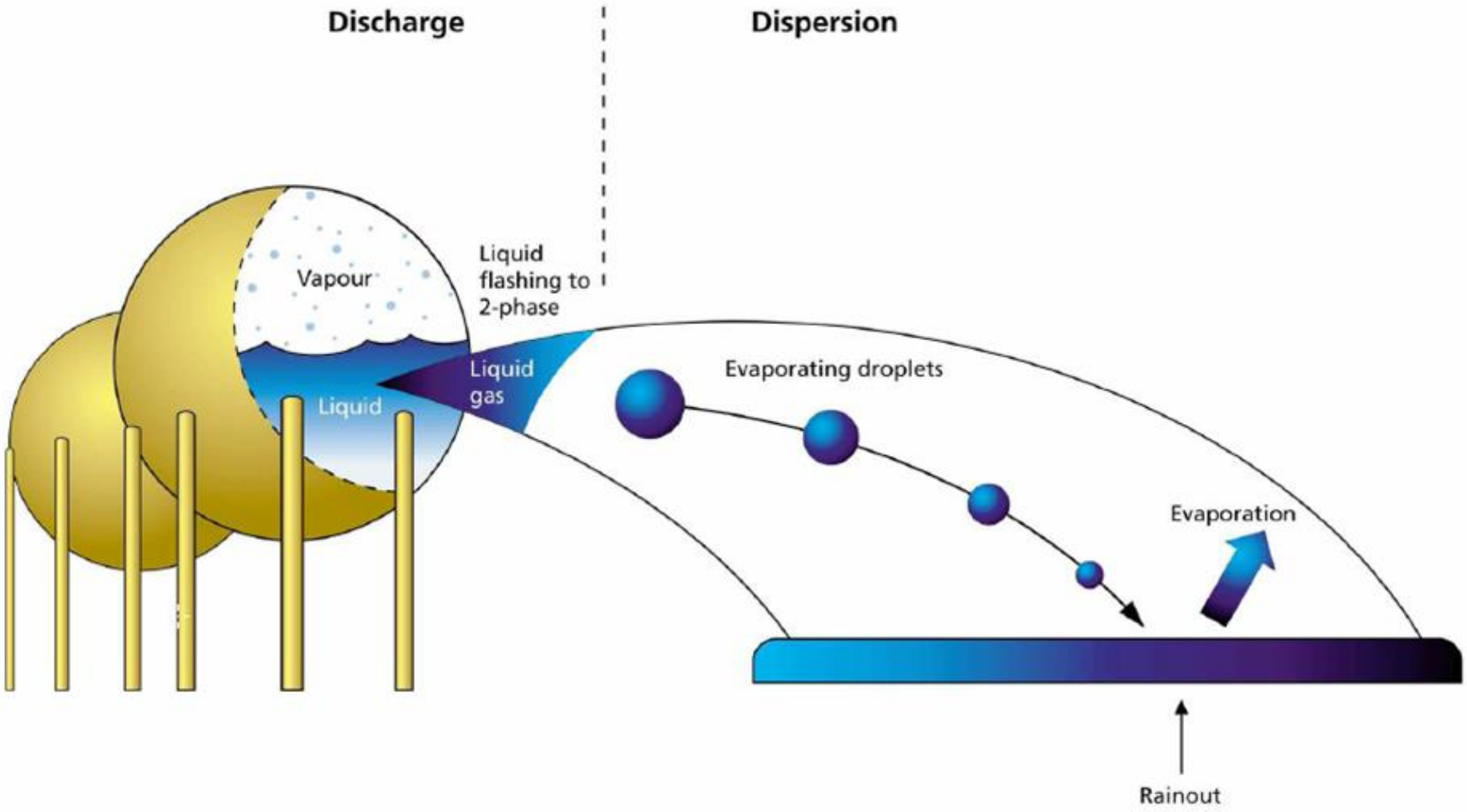
(some) possible LNG release scenarios

Source of release	Scenario	Possible causes
General process and cargo handling	Accidental release from equipment and piping	Lack of flange tightness
		Weld defects
		Corrosion
		Impact
		Supporting structure damage
		Earthquake, floods and other natural hazards
Accidental release from LNG tanks at jetty or on ships	Ship collision	Passing ship adrift
	Ship pressure relief valve	Overpressure
Onshore storage	Tank leakage	**Internal or external leak in tank bottom or wall**
		Catastrophic rupture and leakages
	Tank PSV release	Tank overfilling
		Tank overpressure
		Rollover

Risk – Identification: example Rollover



Risk – Analysis: example spill scenario



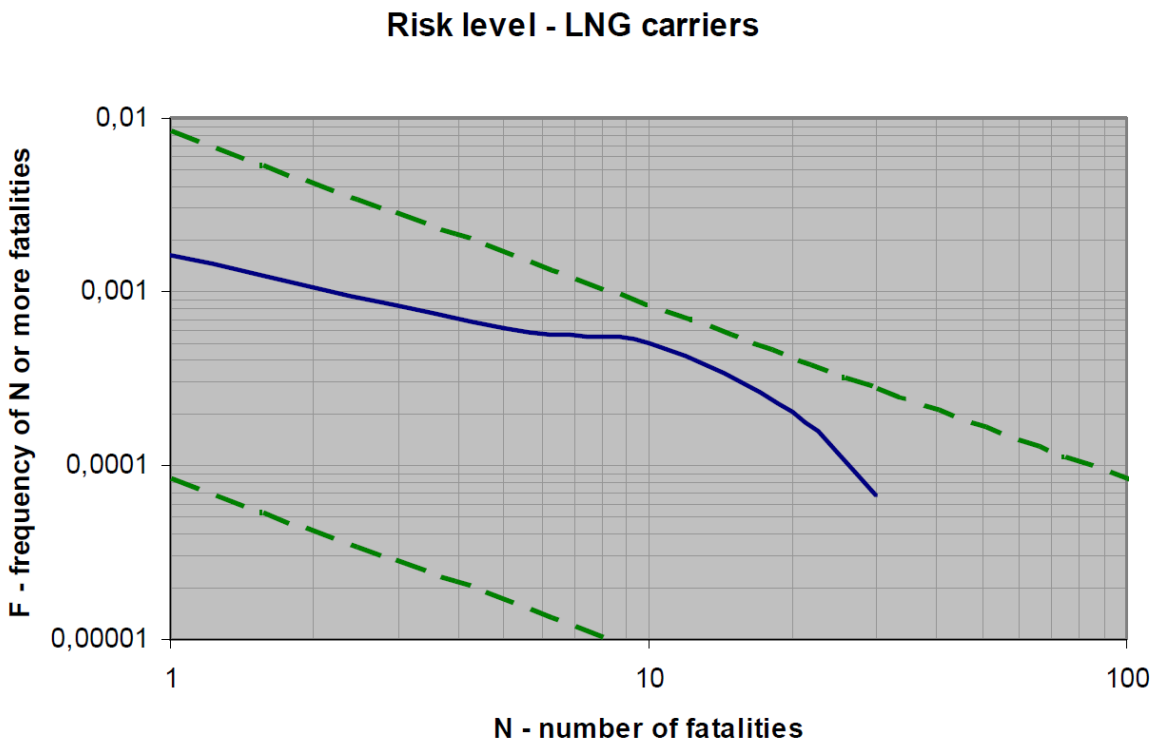
Risk – Analysis: example Simplified event tree

	Hole Size	Gas Ignited at source	Jet Fire Length Distance to target	Can jet fire reach target	Is leak directed at target	Vapour Cloud Dispersion Distance Distance to target	Can flammable vapour reach target	Is wind blowing towards target	Ignition probability at Target	Occupancy at Target	Risk Calculator	Event Risk
	Probability	Probability		Probability	Probability		Probability	Probability	Probability			
	A	B	C	D	E	F	G	H	I	J	K	
Methane Leak	1mm	Yes	5m	No	Yes					Yes	=AxBxD ExJ	
	1.00E-03	0.9	100m	0	0.25					0.33		0.00E+00
		No				50m	No	Yes	Yes	Yes	=AxBxGxHxIxJ	
		0.1				100m	0	0.15	0.9	0.33		0.00E+00
	5mm	Yes	5m	No	Yes					yes	=AxBxDxExJ	
	1.00E-04	0.9	100m	0	0.25					0.33		0.00E+00
		No				110m	Yes	Yes	Yes	Yes	=AxBxGxHxIxJ	
		0.1				100m	1	0.15	0.9	0.33		4.46E-07
	100mm	Yes	150m	Yes	Yes					yes	=AxBxDxExJ	
	1.00E-05	0.3	100m	1	0.25					0.33		2.48E-07
		No				200m	Yes	Yes	Yes	Yes	=AxBxGxHxIxJ	
		0.7				100m	1	0.15	0.9	0.33		3.12E-07
											Total Risk	1.00E-06

Source: OGP draft 116901

Risk – Assessment: example FN-curves – group risk, societal risk

IMO MSC 83/21/1

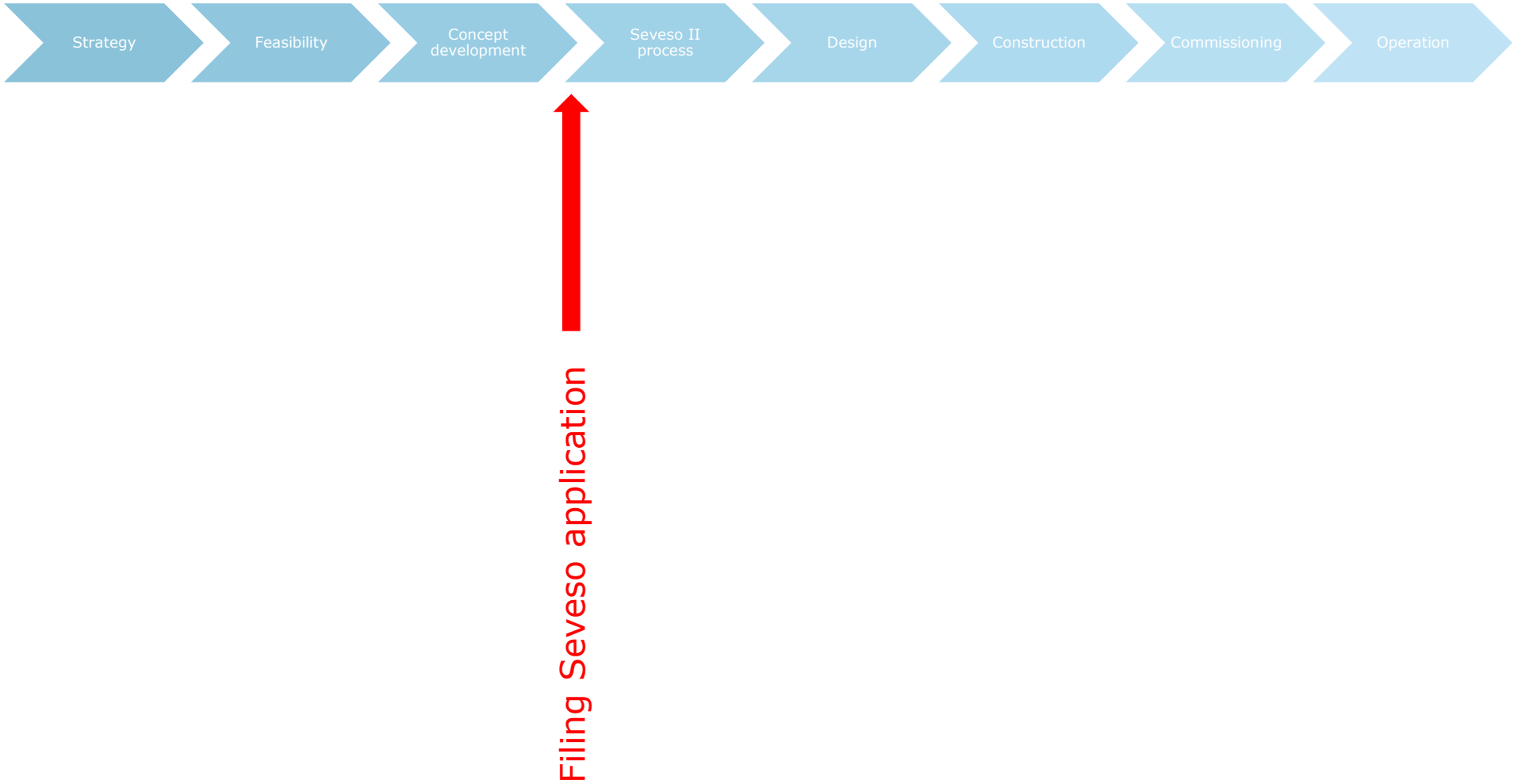


Group

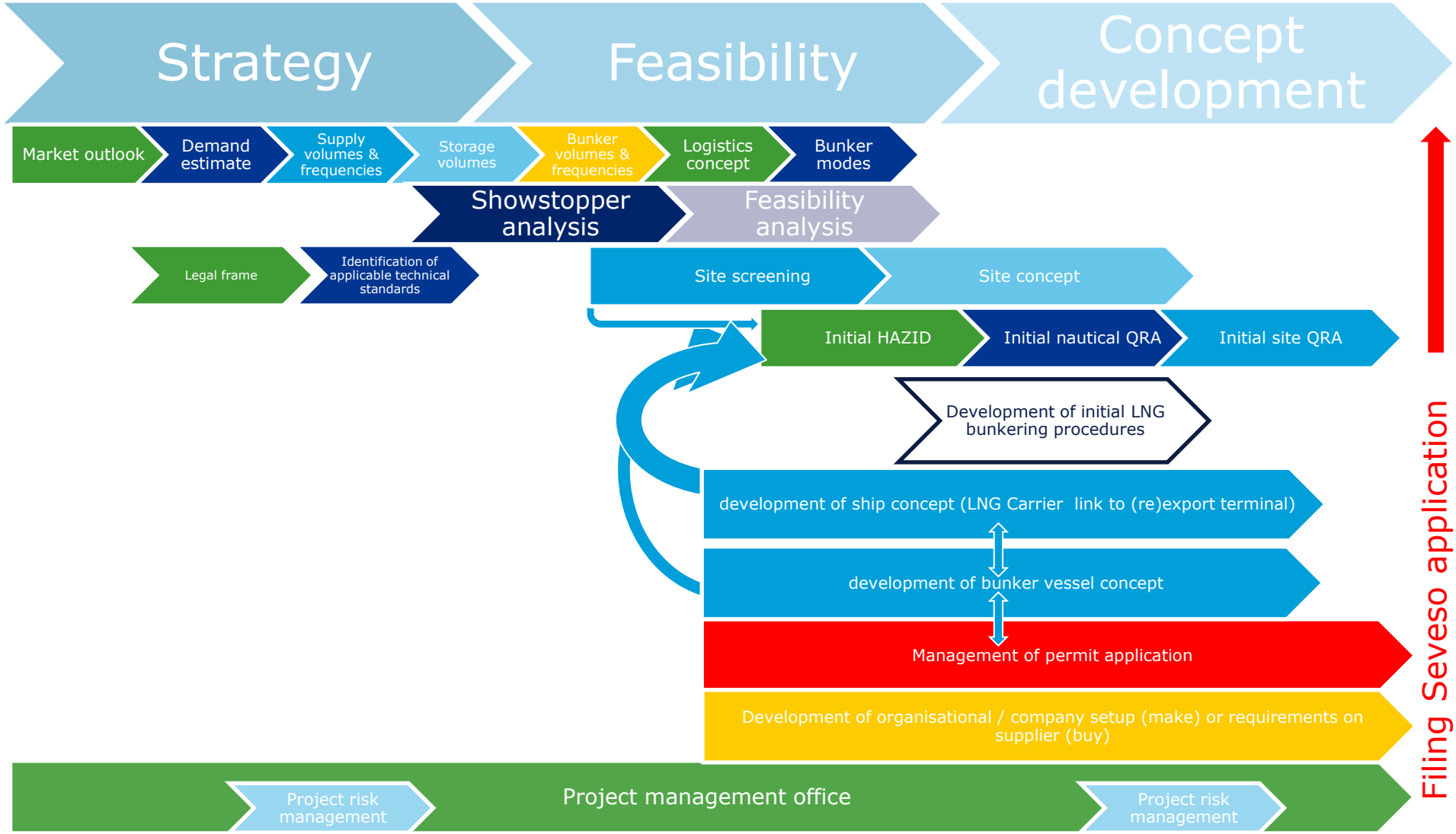
24 / 365

Cumulative

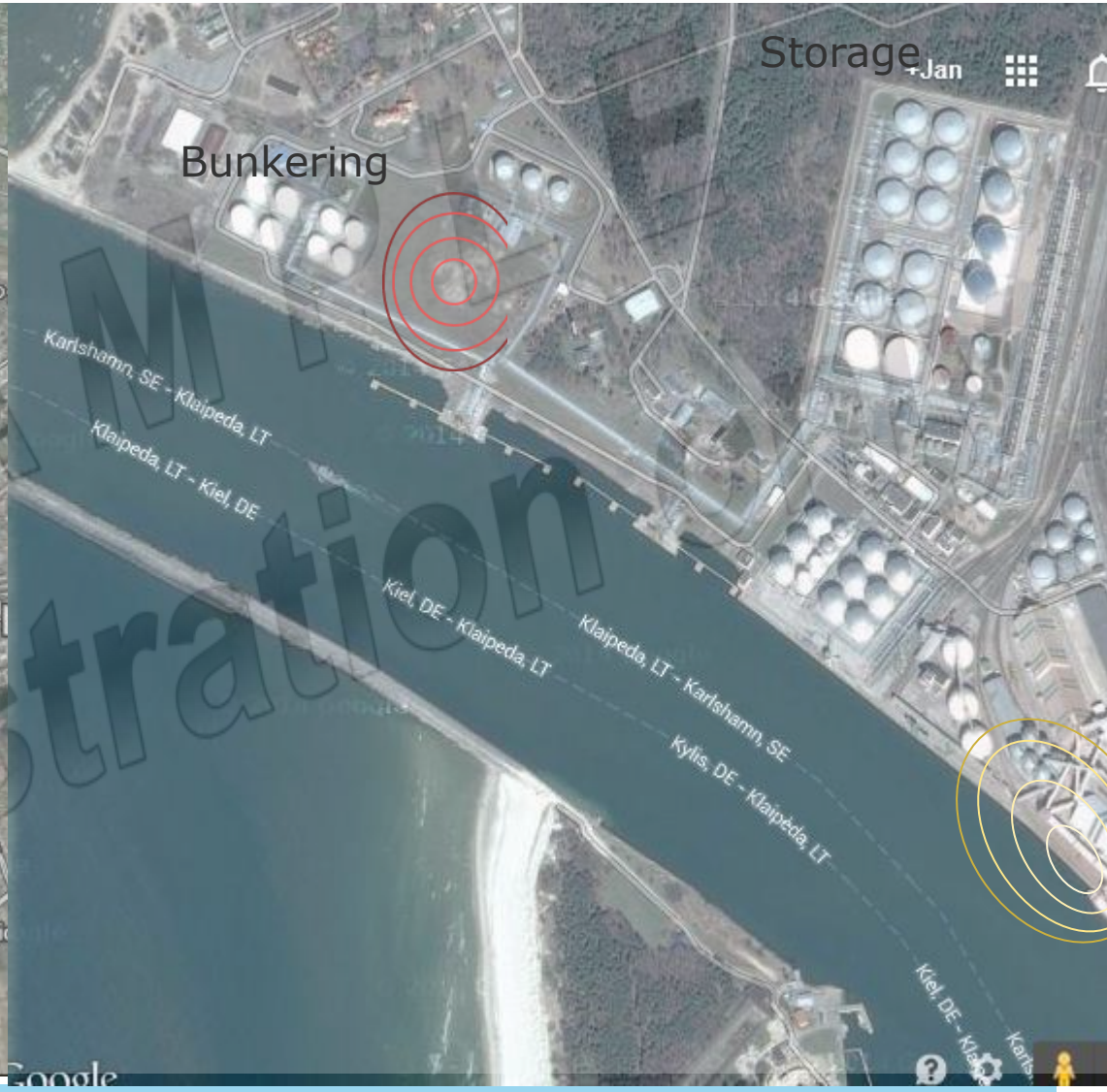
Timeline of typical project – activities in first phase



Risk assessment integrated in overall process



Risk pictures in Port
for / from elements of LNG value chain



Tools in place

Operation	
Commissioning	
Construction	
Design	
Feasibility	
Strategy	

RULES FOR CLASSIFICATION OF
Ships
PART 5 CHAPTER
NEWBUILDINGS
SPECIAL SERVICE AND TYPE – ADDITIONAL CLASS
Liquefied Gas Carriers
JULY 2013

Reference number of document: OGP Draft 118683
Date: 2013-06-04
Secretariat: OGP
Guidelines for systems and installations for supply of LNG as fuel to ships
French title (not required)

RECOMMENDED PRACTICE
DNVGL-RP-0006:2014-01
Development and operation of liquefied natural gas bunkering facilities

Guidance on performing risk assessment in the design of onshore LNG installations including the ship/shore interface

STANDARD FOR CERTIFICATION
No. 3.325
Competence Related to the On Board Use of LNG as Fuel
APRIL 2013

RULES FOR CLASSIFICATION OF
Ships / High Speed, Light Craft and Naval Surface Craft
PART 6 CHAPTER 13
NEWBUILDINGS
EQUIPMENT AND SYSTEMS – ADDITIONAL CLASS
Gas Fuelled Ship Installations
JANUARY 2014

MSC 86/26/Add.1
ANNEX 11
RESOLUTION MSC.285(86)
(adopted on 1 June 2009)
GUIDELINES ON SAFETY FOR NATURAL GAS-FUELLED ENGINE INSTALLATIONS IN SHIPS

Import & large scale storage → Intermediate distribution → Intermediate storage → Bunker / Break Bulk → Marine fuel / other markets

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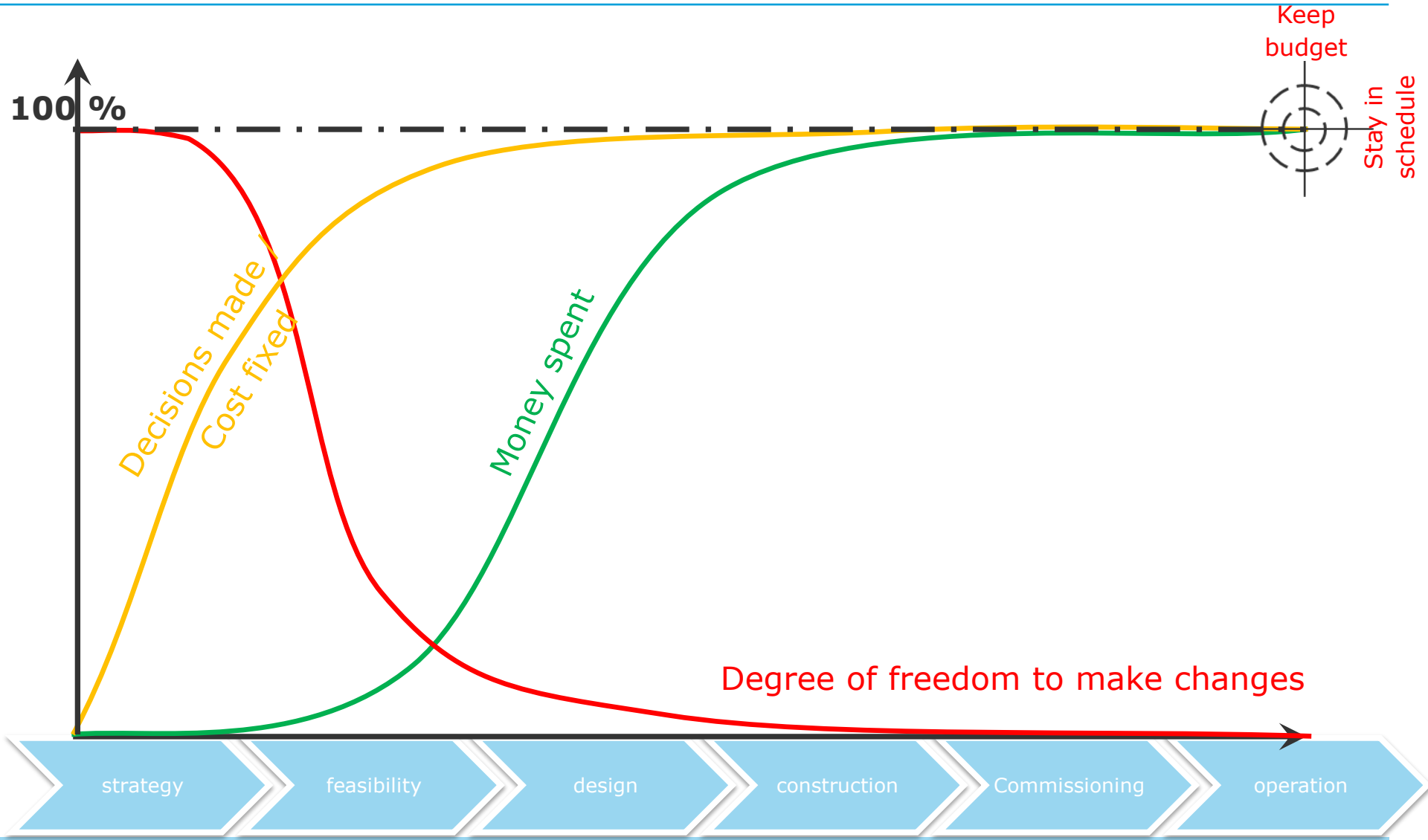
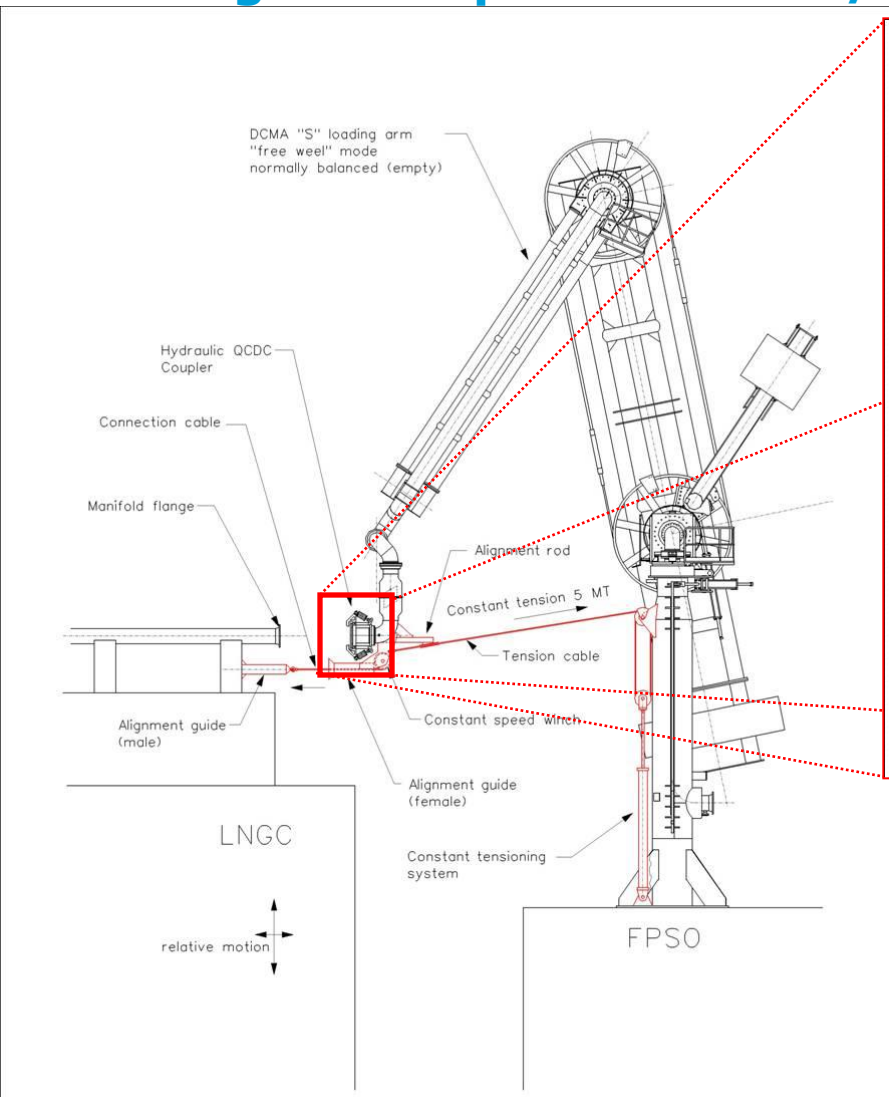
SAFER, SMARTER, GREENER

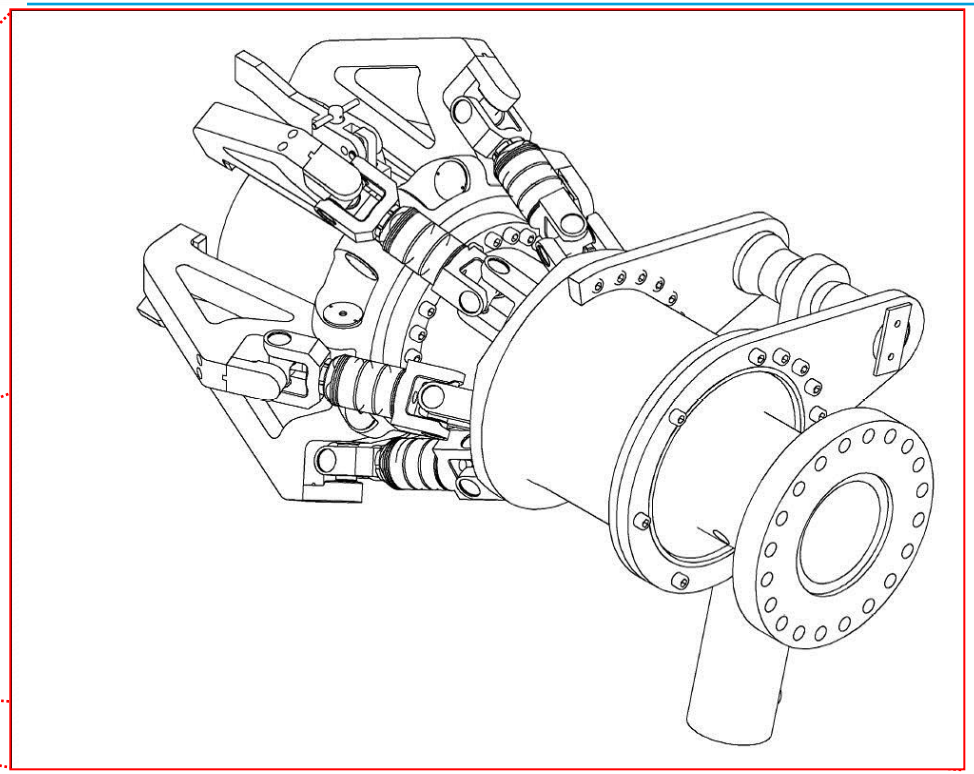
Managing project risks – keep schedule and budget on track



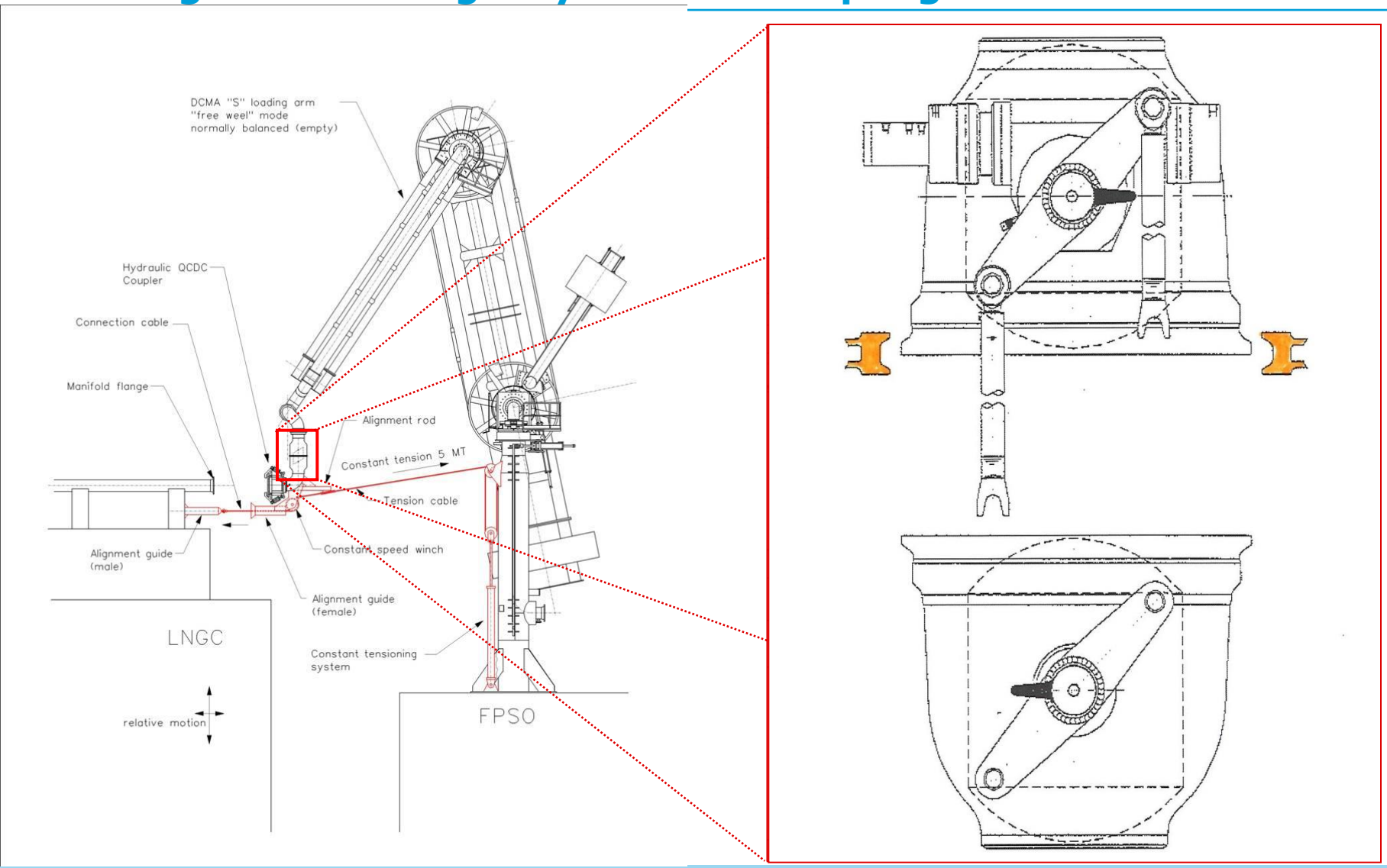
State of the art – hard arms (Marine Loading Arms)

Loading arm – quick connect / disconnect



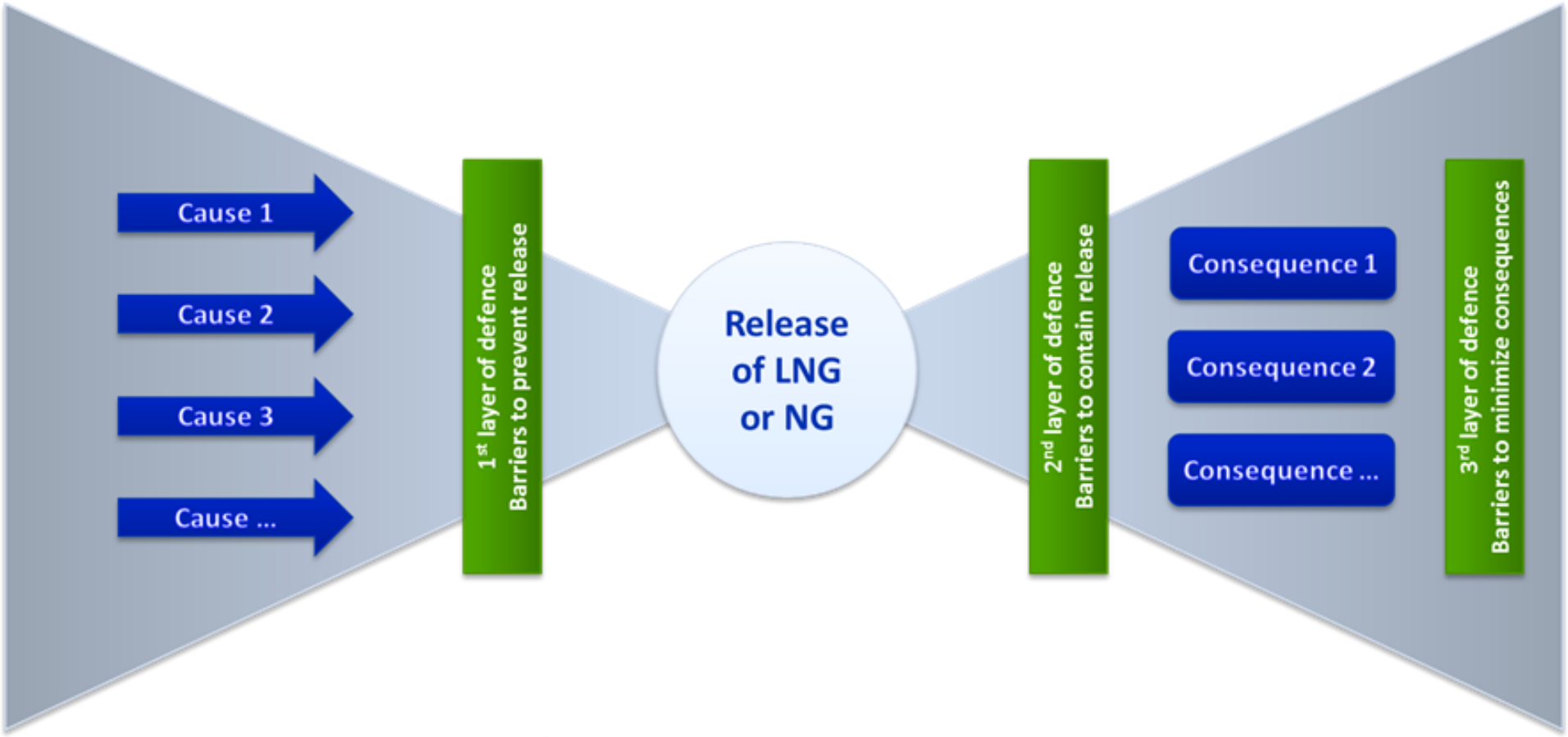


Loading arm – Emergency Release Coupling



Hoses

… the RP suggests how to work with them



Operation & design: 1st layer of defence

- Equipment standard, inspection and testing
- Operational planning
- Compatibility of the transfer systems
- Pre-transfer operations
- transfer hoses
- Couplings
- Emergency Release System, ERS
- Loading arms
- Inerting/purging operations
- Transfer operations
- Transfer stop
- **Trapped LNG**
- Vent mast
- **Draining/stripping operations**
- Disconnection of the systems
- Quantity and properties of the supplied LNG (pressure / temperature)

Operation & design: 2nd layer of defence

- Ignition prevention
- Emergency shut-down system
- Prevention against electrostatic and galvanic ignition
- Leakage detection
- Cryogenic spill protection
- PPE
- Fire protection and suppression
- Operation inside the safety zone

SMS: 3rd layer of defence – Emergency Managment

- Rescuing casualties,
- Safeguarding /evacuating others,
- Minimising damage to property and the environment,
- Preventing escalation / bringing the incident under control.

practical and location- and/or situation-specific emergency procedures and exercises.

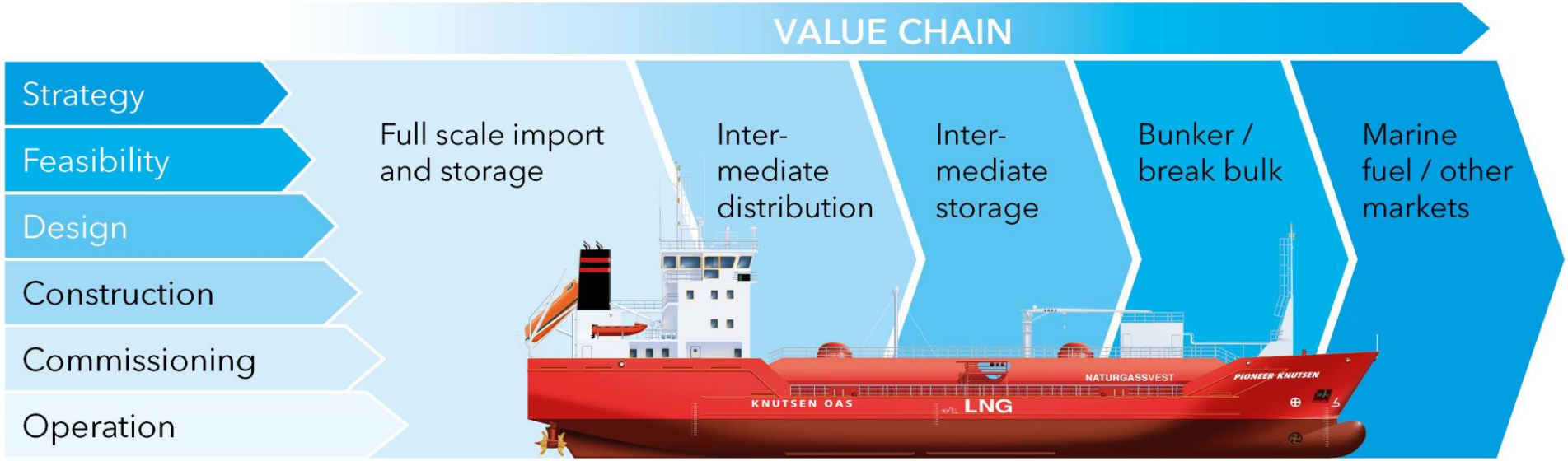
Barriers	High risk hazards	Medium risk hazards with potential fatalities	Other medium risk hazards
Total number of barriers from threat to consequence	5 controls + recovery measures	4 controls + recovery measures	3 controls + recovery measures
Controls (threat)	3 controls to be in place for each identified threat. *Alternative:* 4 controls	2 controls to be in place for each identified threat. *Alternative:* 3 controls	2 controls to be in place for each identified threat
Recovery measures (consequence)	2 recovery measures required for each identified consequence. *Alternative:* 1 recovery measure	2 recovery measures required for each identified consequence. *Alternative:* 1 recovery measure	1 recovery measure required for each identified consequence

Source: OGP draft 116901

Risk Matrix – asset owner

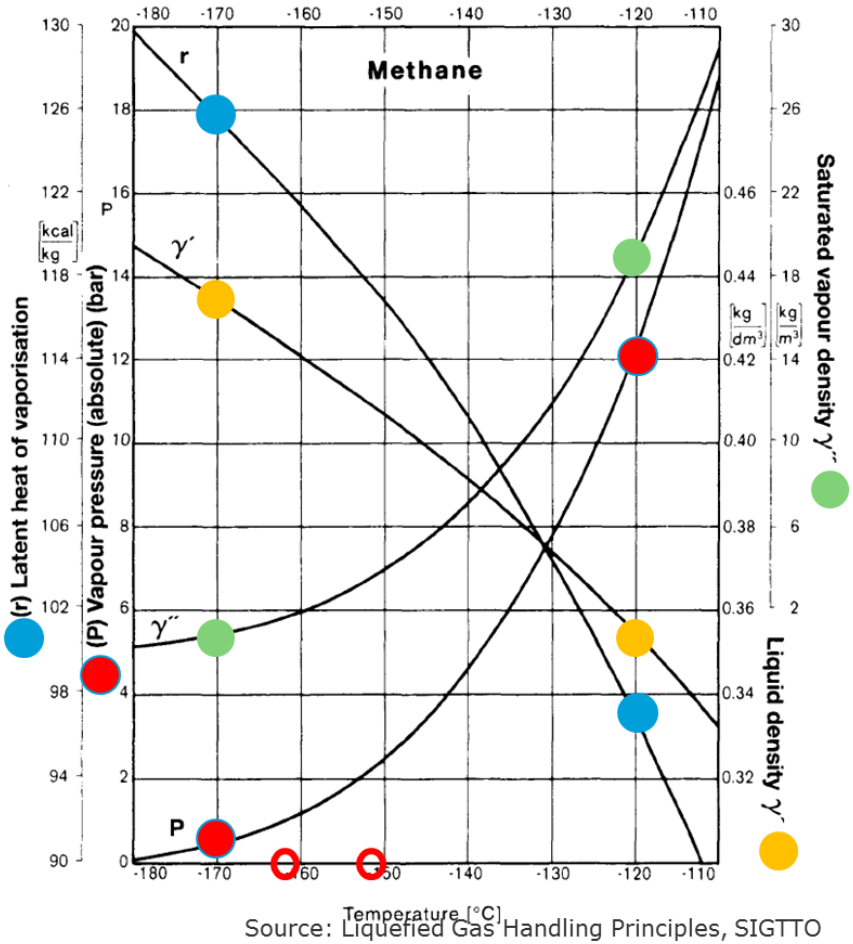
Accident Scenario Frequency (1/year)						$<10^{-6}$	10^{-6} to 10^{-5}	10^{-5} to 10^{-4}	10^{-4} to 10^{-3}	10^{-3} to 10^{-2}	10^{-2} to 10^{-1}	10^{-1} to 1	1 to 100
Value						0,4	0,8	1,6	3,1	6,3	12,5	25	100
Area of assessment	Specific sector of activity at global level					Unheard of	It has not happened	It has happened before	It has happened in the last five years	It happens on an annual basis	It happens on a monthly basis		
	Specific sector of activity in Repsol YPF									It has happened before	It has happened in the last five years	It happens on an annual basis	It happens on a monthly basis
	Area of assessment according to the area of business/activity										It has happened before	It has happened in the last five years	It happens on an annual basis
Consequences													
Level of consequences	Personal injury	Damage to property and loss of profits. Environmental remediation costs	Environmental damage	Level of diffusion; reputation	Value								
Low	Incident not causing injury leave	5k - 100k	Environmental incident in an area without guaranteed containment that causes local environmental damage within the limits of the property	No diffusion	1.7								
Moderate	Up to 30 days of injury leave < 1% probability of 1 death	100K - 1M	Relevant environmental damage that exceeds the levels of reference for environmental quality or is capable of generating legal action and does not have permanent effects	Green Level Crisis	3								
Serious	More than 30 days of injury leave <10% probability of 1 death	1M - 10M	Serious environmental damage that could affect the property's environment, which exceeds in large areas the reference levels for environment quality and could affect third parties	Yellow Level Crisis	7								
Very serious	Could cause a death or permanent injuries	10M - 100M	Very serious environmental damage. The company is required to provide significant correction and/or compensation measures; in large areas it exceeds the reference levels for environmental quality; high probability of permanent residual damage	Red Level Crisis	16								
Disastrous	Could cause between 2 and 9 deaths	100M - 1000M	Catastrophic environmental damage; loss of environmental resources and services. Permanent damage	Temporary international affectation	40								
Catastrophic	Could cause 10 deaths or more	> 1000M	Catastrophic and widespread environmental damage; extensive loss of environmental resources and services. Permanent damage	Permanent international affectation	100								

Opportunities in an emerging industry



- First-mover advantage
- Brand
- Technology leadership
- Alliances
- Business model
- Diversified energy supply
- Improved local environment
- Societal wealth

Supply chain management



Source: Liquefied Gas Handling Principles, SIGTTO

2014

Atmospheric -> Pressurized –> Pressurized

Atmospheric -> Atmospheric –> Pressurized

2016+

Atmospheric -> Pressurized –> Atmospheric

Atmospheric -> Atmospheric –> Atmospheric

small scale LNG in the big picture

Operation	
Commissioning	
Construction	
Design	
Feasibility	
Strategy	

Tomorrow's markets

Today's infrastructure development

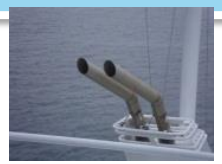
Import & large scale storage

Intermediate distribution

Intermediate storage

Bunker / Break Bulk

Marine fuel / other markets



Netherlands

Netherlands	Risk based
ID/ Reference	BEVI 2008, Besluit van 27 mei 2004, houdende milieukwaliteitseisen voor externe veiligheid van inrichtingen milieubeheer (Besluit externe veiligheid inrichtingen)
Risk contour for land use planning	Vulnerable objects are divided in two classes. Legally binding endpoints apply The first groups accounts hospitals, schools, and residential areas; for these objects, a risk tolerability threshold of 10^{-6} event/year applies. The second group accounts less vulnerable objects as industrial zones, office buildings or recreational facilities For these facilities, a tolerability threshold of 10^{-5} event/year applies.
Societal	The definition of societal risk (SR) as the chance, for a number of people >*N*, to die as a direct consequence of their presence in the vicinity of a dangerous facility in which an accident occurs; non-binding tolerability endpoints apply. The acceptability criteria for an accident are 100 times stricter for every expected tenfold in number of victim (i.e. the acceptability of a disaster with 10 lethal victims is set on 10^{-5} event/year, for a disaster with 100 lethal victims 10^{-7} event/year, etc.).
Other	
Comments	QRA's are performed using standard scenarios, consequence models and impact criteria. A computer program called SAFETI-NL with a tight limited degree of freedom is used to ensure consistent results.

Source: OGP draft 116901

Japan

Japan	Prescriptive
ID/ Reference	LNG terminal shall be designed and installed according to the designated laws and regulations. The designated laws and regulations are the nongovernmental guidance issued by the Japan Gas Association. The guidance is specific for LNG
Description	Physical effects model give the relationships between the distance and effects. The further away the less the consequences. Therefore certain threshold values are set for the effect to decide on distance. The threshold values are set based the extent of damages. a) Radiation heat from pool fire The level of damage by radiation heat is determined by the dose (combination of intensity and exposure time) a human body. For a long duration fire like a pool fire, the permissible limit of radiation is around 2,324 kJ/m^{2}s (2,000 kcal/m^{2}h). b) Flash fire Radiation effects from flash fires are, in view of the short duration, negligible. People caught in the flammable range, between ½ LFl and 2*LFL, will be affected. c) Explosion Suitable threshold values should be set before executing the risk assessment. According to the Japanese High-Pressure Gas Safety Law and Safety Regulation for Plant Complex the limit value of blast pressure-for new installation is set to 9,800Pa (0.1 kgf/cm2) and a certain distance is to be secured
Comments	

BImSchG

BImSchV

KAS 18

Source: OGP draft 116901

Germany

Major accident scenario

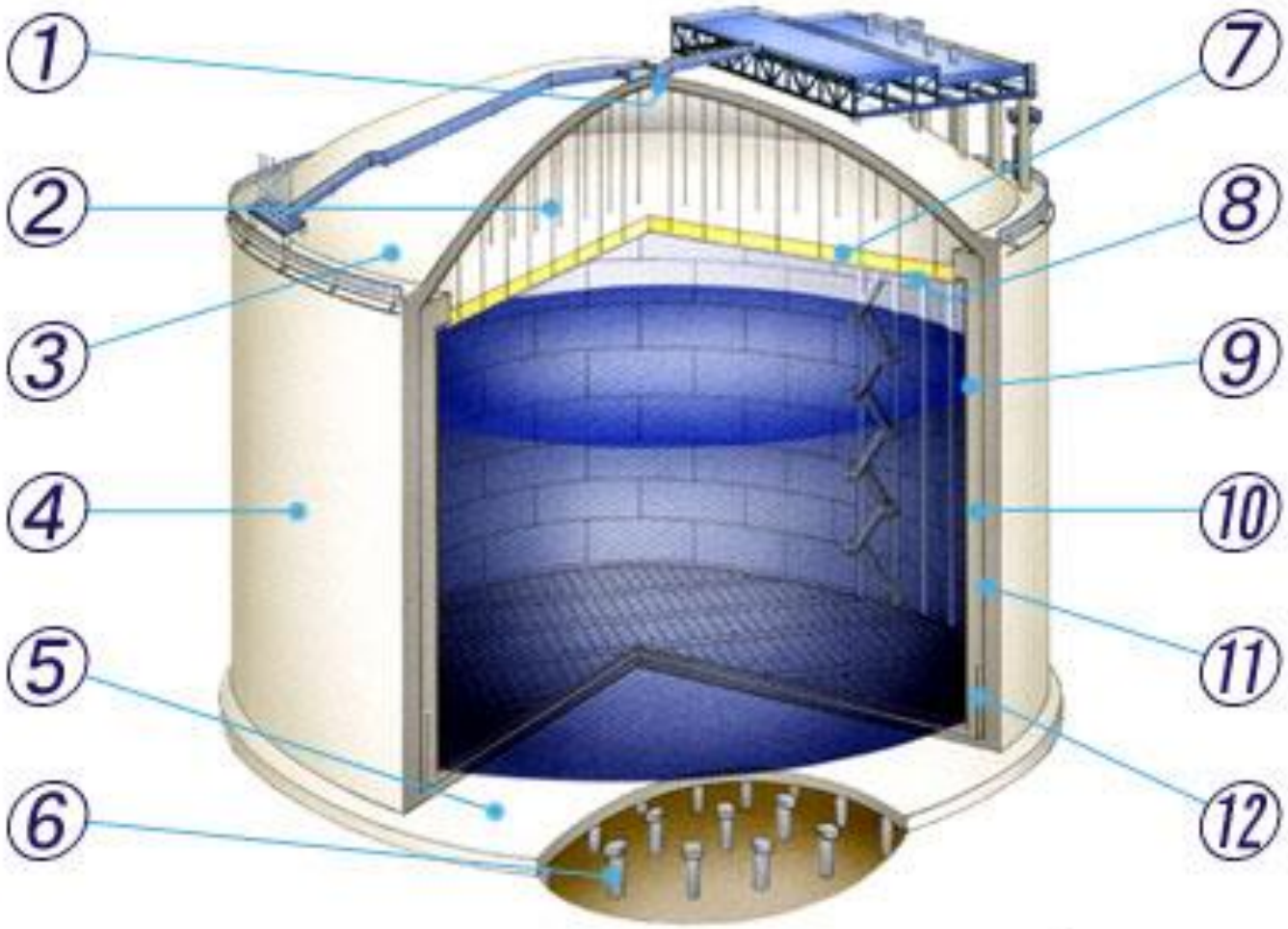
BImSchG

BImSchV

KAS 18

Large jetty / small carrier

Typical atmospheric tank design (Mitsubishi)

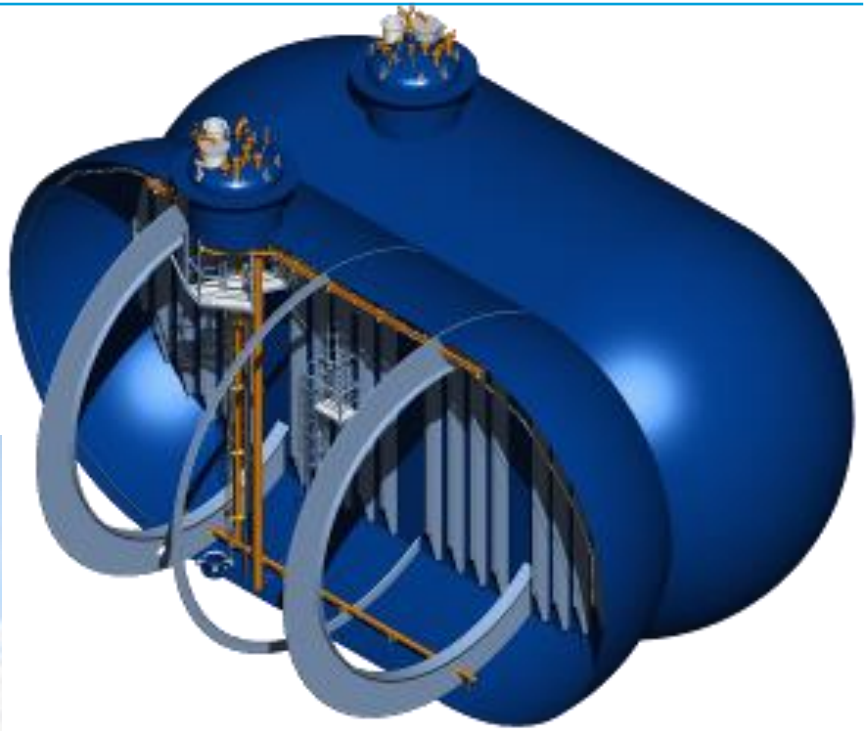


Further distribution

Cargo capacity:	1.100m3
Propulsion:	2 gas engines + 2 diesel engines

Mid Size Import Terminal

Pressure vessel (here: IMO type C)



TGE Marine Gas Engineering

Ship to Ship, “Other” to ship

Photo: Car