Annex B: Risk Reduction Potential

Layer of Protection	RCO	Description	OD/BD	Tier	Node	K-factor [%]									Justification
						Twin Island Gen ship 1: 18000 TEU			Single Island Gen ship 2: 7500 TEU			Feeder Gen ship 3: 3500 TEU			
						min	likely	max	min	likely	max	min	likely	max	
Prevention	P1	Container screening tool	OD/BD	Fire/TEU.year		93,8%	96,9%	100,0%	93,8%	96,9%	100,0%	93,8%	96,9%	100,0%	Same for all ship types
	P4	Improved control of lashing	OD/BD	Fire/TEU.year		98,4%	99,2%	100,0%	98,4%	99,2%	100,0%	98,4%	99,2%	100,0%	Same for all ship types
Detection	D1	Improving current smoke detection system	BD	Smoke detection & CO2 system	Slow	1,5%	3,1%	6,1%	1,5%	3,1%	6,1%	1,5%	3,1%	6,1%	1 case from unsuccessful to controlled in the event tree
					Fast	1,3%	2,7%	5,3%	1,3%	2,7%	5,3%	1,3%	2,7%	5,3%	1 case from unsuccessful to controlled in the event tree
	D2	Heat detection	OD	Detection & Local first response on COO (including accessibility, MFF and local bnd	Slow	1,5%	3,1%	6,2%	1,8%	3,6%	7,2%	1,6%	3,1%	6,2%	Fault tree modification / Late detection set to 50% (base on coverage of containers)
					Fast	3,5%	7,0%	13,9%	4,6%	9,2%	18,4%	4,6%	9,1%	18,2%	Different due to fire growth and MFF time
			BD	Detection (manual/random) & Local first response on COO (including accessibility, MFF and local bnd cooling)	Slow	3,9%	7,9%	15,8%	4,9%	9,7%	19,4%	4,4%	8,8%	17,7%	Fault tree modification / Max: Full coverage, no late detection, there is an opportunity to make a first response / Not sending people in case of fire / No weather effect and no blind spots
					Fast	7,6%	15,2%	30,5%	10,1%	20,2%	40,5%	4,4%	8,8%	17,7%	Fault tree modification / Same logic as slow fire
				Smoke detection & CO2 system	Slow	2,5%	5,0%	10,0%	2,5%	5,0%	10,0%	2,5%	5,0%	10,0%	Detection of a heat spot can lead to a faster release of CO2 / No difference between the ships, the size does not influence the release speed of the CO2
					Fast	1,3%	2,5%	5,0%	1,3%	2,5%	5,0%	1,3%	2,5%	5,0%	Same logic as slow fire / Half efficiency of CO2 on fast fires
	D3	Fixed IR cameras	OD	Detection & Local first response on COO (including accessibility, MFF and local bnd cooling)	Slow	2,3%	4,7%	9,3%	2,7%	5,4%	10,8%	0,6%	2,4%	9,4%	Fault tree modification / Higher than D2 OD / Full coverage OD / 75% efficiency, blind spots, and limited view
					Fast	5,2%	10,5%	20,9%	6,9%	13,8%	27,6%	1,7%	6,9%	27,4%	Fault tree modification / Same logic as slow fire
	D4	CCTV - AI - smoke detection	OD	Detection & Local first response on COO (including accessibility, MFF and local bnd cooling)	Slow	0,7%	1,4%	2,8%	0,8%	1,6%	3,2%	0,2%	0,7%	2,8%	Fault tree modification / Max: 30% of IR camera (reduction of 50%, day/night + 20%, it needs smoke rather than temp)
					Fast	1,6%	3,1%	6,3%	2,1%	4,1%	8,3%	0,3%	1,4%	5,5%	Fault tree modification / Same logic as slow fire / Additional reduction of 10% because the fire needs to produce smoke (fast fire already significant)
	D5	Portable IR cameras for crew to enhance manual detection	OD	Detection & Local first response on COO (including accessibility, MFF and local bnd cooling)	Slow	1,4%	2,8%	5,7%	1,0%	2,1%	4,1%	0,4%	0,8%	1,7%	Fault tree modification / Max: "Poor location" (confirmation) node to 0%
					Fast	0,6%	1,1%	2,3%	0,4%	0,8%	1,6%	0,2%	0,3%	0,6%	Fault tree modification / Max: "Poor location" (confirmation) node to 0%
			BD	Detection (manual/random) & Local first response on COO (including accessibility, MFF and local bnd cooling)	Slow	1,0%	2,0%	4,0%	0,8%	1,5%	3,0%	0,4%	0,8%	1,5%	No FT for BD detection / Based on ratio between OD slow/fast and BD slow/fast
					Fast	0,4%	0,8%	1,6%	0,3%	0,6%	1,1%	0,1%	0,3%	0,6%	No FT for BD detection / Based on ratio between OD slow/fast and BD slow/fast

	ID	Measure	Type	System	Fire										Notes
Firefighting	F1	Increasing effectiveness of current CO2 system	BD	Smoke detection & CO2 system	Slow	5,0%	10,0%	20,0%	5,0%	10,0%	20,0%	5,0%	10,0%	20,0%	Fault tree modifiation Less 'inadequate amount of CO2', and less 'Leaks' and 'crew more confident in activating the system', Same regulation, then minimal size impact
					Fast	1,3%	2,5%	5,0%	1,3%	2,5%	5,0%	1,3%	2,5%	5,0%	Exponential - decision time, heat built is higher when detected Fast fire 15 times growth slow fire
					Explosion	0,6%	1,3%	2,5%	0,6%	1,3%	2,5%	0,6%	1,3%	2,5%	Half - damage to the infrastructure
	F2	Improved manual firefighting tools for individual container breaching and firefighting	OD	Detection & Local first response on COO (including accessibility, MFF and local bnd cooling)	Slow	3,1%	6,2%	12,5%	5,8%	11,7%	23,4%	6,1%	12,1%	24,3%	Fault tree modifiation Failure of 'No efficient FiFi inside COO' just by 'COO out of reach'
					Fast	1,5%	2,9%	5,8%	2,3%	4,6%	9,2%	2,3%	4,7%	9,4%	Fault tree modifiation Same logic as slow fire
					Explosion	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	NA
	F3	Manual firefighting tools that increase reach	OD	Detection & Local first response on COO (including accessibility, MFF and local bnd cooling)	Slow	10,4%	20,9%	41,7%	9,2%	18,4%	36,9%	9,7%	19,3%	38,6%	Fault tree modifiation Failure of 'No efficient FiFi inside COO', made 'COO out of reach'=0 'COO bnd cooling failure' also 'COO out of reach'=0
					Fast	4,2%	8,4%	16,7%	3,1%	6,3%	12,6%	3,2%	6,5%	12,9%	Fault tree modifiation Same logic as slow fire
					Explosion	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	NA
	F4	Methods for unmanned fire fighting	OD	Detection & Local first response on COO (including accessibility, MFF and local bnd cooling)	Slow	1,7%	3,5%	6,9%	3,3%	6,7%	13,4%	3,5%	7,0%	14,1%	Fault tree modifiation Fixed on a place and less tiredness from the crew. On 'COO bnd cooling failure' acount for half the failure on 'bnd cooling on COO not efficient' and half failure on human element
					Fast	0,9%	1,7%	3,5%	1,3%	2,7%	5,3%	1,4%	2,8%	5,5%	Event tree modification Same logic as slow fire
					Explosion	0,9%	1,7%	3,5%	1,3%	2,7%	5,3%	1,4%	2,8%	5,5%	Event tree modification Same as fast
	F5	Watermist canon	OD	Detection & Local first response on COO (including accessibility, MFF and local bnd cooling)	Slow	2,5%	10,0%	39,9%	2,0%	8,2%	32,7%	2,2%	8,6%	34,4%	Fixed system, better reach, water mist more efficient cooling effect
					Fast	1,1%	4,3%	17,4%	0,8%	3,2%	12,7%	0,8%	3,3%	13,2%	Then 'COO out of reach' and 'bnd on COO not efficient'=0.
					Explosion	1,1%	4,3%	17,4%	0,8%	3,2%	12,7%	0,8%	3,3%	13,2%	Event tree modification Same as fast

						GS1			GS2			GS3			Comment
Confinement	C1	Active protection underneath hatch covers to protect from fire spread towards the deck	BD	Fire-fighting / Containment in HOO	Slow	18,6%	37,1%	74,3%	16,6%	33,2%	66,4%	15,8%	31,5%	63,0%	Fault tree modification Without WS and flooding, 100% propagation to bay. With WS, 26% propa --> 74% reduction. Detail of calculation: P(WS working on demand)=90% P(Early activation)=70% P(no propa above|Early)=100% P(no propa above|Late)=1-7/12 => P(no propa above)=74% GS2: same as GS1, but less tiers, hence more chances to propagate upwards P(no propa above|Late)=1-7/8 GS3: Same as GS1, but less tiers, hence more chances to propagate upwards P(no propa above|Late)=0%
					Fast	13,3%	26,6%	53,3%	8,7%	17,4%	34,9%	6,8%	13,5%	27,0%	idem with 30% early/70% late
					Explosion	9,4%	18,8%	37,5%	2,8%	5,6%	11,3%	0,0%	0,0%	0,0%	idem with 0% early/100% late
	C2	Passive protection to protect from fire spread towards the deck	BD	Fire-fighting / Containment in HOO	Slow	6,3%	12,5%	25,0%	6,3%	12,5%	25,0%	6,3%	12,5%	25,0%	Low Less effective on the fire outcome
					Fast	12,5%	25,0%	50,0%	12,5%	25,0%	50,0%	12,5%	25,0%	50,0%	Medium Fast fire, then happy to have time a bit more time
					Explosion	10,2%	20,5%	40,9%	9,4%	18,8%	37,5%	8,3%	16,7%	33,3%	Same as fast but penalized for damage (Potential damage to passive protection) more effective if fire is right under the protection GS3: 2/6 tier below deck GS2: 2/8 tier below deck GS1:2/11 tier below deck
	C3	Fixed external container stack cooling system to stop spread between stacks	OD	Fire-fighting / 1st bay boundary cooling	Slow	11,3%	22,5%	45,0%	16,1%	32,1%	64,3%	12,9%	25,7%	51,4%	Very high GS3: only 1 tier over lashing bridge reachable containers (4/7) GS2: only 1 tier over lashing bridge reachable containers (5/7) GS1: only 1 tier over lashing bridge reachable containers (5/10)
					Fast	5,6%	11,3%	22,5%	8,0%	16,1%	32,1%	6,4%	12,9%	25,7%	Manual activation system Larger fire 50% of slow fire
					Explosion	2,8%	5,6%	11,3%	4,0%	8,0%	16,1%	3,2%	6,4%	12,9%	Same as fast 50/50 chance of potential damage
	C4	Flooding cargo hold to limited degree	BD	Fire-fighting / Containment in HOO	Slow	11,3%	22,5%	45,0%	14,1%	28,1%	56,3%	18,8%	37,5%	75,0%	Without WS and flooding, 100% propagation to bay. With flooding only, 55% propa --> 45% reduction. Detail of calculation: P(flooding works)=90% P(no propa to other deck|flooding works)=50% ==> P(no propa)=50%*90%=45% GS3: same as GS1, but less tiers, hence more chances to be under WS (i.e. P(success|work)=5/6) GS2: same as GS1, but less tiers, hence more chances to be under WS (i.e. P(success|work)=5/8)
					Fast	7,4%	14,9%	29,7%	9,3%	18,6%	37,1%	12,4%	24,8%	49,5%	Less chance of success than slow due to faster fire
					Explosion	3,7%	7,4%	14,9%	4,6%	9,3%	18,6%	6,2%	12,4%	24,8%	Less chance of success than slow and fast due to faster fire