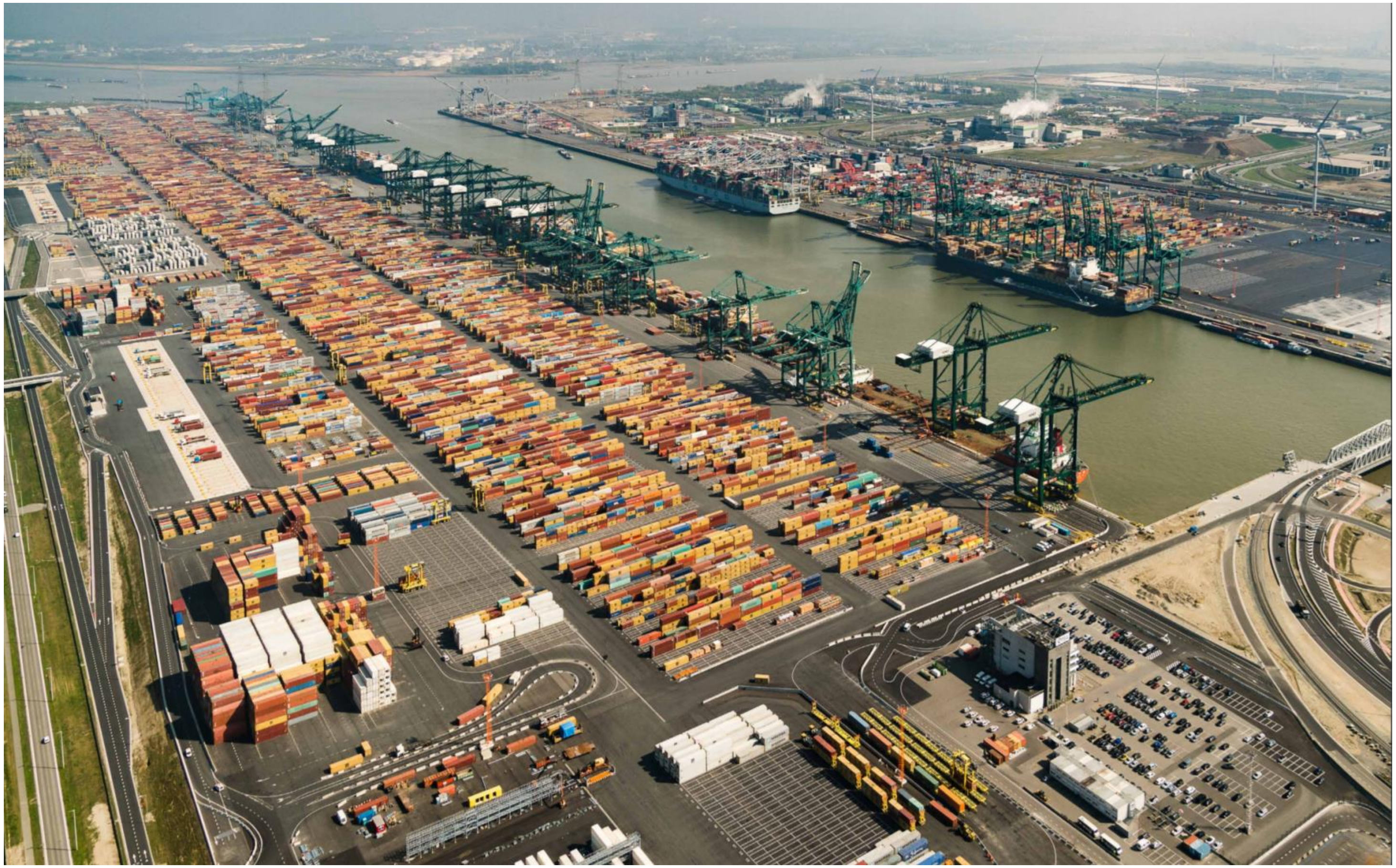
Antwerp Port Expansion
NGICT Alternative design



Introduction

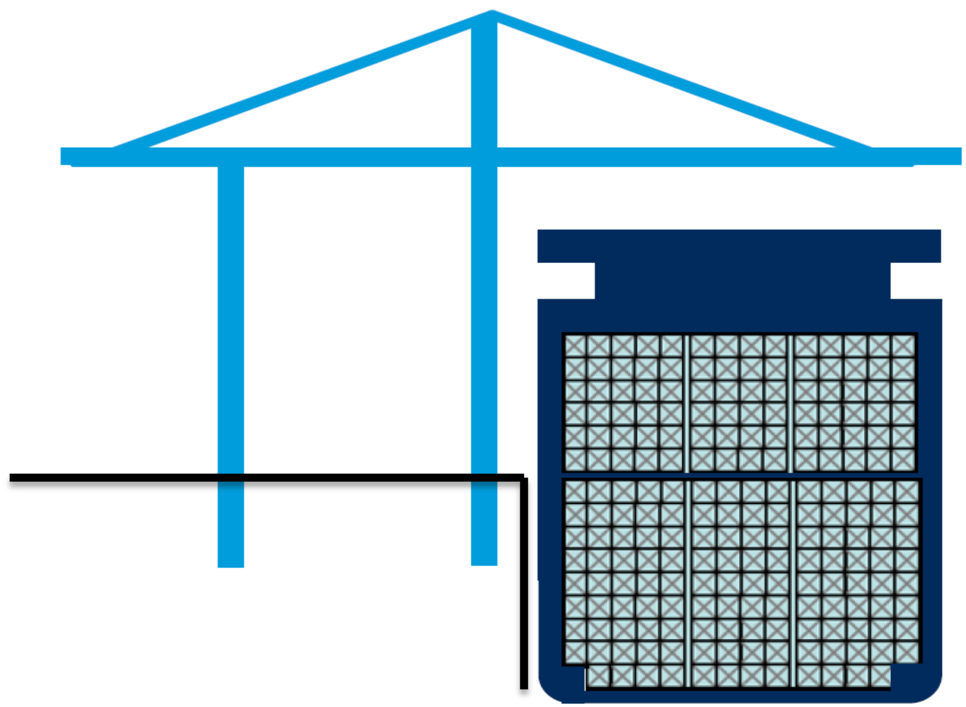
- NGICT requested Solid Port Solutions to make an independent comparison of 3 terminal systems for the Port of Antwerp. The study should give the comparison results for Performance, Throughput Capacity, CAPEX and OPEX.
- The 2 existing modes of terminal operations in Antwerp; full Straddle Carrier and ASC are included in the study and compared with the NGICT system based on Over Head Bridge Crane technology.
- In the study an alternative design for the port expansion is used for the 3 different designs of the container terminal.

Business Trends (source Drewry)

Opex and capex costs are rising

$ $ $ $

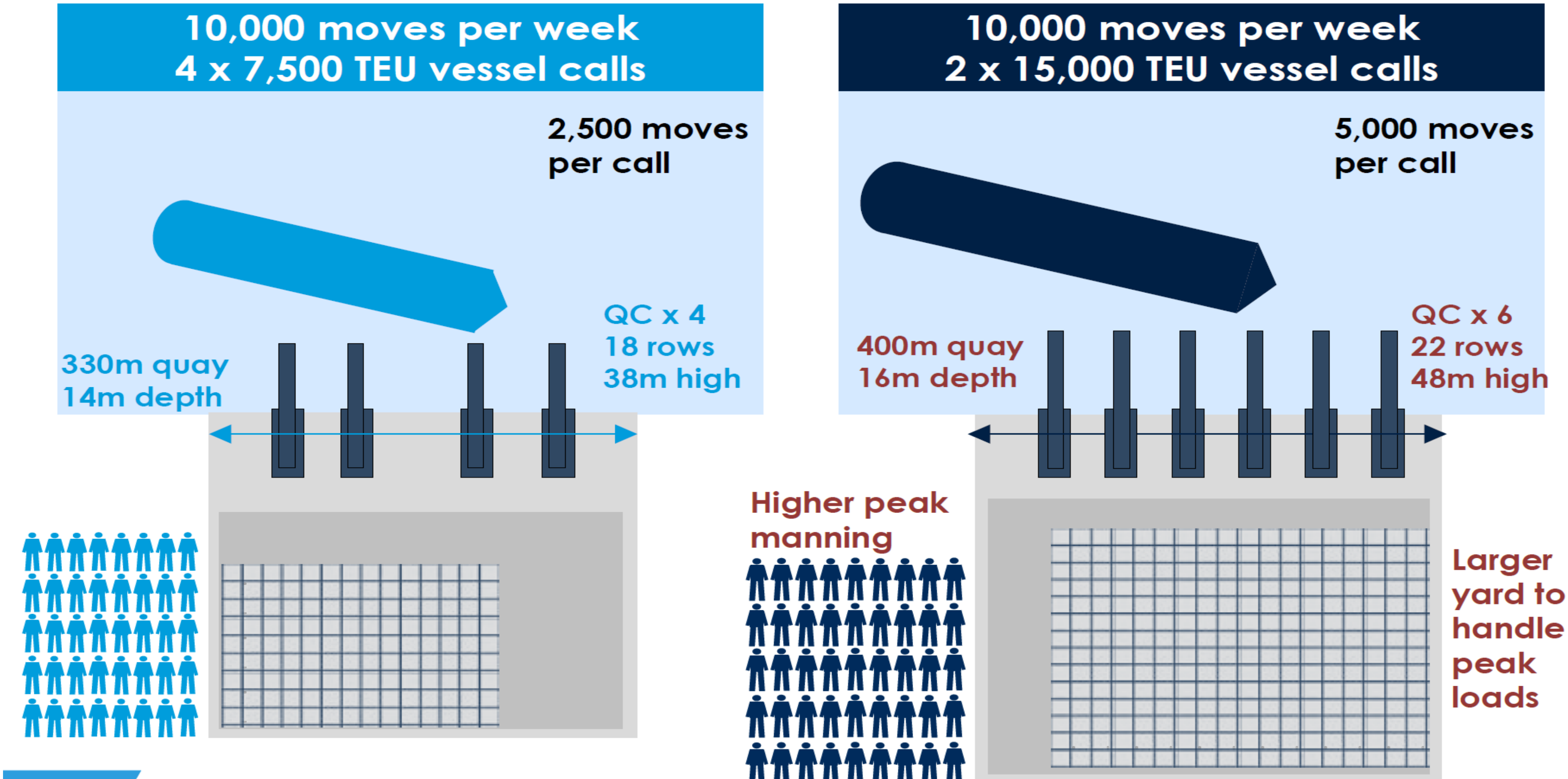
- Larger cranes (outreach and height)
- More cranes
- Longer and deeper berths
- Deeper approach channels
- Greater air draft
- Larger or more densely stacked yard



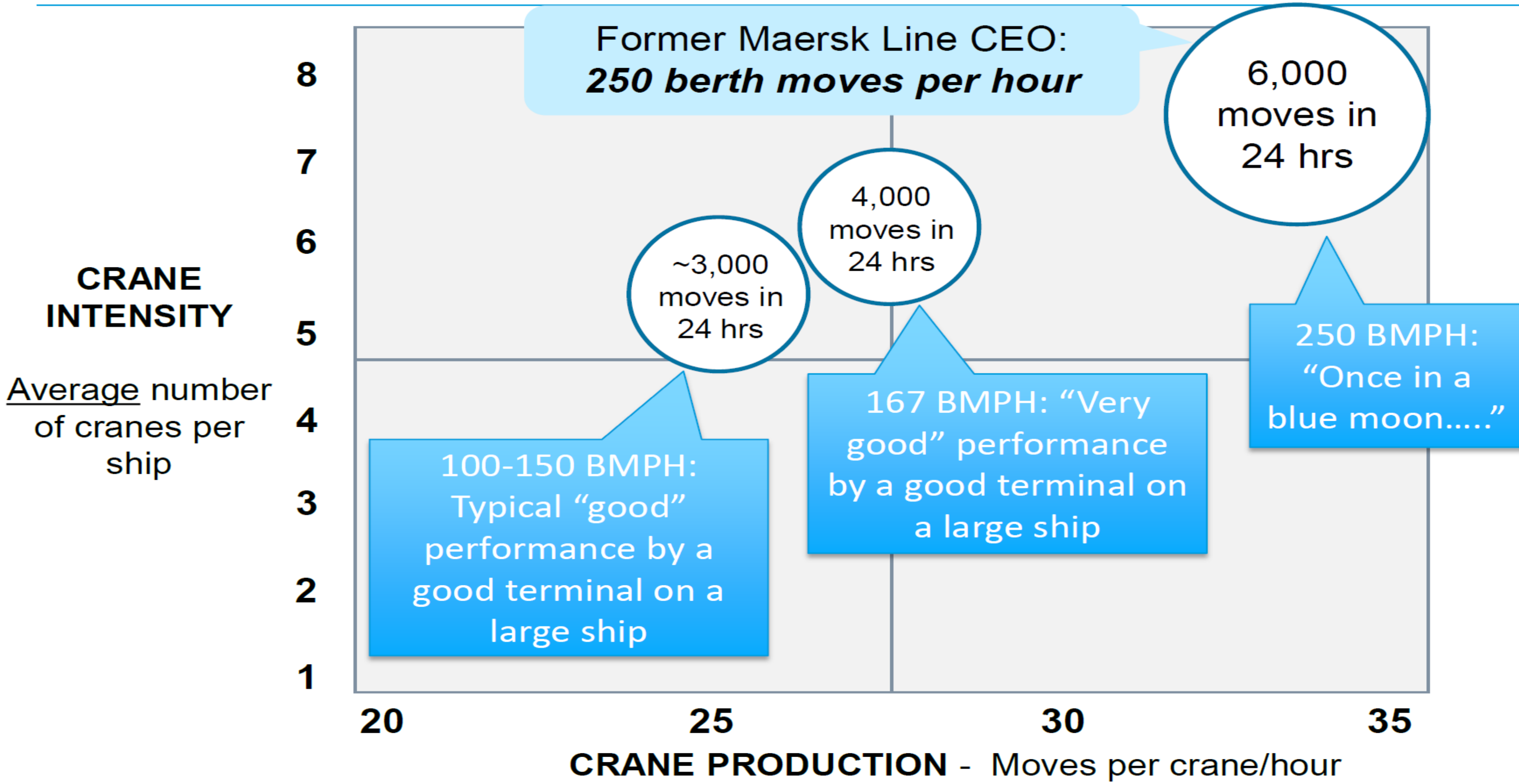
- Higher crane and berth productivity demands
- Greater peaks

Business Trends (source Drewry)

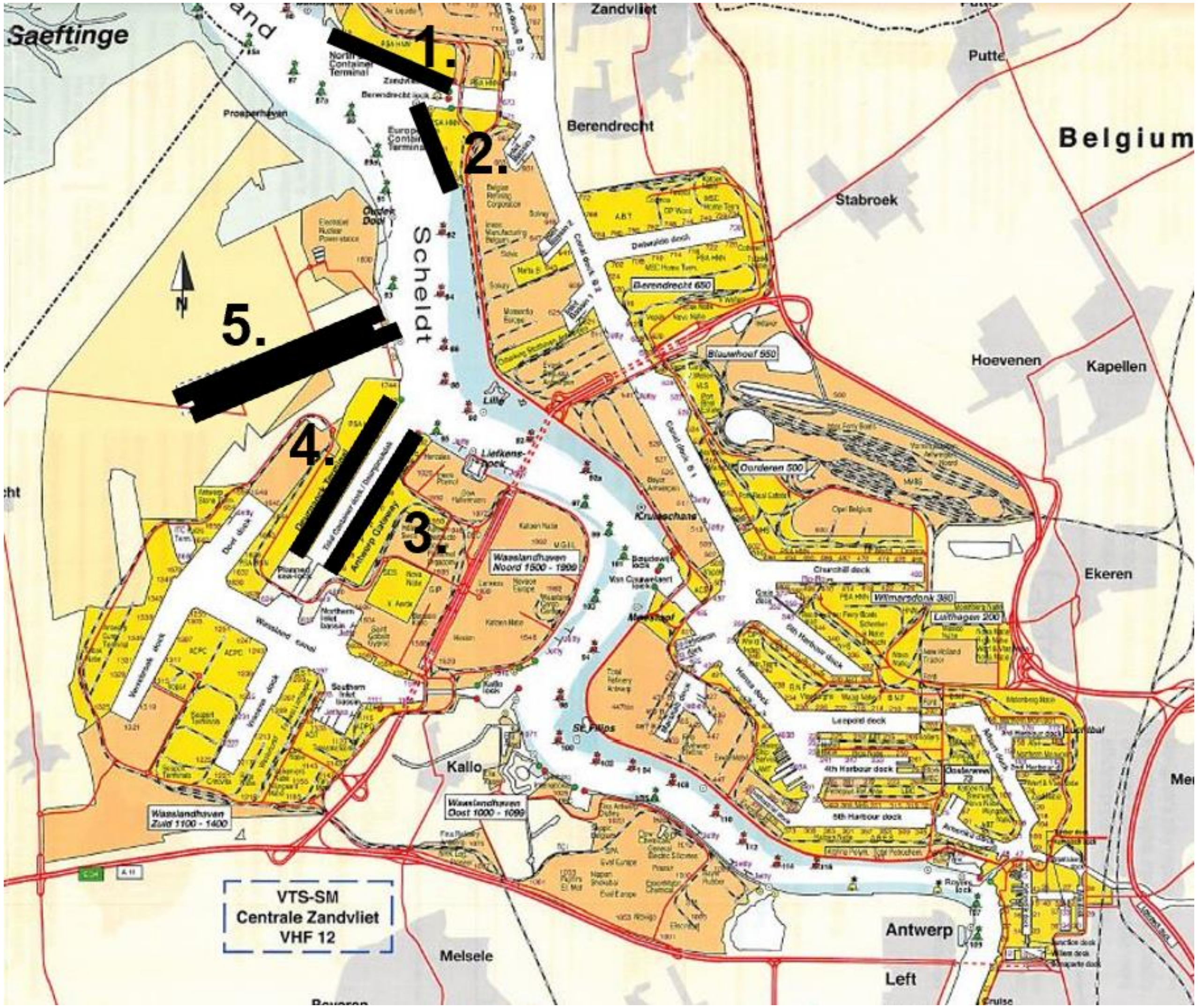
Volume peaks are the most serious issue



Unrealistic pressure for higher berth productivity?



Alternative design NGICT



EXISTING SITUATION 2018
4-TIDAL DEEPSEA TERMINALS OUTSIDE THE LOCKS:

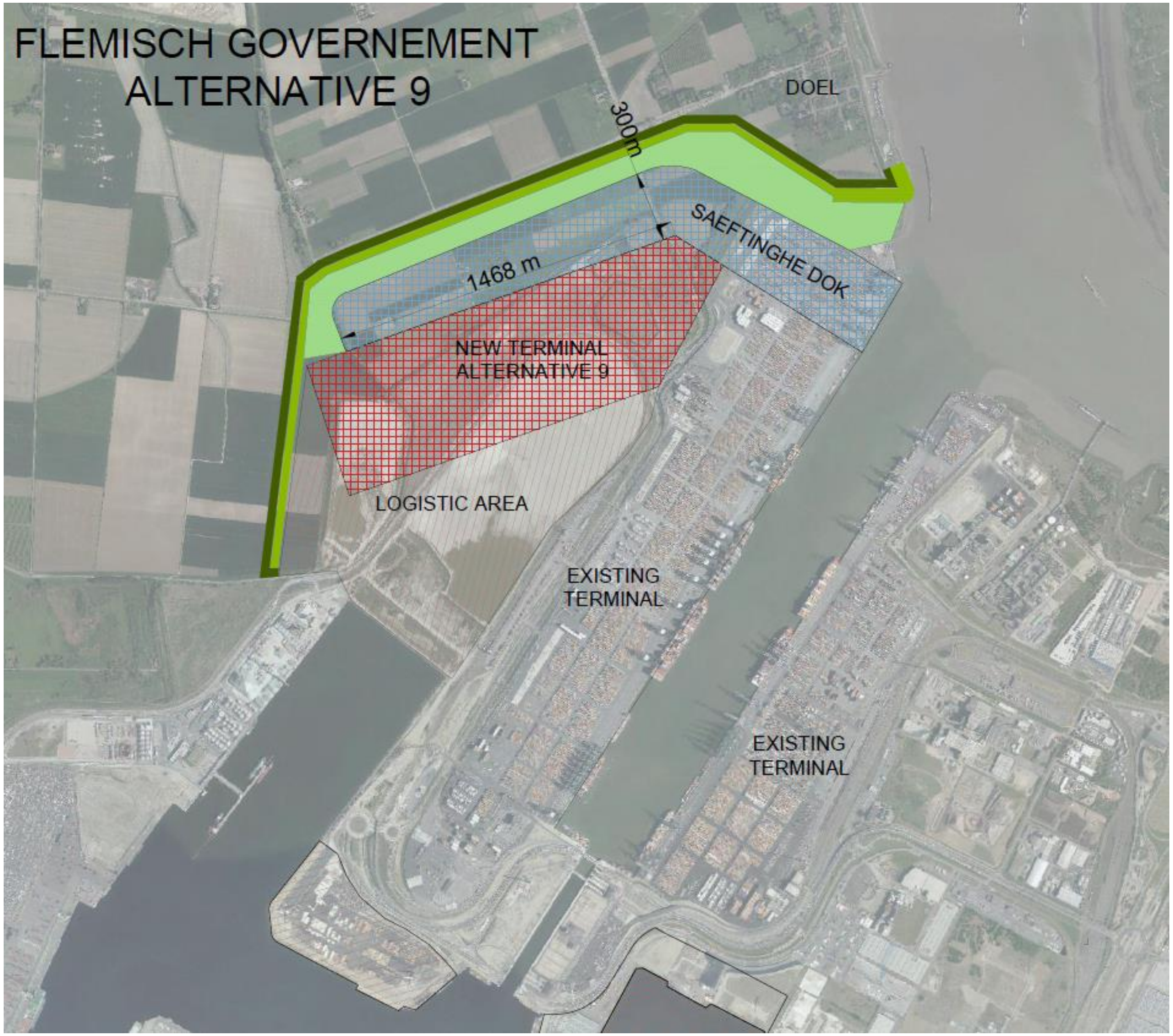
1. **NOORDZEE TERMINAL**
2. **EUROPA TERMINAL**
3. **PSA (EASTSIDE DEURGANCKDOK)**
4. **MPET (WESTSIDE DEURGANCKDOK)**

FUTURE SITUATION (2021):

5. **PLANNED SAEFTINGEDOK SINCE 2005 AND STILL IN STAGE OF INVESTIGATIONS AND JUSTIAL PROCEDURES**

Alternative design NGICT

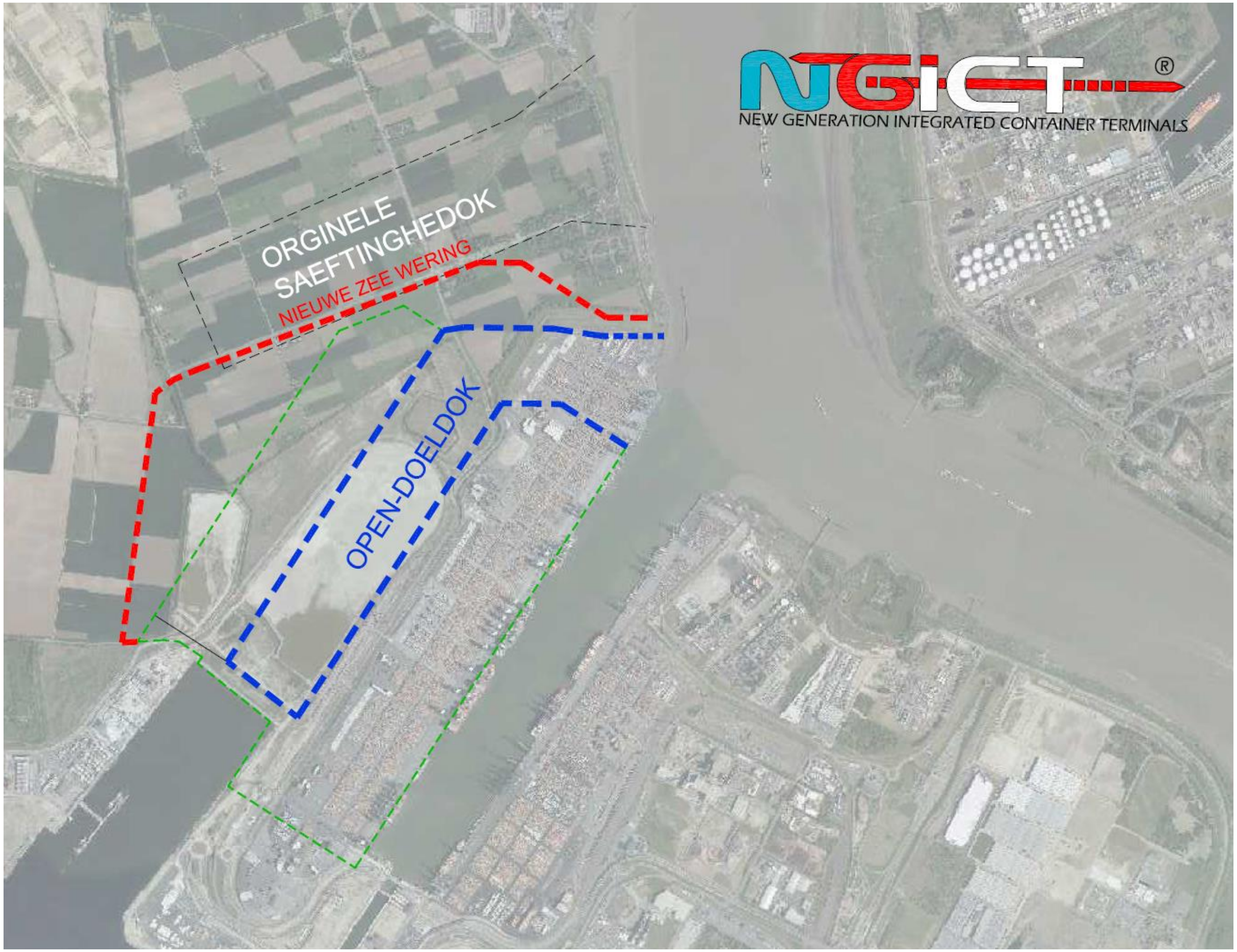
Alternative design NGICT



Alternative 9:

- **1468 m deepsea quay**
- **300 m barge/feeder quay**
- **Demolition 300 m existing quay**
- **Around 2.5 M TEU additional capacity**
- **Big investment for only 1468 m additional deepsea quay**

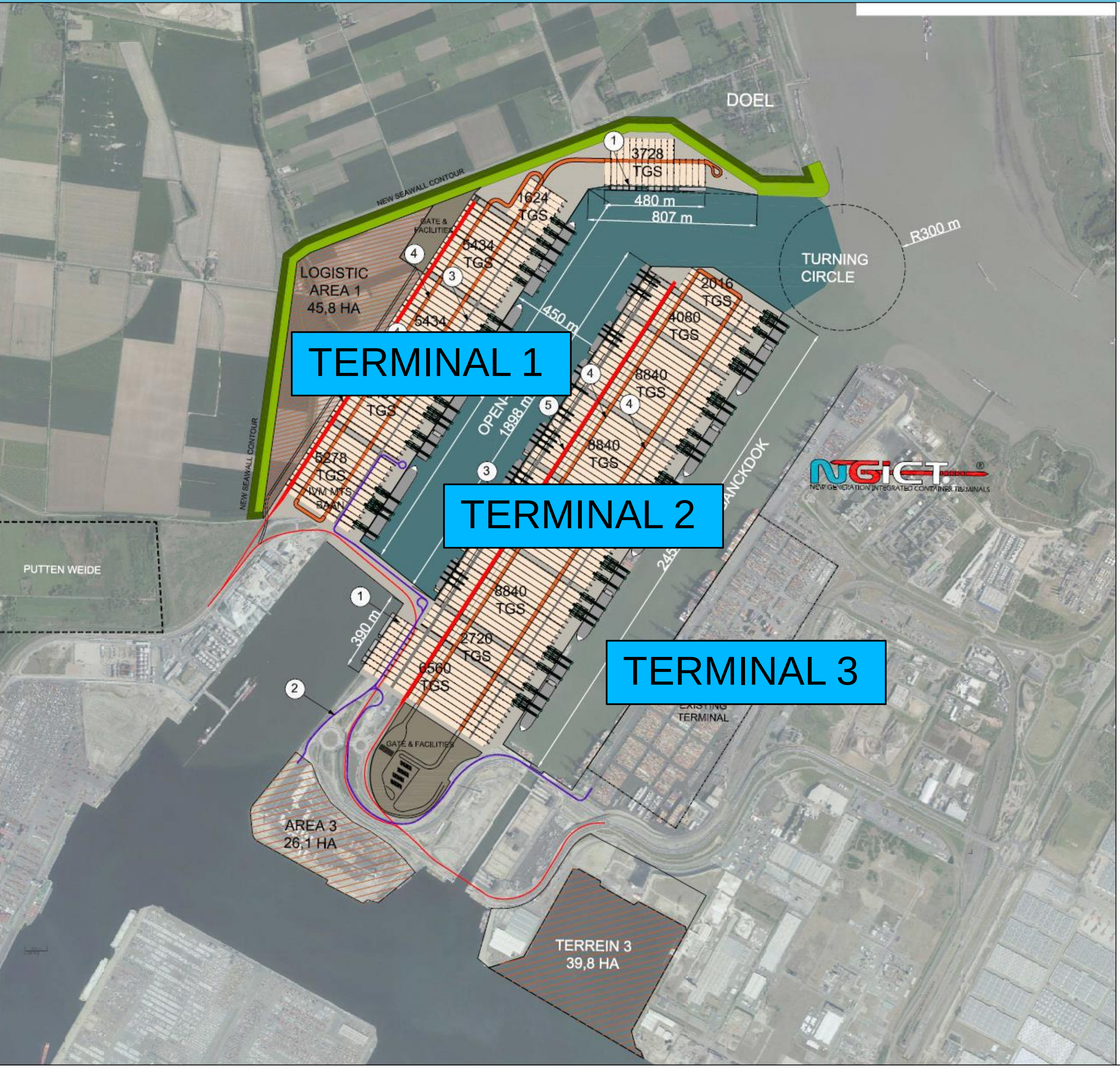
Alternative design NGICT



Alternative 10:

- **Within the bounderies of alternative 9.**
- **Additional 3900 m deepsea quay**
- **Additional 900 m barge/feeder quay**
- **Demolition 300 m existing quay**
- **Around 8 - 9 M TEU additional deepsea capacity**

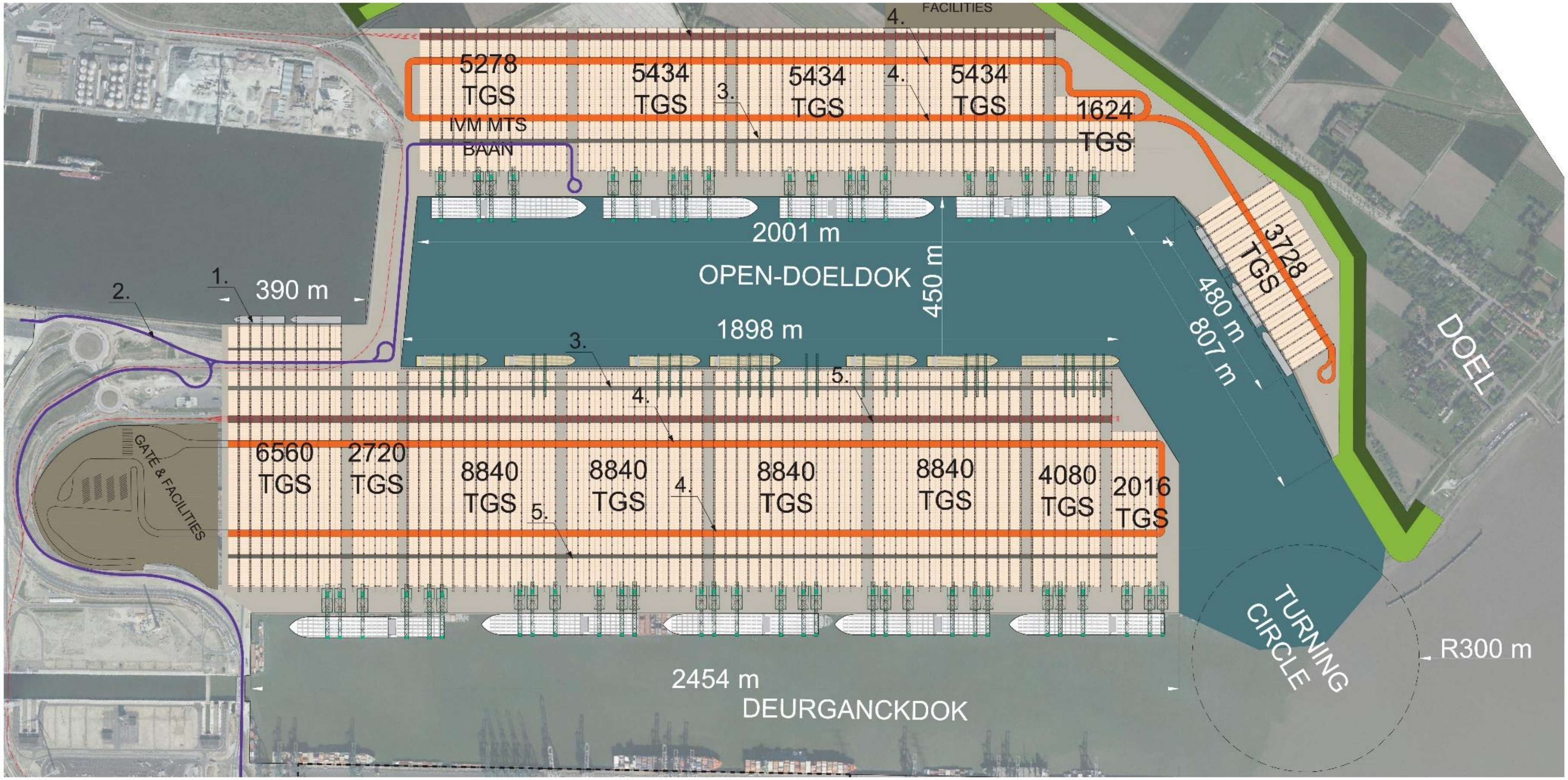
Alternative design NGICT



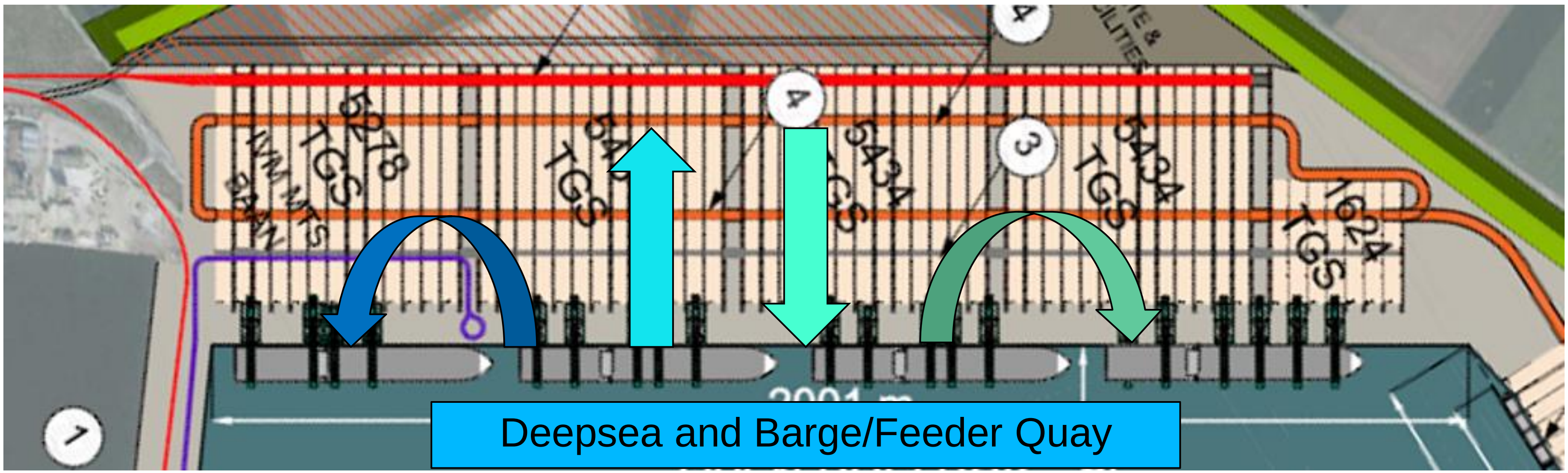
NEW GENERATION INTEGRATED CONTAINER TERMINALS

1. Barge terminal
2. CER
3. 2x (1 over 2) shifter tracks
4. Truck lanes laden & lossen
5. 4 spoorbanen laden & lossen

Alternative design NGICT

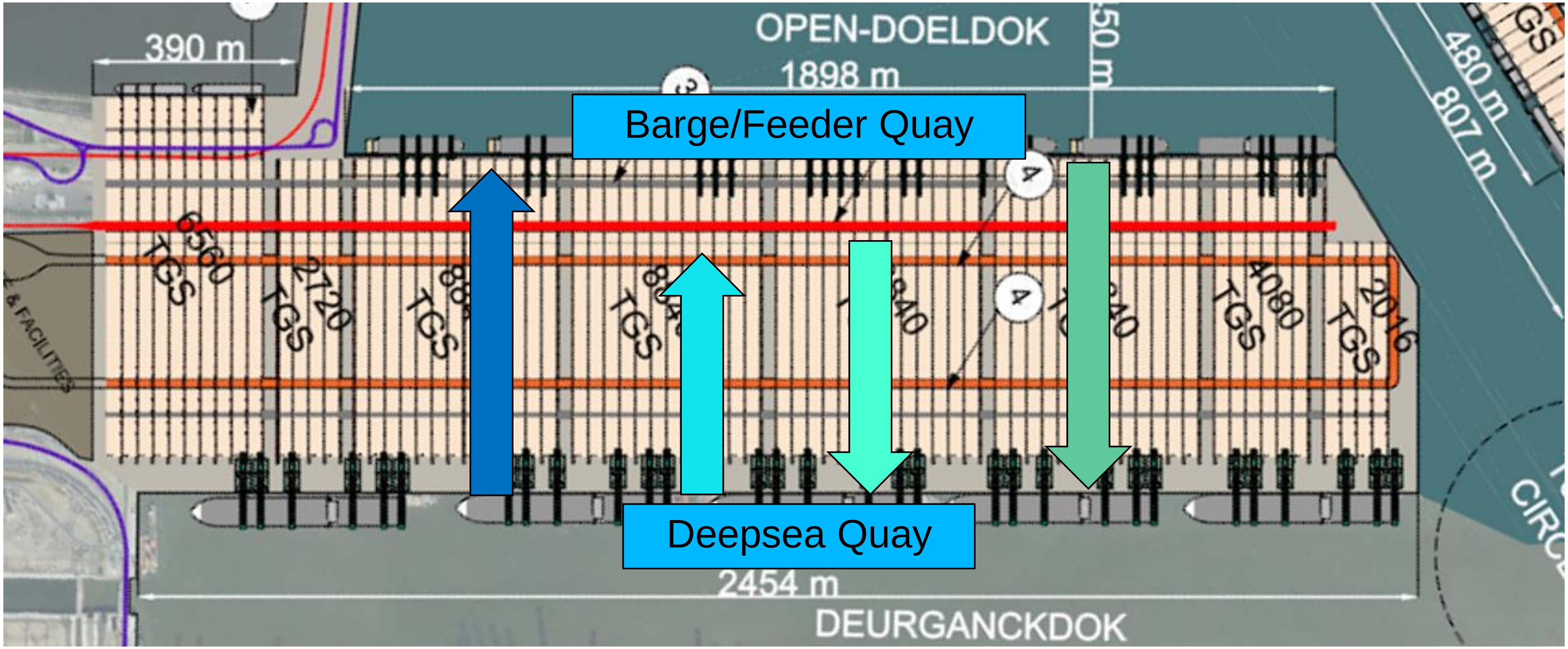


Terminal 1



- Deepsea and TS via the same quay
- Quay capacity is limitation for Terminal capacity
- 2100 TEU/m x 2000 m = 4.2 M TEU capacity

Terminal 2 comparison



- Deepsea and Transshipment via different quay
- Yard capacity is sufficient to maximize Quay capacity
- 2100 TEU/m x 4350 m = 9.1 M TEU capacity

Summary of results

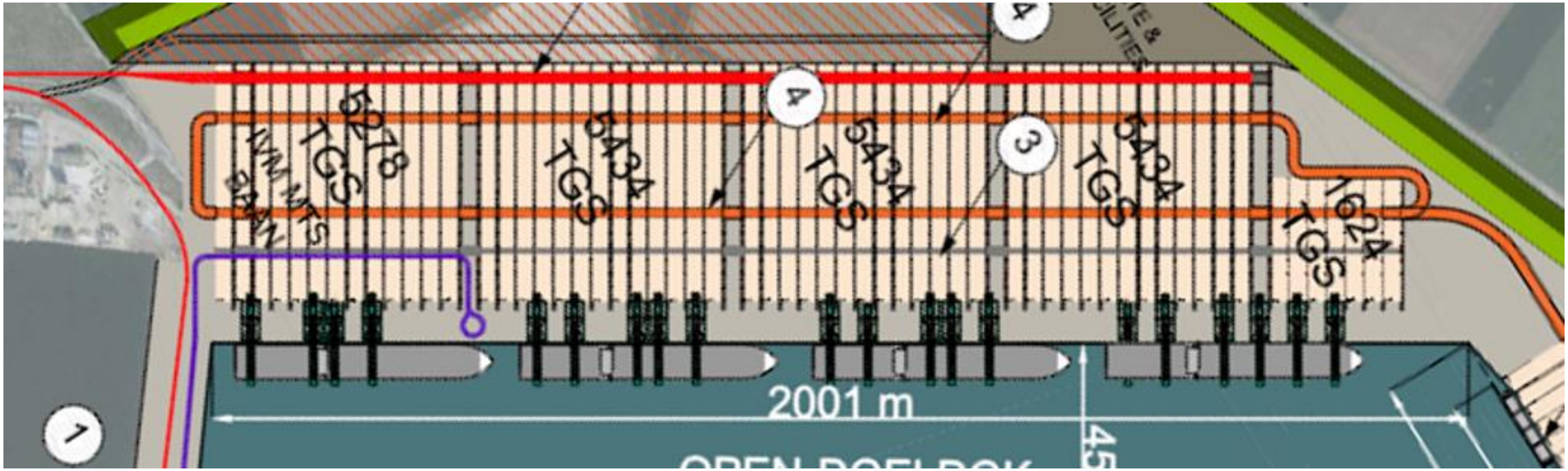
- The NGICT alternative design can deliver:

- 3.900 meter additional deepsea quay length
- 900 meter additional Barge/Feeder Quay
- 8 – 9 Million TEU additional capacity
- Most efficient container terminal operations against lowest cost
- A handling system designed for high transshipment rates
- On dock rail facilities without additional horizontal transport
- Highest yard and terminal utilization rate
- Deepsea and shorstsea/barge operations on different quay

Definitions

ASC	Automated Stacking Crane
AGV-L	Automated Guided Vehicle with lifting principle
ALV	Automated Lifting Vehicle / Autostrad 1 over 1
ATT	Automated Terminal Tractor
OHBC	Over Head Bridge Crane
QC	Quay Crane
RC	Rail Crane
HTS	Horizontal Transport System
RMG	Rail Mounted Gantry Crane

Terminal 1 Yard systems compared



- **System A (Automated)**
  ASC 10-wide perpendicular with AGV-L and AutoTug to Rail (mixed traffic). Truck handled by ASC directly.

- **System B (Automated)**
  OHBC system with independent upper/lower crane and ALV for Waterside operation. Truck handled directly. Rail handled by integrated OHBC/Railcrane.

- **System C (Manual)**
  Full manual Straddle SC (1 over 3) for Waterside, Truck and Rail

Detailed Assumptions Terminal 1

General assumptions			Terminal 1				
					productivity		
QC					35	cmph	35 m span
Maximum working hours yard cranes per year					5256	hour	
Railcrane	RMG				25	cmph	
Quay	2000	m					
# berths	5						
# QC	22				770	cmph	Waterside
# RC	2				50	cmph	Rail
TEU-factor		1.7					
Throughput per berth		deepsea	700,000	TEU	411,765	containers	
Total throughput		deepsea	3,500,000	TEU	2,058,824	containers	
Transshipment		25%	875,000	TEU	514,706	containers	
Bargevolume		25%	656,250	TEU	386,029	containers	
Railvolume		15%	393,750	TEU	231,618	containers	
Truckvolume		60%	1,575,000	TEU	926,471	containers	
Deepsea and TS volume			4,375,000	TEU	2,573,529	containers	
Total volume quay			5,031,250	TEU	2,959,559	containers	
Gate opening hours p/d			14	hr	weekdays	260	days p/y
Peakfactor Gate		1.40					
Peak hour trucks					356	cmph	
Mean Dwelltime		5	days				
Stacking height yard		5	ASC/OHBC	3	SC 1 over 3		
Maximum density		80%					
Peakfactor yard		1.25					
TEU visits per slot		46.72	yard				
Total required TEU slo		74,914	TEU				
Width of rail terminal		60	m	for Systems A and B			

Example SYSTEM A

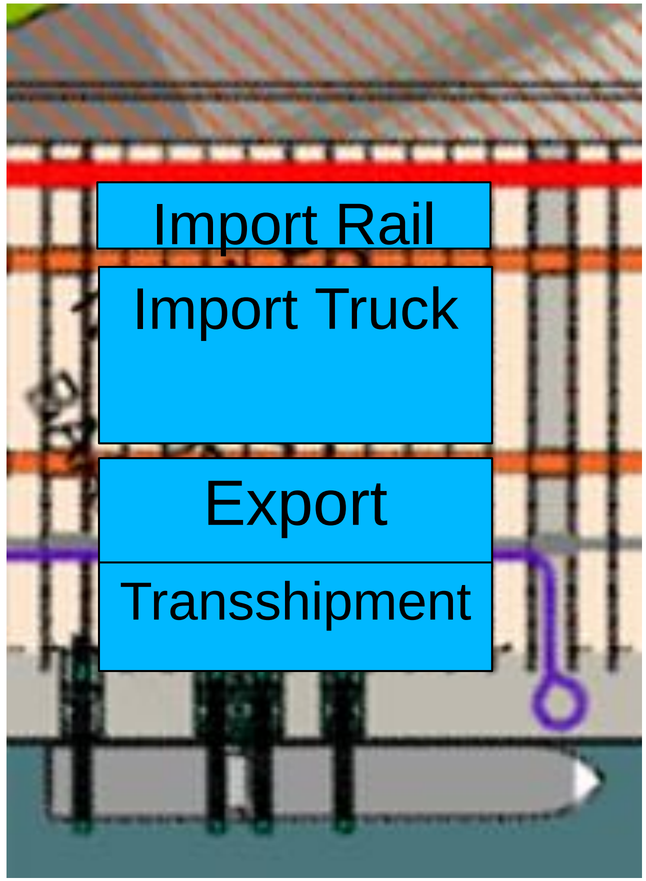
Main Characteristics SYSTEM A

- ASC blocks perpendicular to the quay
- End loaded, 2 ASC's per block
- 10-wide , 5 high, 34 TEU long , block width 37 m
- Total number of ASC blocks: 52 (=1840 m)
- HTS quay: AGV-L full electric
- HTS rail: AutoTug with decoupled chassis at transfer points
- Avg ASC in/out handlings waterside: 16 cmph
- Avg ASC in/out handlings landside: 12 cmph
- Avg ASC productivity: 18 cmph
- Percentage housekeeping moves: 100%
- Average AGV-L productivity 9.0 cmph (incl. twin-carry)
- Average AutoTug productivity 6.0 cmph

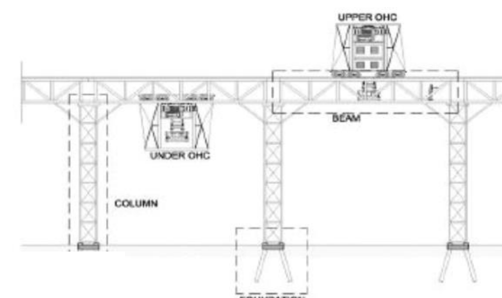
Performance Terminal SYSTEM A

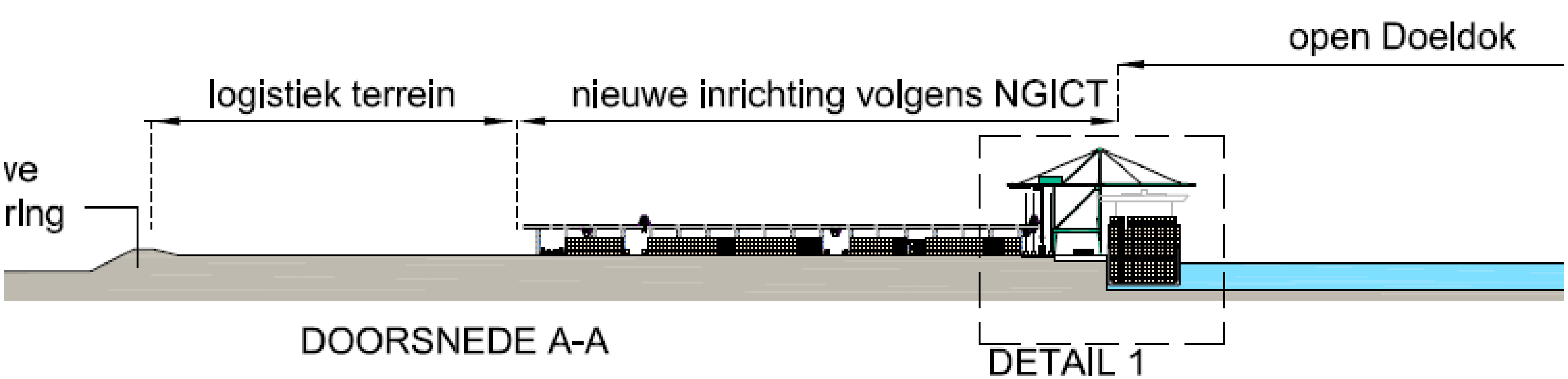
Yard Design A	ASC/AGVL		
Stack	End loaded ASC blocks, 2 ASC's per block	16	cmph
Block width dimension		37	m
HTS Quay	AGV-Lift, back reach operation QC	9	cmph
HTS Rail	AutoTug / Chassis	6	cmph
HTS Truck	direct by LS ASC	12	cmph
Mean ASC productivity (including housekeeping)		18	cmph
Percentage housekeeping moves		100%	
Maximum # blocks		52	
# of ASC's		104	
Stack capacity		88,400	TEU slots
Stack capacity		4,372,992	TEU /yr
Landside handling capacity		624	cmph
Waterside handling capacity		832	cmph
Total ASC moves per year		8,235,294	p/y
Total handlings per ASC		79,186	p/y
# of AGV-LIFT		86	
# of TT		8	
# of Railcrane		2	
length of rail		310	m
total length of rail		32.2	km
width yard area		1,924	m
Total yard area		65	ha
Throughput yard		66,880	TEU/ha/yr
width truck road		40	m
Width quay area		115	m
Total terminal depth		525	m
Total terminal area		105	ha
Throughput per ha		41,667	TEU/ha/yr

Example Terminal System B

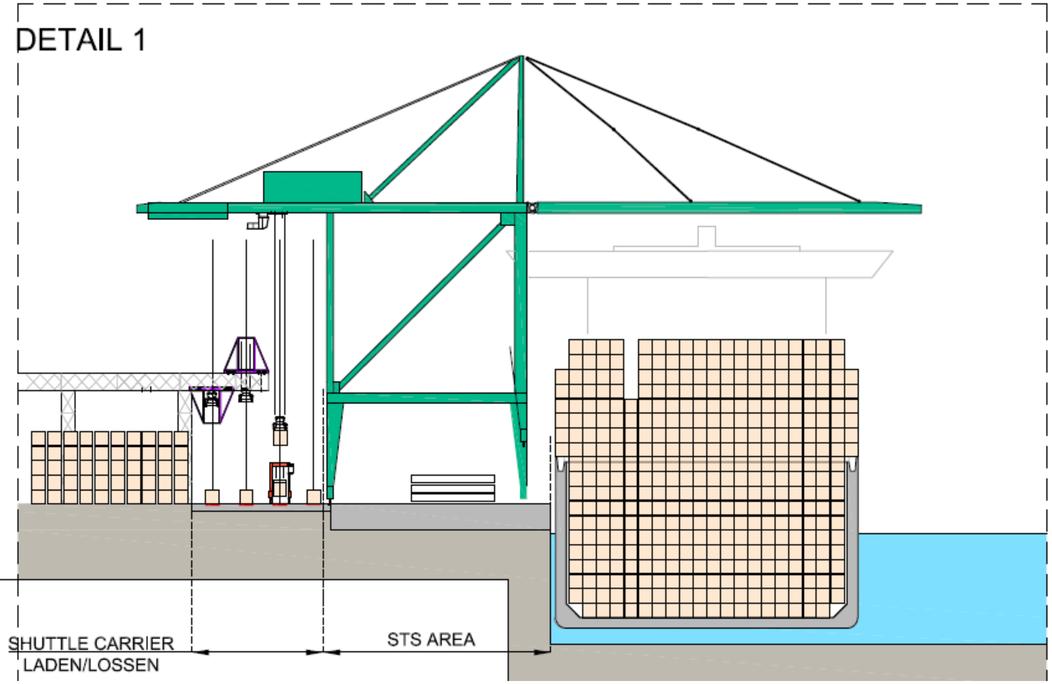


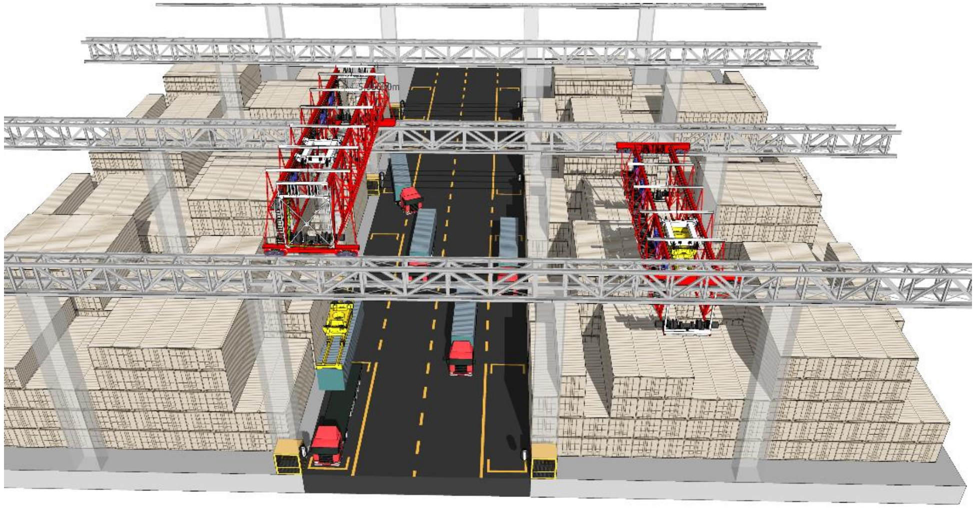
The support structure consists out of modular steel columns and girders which make phased extension of terminals possible. Conservation up to 40 years without high maintenance costs is possible.

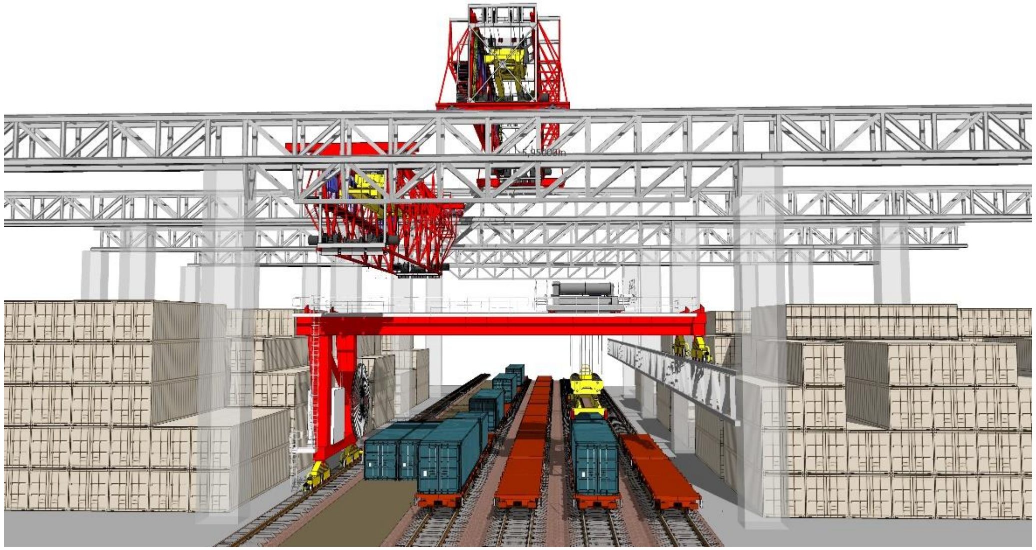


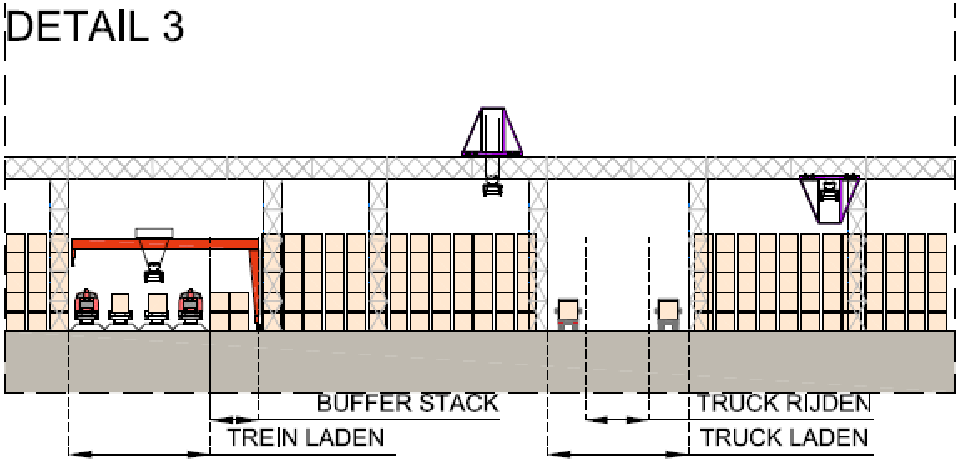


Example Terminal SYSTEM B

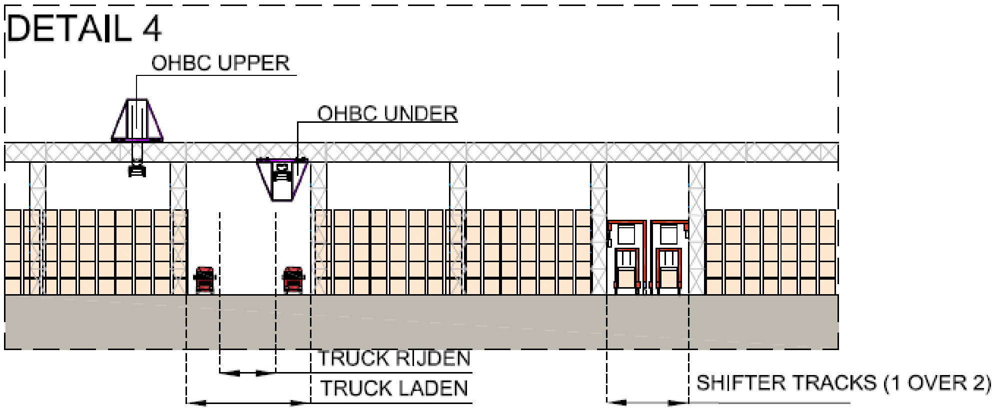


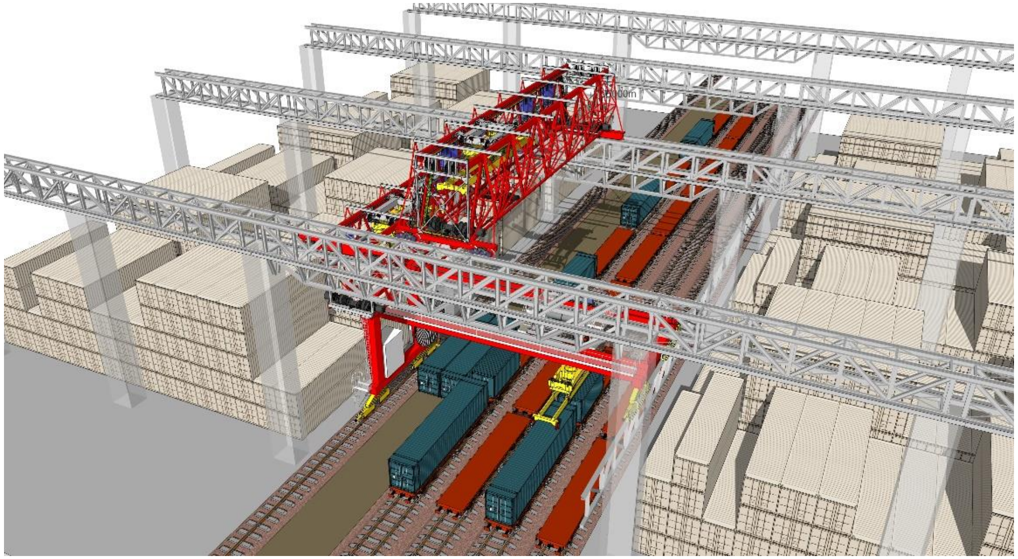


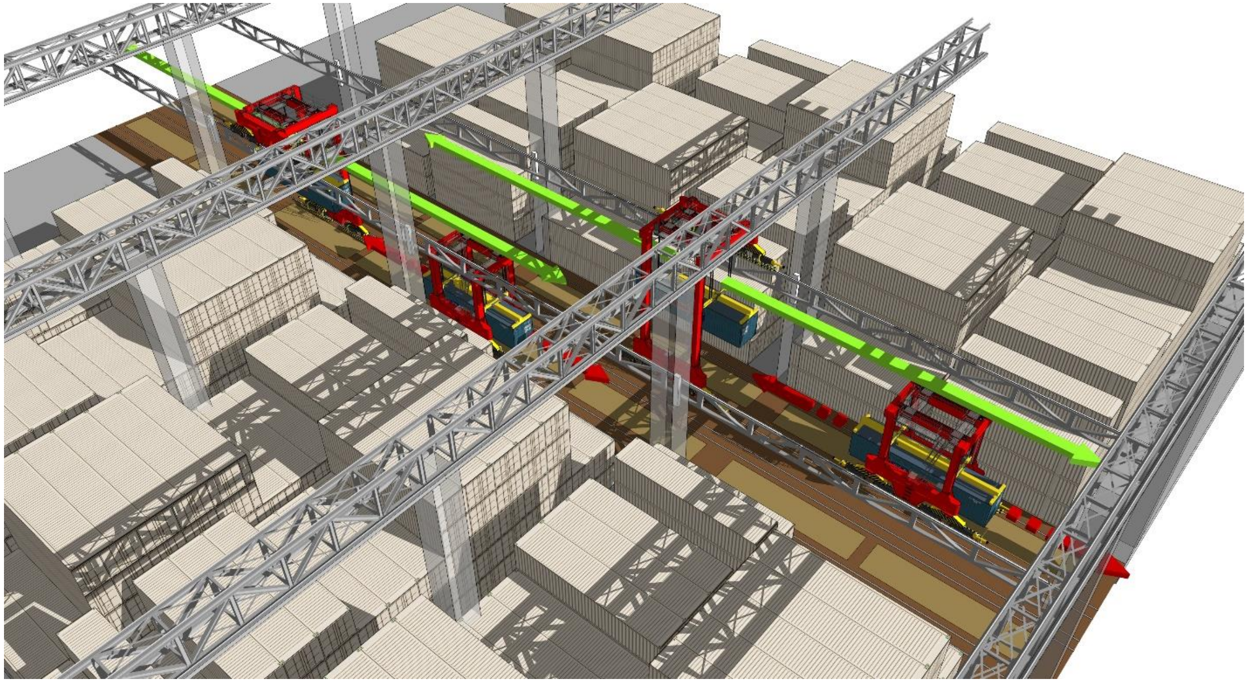




Example Terminal SYSTEM B







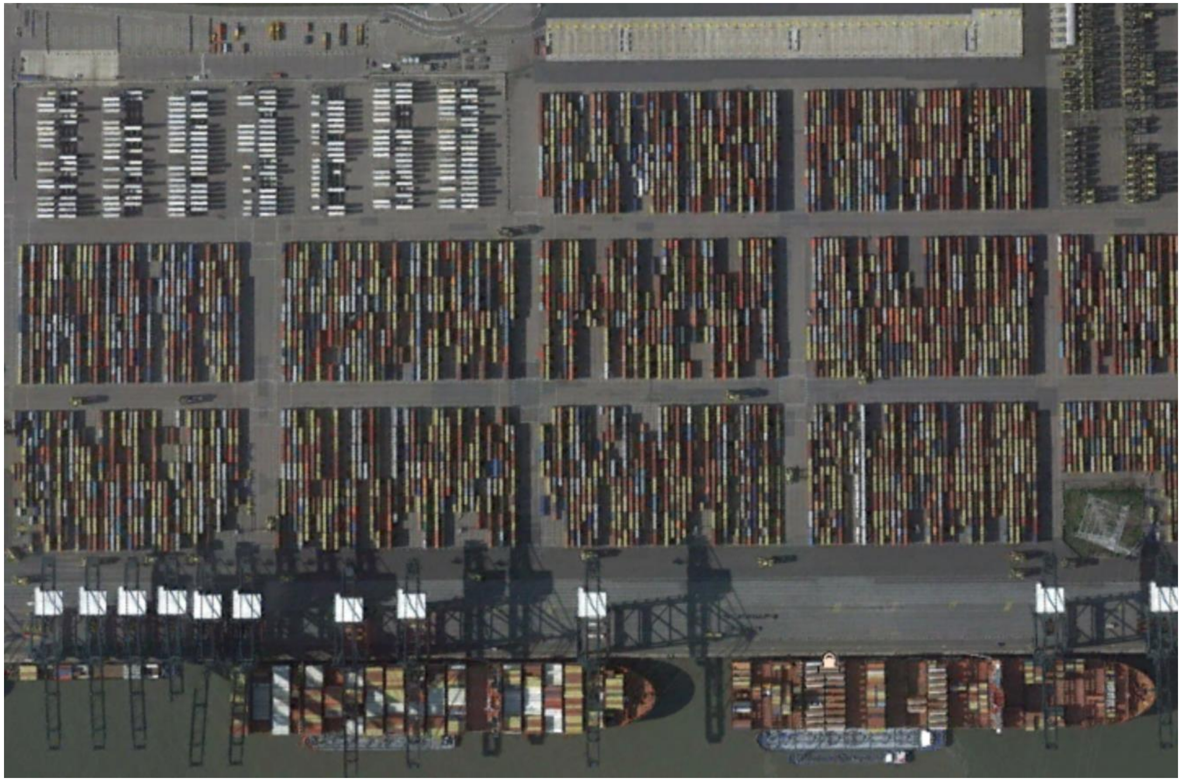
Main Characteristics SYSTEM B

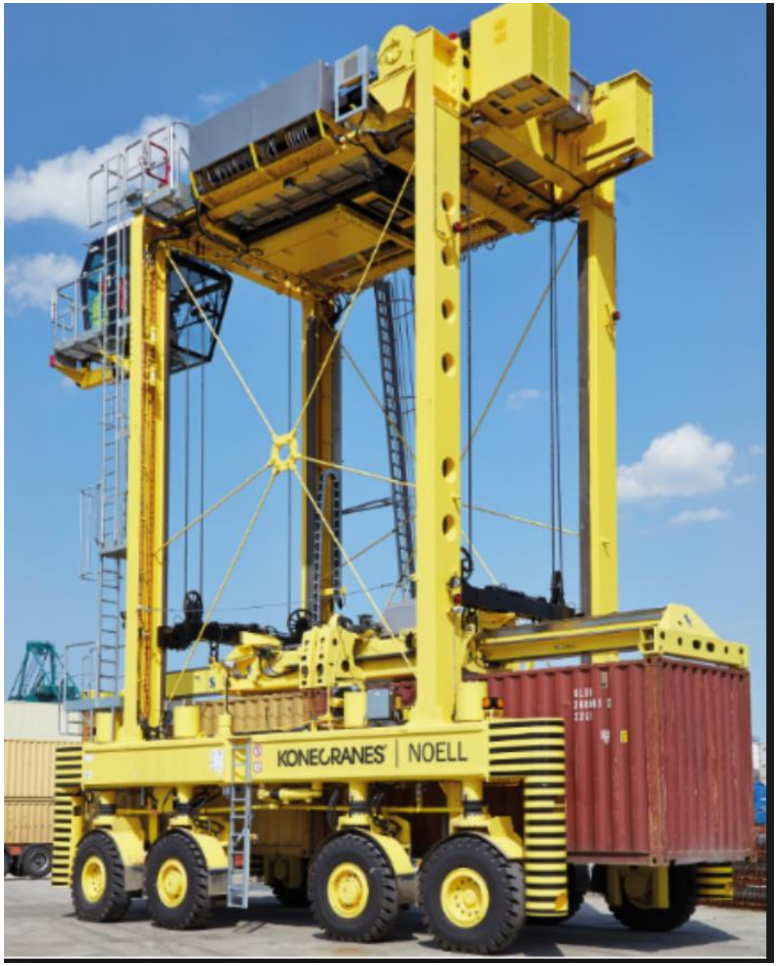
OHBC blocks perpendicular to the quay	
End loaded for quay and rail	
2 lanes in the yard for handling trucks	
2 OHBC's per block, 1 upper and 1 lower, independent crossing	
4-TEU wide , 5 high, 70 container long , block width 30 m	
Total number of OHBC blocks:	62 (=1860 m)
HTS quay:	ALV full electric, 1 over 1
Average in/out handlings waterside:	18 cmph
Average in/out handlings landside:	16 cmph
Average OHBC productivity:	20 cmph
Percentage housekeeping moves:	40%
Average ALV productivity quay	12 cmph (incl. twin-carry)
Rail crane directly served by OHBC	20 cmph

Performance Terminal SYSTEM B

Yard Design B	Dual OHBC/ALV		
Stack	Dual OHBC	18	cmph
HTS Quay	ALV, 1 over 1	12	cmph
HTS Truck	direct by OHBC	16	cmph
Mean OHBC productivity (including housekeeping)		20	cmph
Percentage housekeeping moves		40%	
Block width dimensions		30	m
# blocks		62	
# of OHBC's		124	
Stack capacity		86,800	TEU slots
Stack capacity		3,707,699	TEU /yr
Landside handling capacity		992	cmph
Waterside handling capacity		1,116	cmph
Total OHBC moves per year		5,764,706	p/y
Total handlings per OHBC		46,490	p/y
# of ALV, 1 over 1	Waterside	64	
# of special NGICT railcranes		2	
length of rail		302	m
total length of rail		37.4	km
width yard area		1,860.0	m
Total yard area		48	ha
Throughput yard		90,467	TEU/ha/yr
Service road perimeter fence		8	m
Width quay area		100	m
Total terminal depth		410	m
Total terminal area		80	ha
Throughput per ha		54,688	TEU/ha/yr

Example SYSTEM C





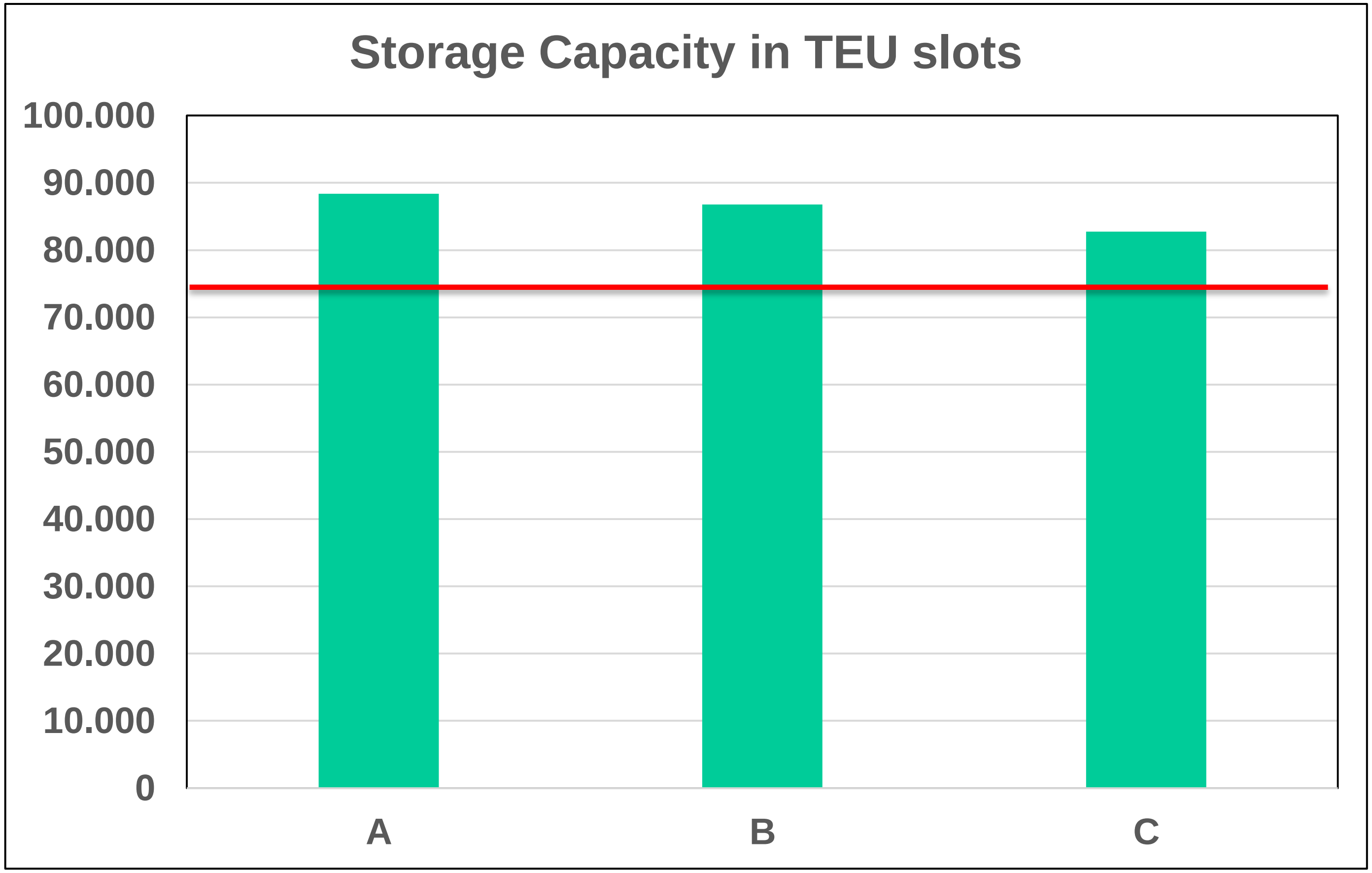
Main Characteristics SYSTEM C

- SC blocks parallel to the quay
- Each block: 38 rows , 3 high, 20 TEU long ,
- Block dimensions: 176 x 145 m , total width 11 x 176 = 1312 m
- Total number of SC blocks: 33
- Average SC productivity waterside: 10 cmph
- Average SC productivity truck: 10 cmph
- Average SC productivity rail: 8 cmph
- Percentage housekeeping moves: 20%

Performance Terminal SYSTEM C

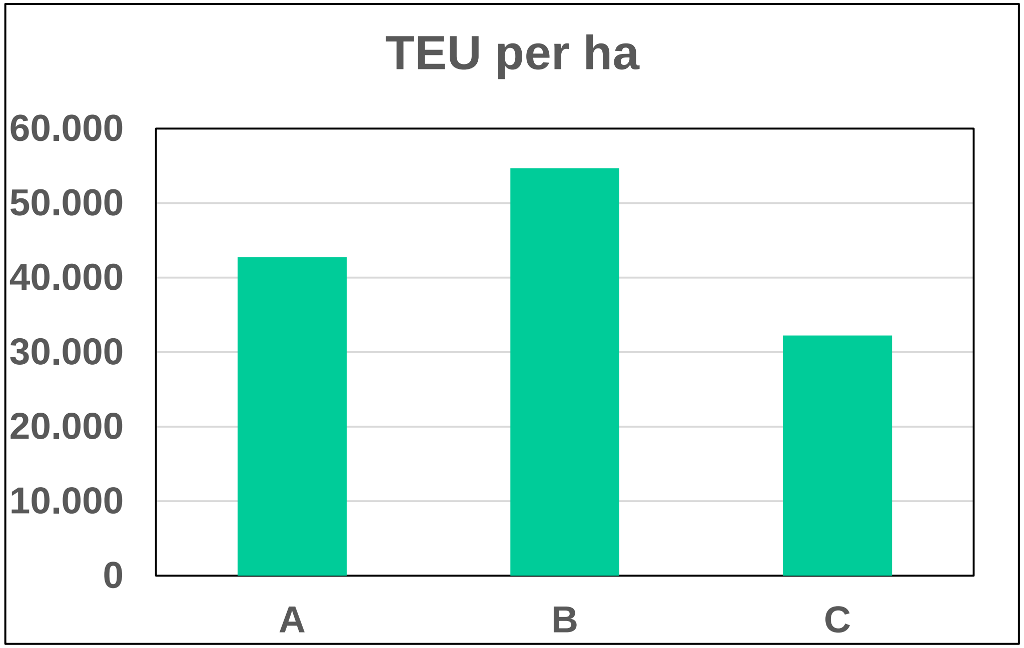
Yard Design C		Full SC operations		
Stack	SC		10	cmph
HTS Quay	SC		10	cmph
HTS Rail	SC		8	cmph
HTS Truck	SC		10	cmph
Percentage housekeeping moves			20%	
Stack capacity			82,764	TEU slots
Stack capacity			3,866,734	TEU/yr
# of SC		Waterside	77	
# of SC		Rail	6	
# of SC		Truck	36	
Subtotal			119	
# of SC		Housekeeping	12	
Total SC			131	
Total yard handlings			4,941,176	p/y
Ttotal handlings per SC			37,785	p/y
# of railcrane			2	
Total width yard			1,936	m
Total yard area			92	ha
Throughput yard			47,675	TEU/ha/yr
Width landside area trucks			60	m
Width quay area			85	m
Total terminal depth			679	m
Total terminal area			136	ha
Throughput per ha			32,216	TEU/ha/yr

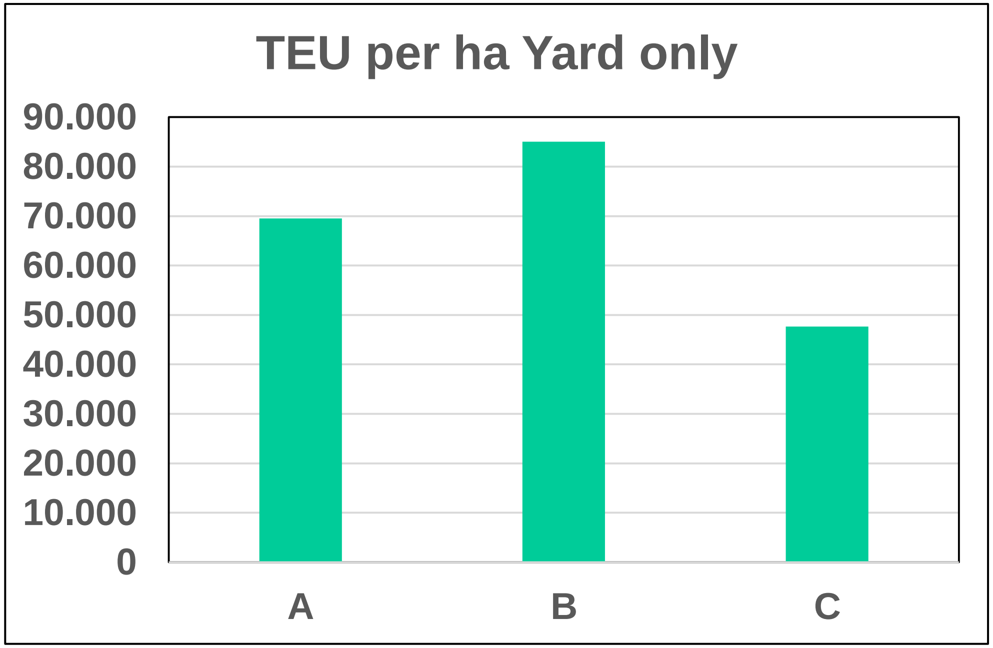
Performance Comparison



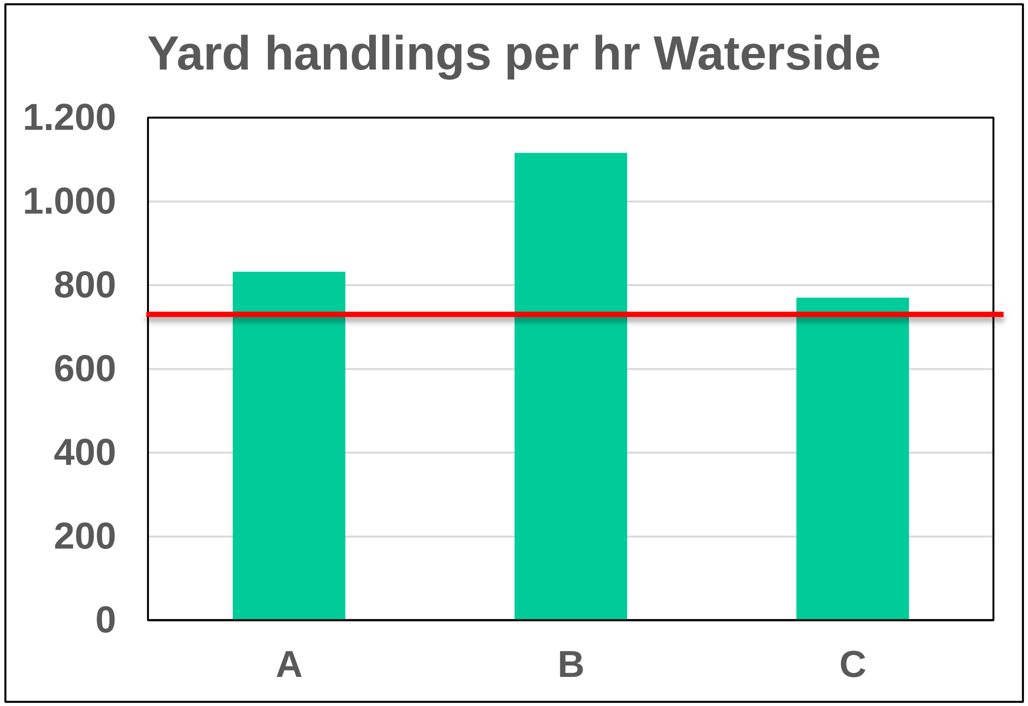
Performance Comparison

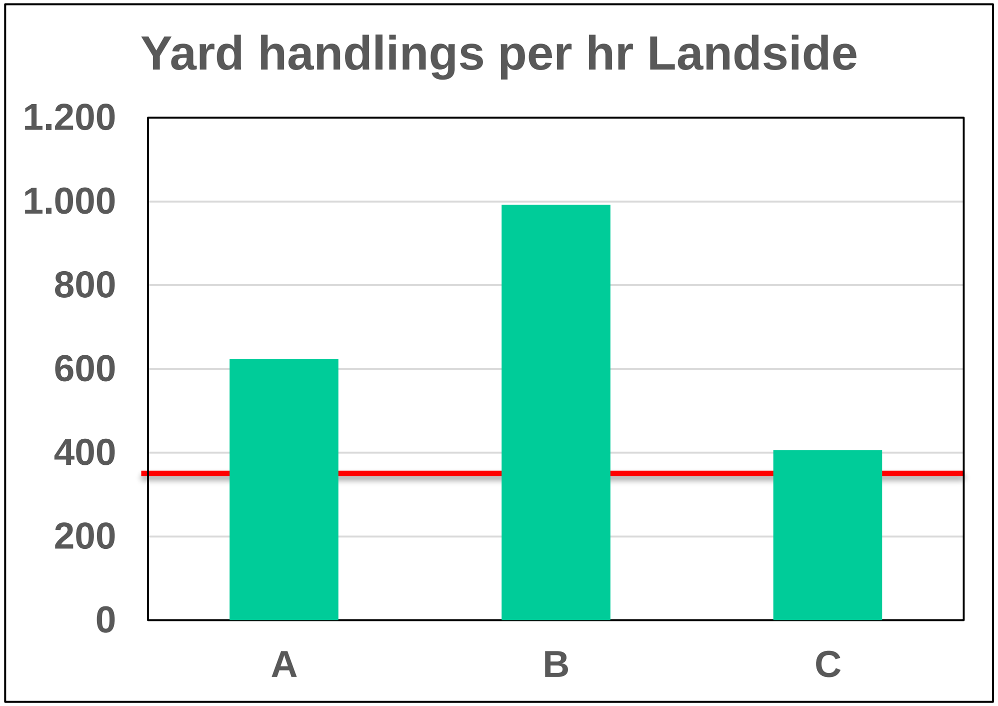
TEU per ha





Peak handling capacity per hour



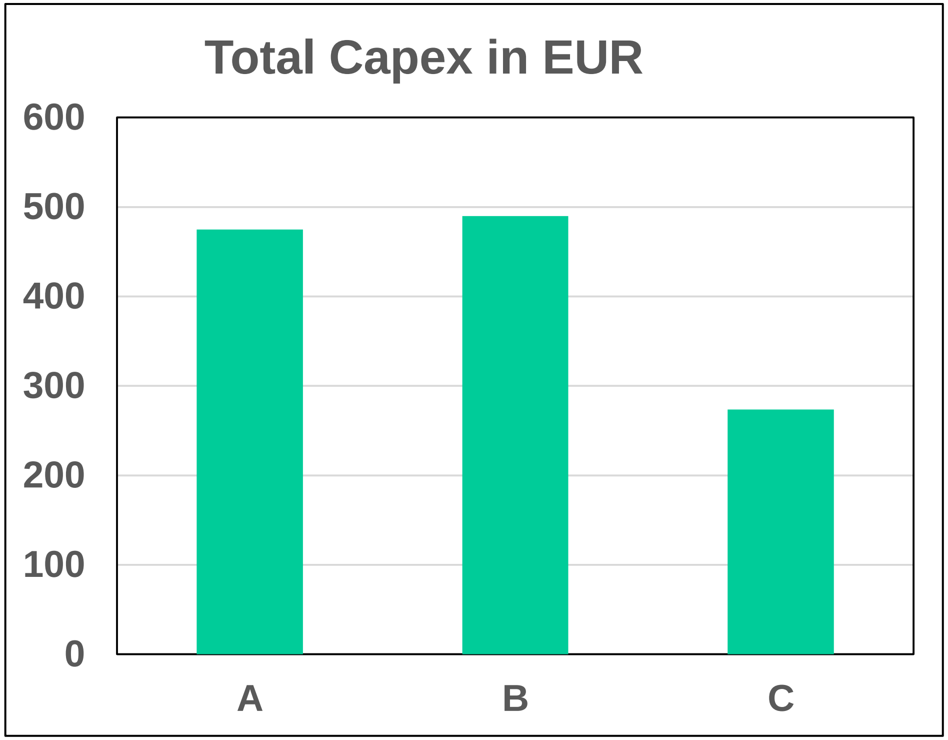


Differential CAPEX Comparison

Prices		Numbers		
	EURO	A	B	C
ASC 10-wide	€ 2,700,000	104		
AGVL Elec	€ 600,000	86		
AutoTug Elec	€ 300,000	8		
ALV, 1 over 1 Elec	€ 1,000,000		64	
SC 1 over 3	€ 1,000,000			131
Railcrane	€ 3,500,000	2		2
Railcrane NGICT	€ 1,800,000		2	
OHBC, 30 m	€ 1,400,000		124	
KM Rail ASC	€ 1,000,000	31		
KM Rail OHBC	€ 4,500,000		37	
Civil Infra per ha	€ 1,000,000	102	80	136

Differential CAPEX Comparison

	CAPEX	in M EURO	
	A	B	C
	281	0	0
	51	0	0
	3	0	0
	0	64	0
	0	0	131
	7	0	7
	0	4	0
	0	174	0
	31	0	0
	0	169	0
	102	80	136
Total	475	490	274



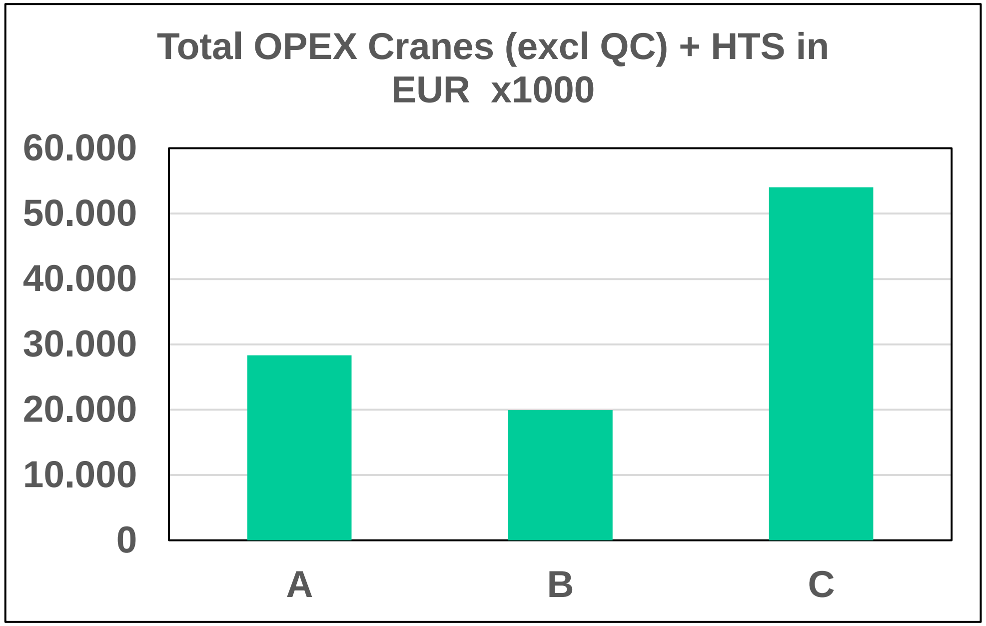
Differential OPEX Comparison

OPEX per move & per hour				Number of container handlings		
	per container	cmph	per hr	A	B	C
ASC	€ 1.33	18	€ 24.0	8,235,294		
AGVL	€ 2.67	9	€ 24.0	2,058,824		
AutoTug	€ 3.00	6	€ 18.0	231,618		
ALV with OHBC	€ 2.50	12	€ 30.0		2,058,824	
SC	€ 8.00	10	€ 80.0			4,941,176
RC	€ 4.00	20	€ 80.0	231,618		231,618
RC NGICT	€ 2.00	20	€ 40.0		231,618	
OHBC	€ 1.10	20	€ 22.0		5,764,706	
Landlease	€ 100,000.00	ha		102	80	136

Price per handling: labor + energy + tyres + M&R

Differential OPEX Comparison

		OPEX per year in EUR x 1000		
		A	B	C
ASC		10,980	0	0
AGVL		5,490	0	0
AutoTug		695	0	0
ALV with OHBC		0	5,147	0
SC		0	0	39,529
RC		926	0	926
RC NGICT		0	463	0
OHBC		0	6,341	0
Landlease		10,240	8,000	13,580
	Total	28,332	19,951	54,036



KPI's Terminal 1

25%	Transshipment				
	KPI per year	ASC	OHBC	SC	Required
	Deepsea volume	3,500,000	3,500,000	3,500,000	3,500,000
	TS volume	875,000	875,000	875,000	875,000
	Total volume	4,375,000	4,375,000	4,375,000	4,375,000
	TEU slots	88,400	86,800	82,764	74,914
	TEU/ha	42,725	54,688	32,216	
	TEU/ha yard only	69,538	85,069	47,675	
	TEU/ m quay	2,188	2,188	2,188	
	TEU/ QC	198,864	198,864	198,864	
	TEU/ yardcrane	134,615	79,032	64,234	

Findings and Remarks

- All systems can deliver the required performance if no limitation in terminal depth
- Lowest Capex: Full SC
- Lowest Opex: OHBC/ALV
- OHBC/ALV gives the highest TEU/ha ratio (best land utilization)
  22 ha less with ASC and 56 ha less with SC
  This land can be used for additional logistic area
- Simulation is required to validate the result

Findings and Remarks

- The OHBC system is capable to deliver a much higher performance at both water and landside compared with the other systems against lower operational cost.

- To utilize this additional capacity other factors play a role:

    1. Quay utilization factor (TBA assumption max 60%)
    2. Horizontal transport system performance
    3. Berth productivity per vessel (more QC's per vessel)

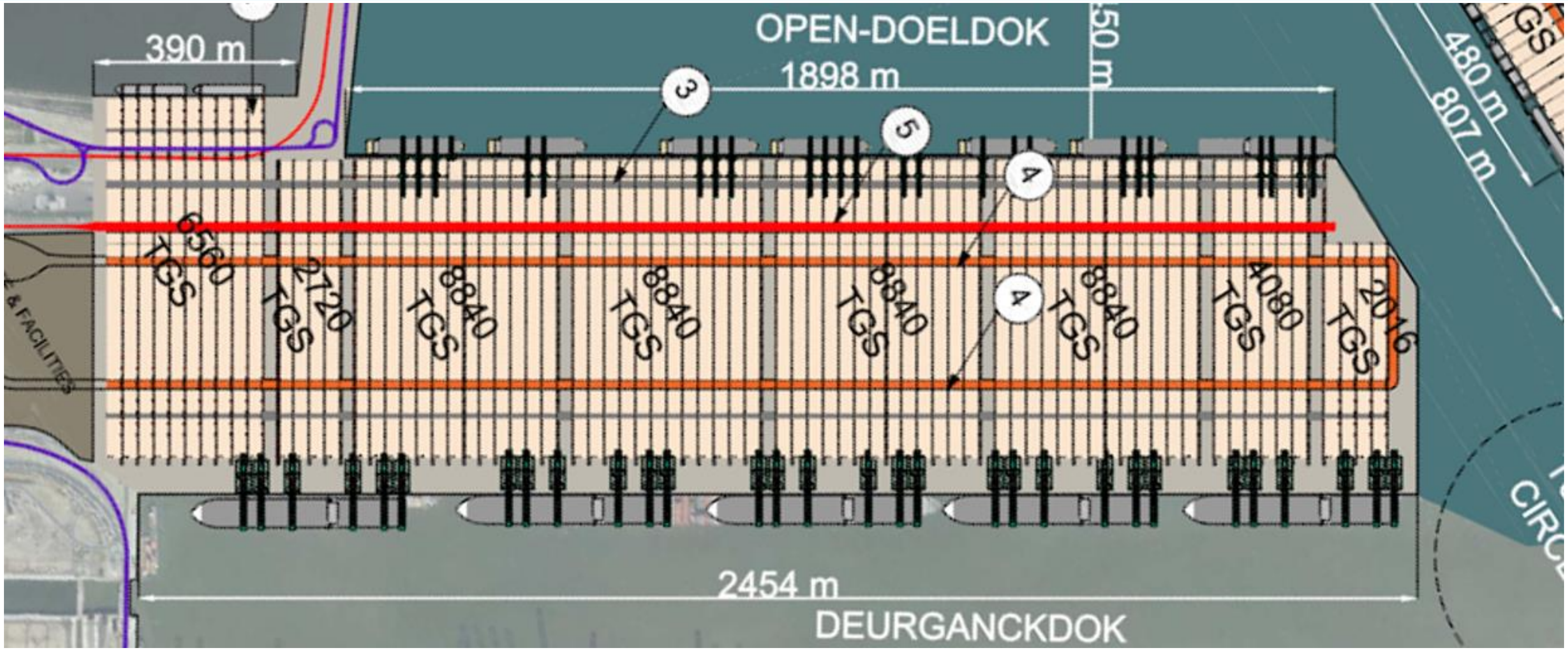
- We didn't calculate any additional capacity from the higher performance of the yard system and assumed the quay capacity to be the limitation in line with the outcome of the TBA report.

- Further optimization could result in a higher throughput on the quay exceeding the 2,100 TEU / m quay

Conclusions

- The OHBC system has the best performance for Terminal 1.
- OPEX cost could decrease significantly when automation will be introduced.

Terminal 2 yard systems compared



- **System A (Automated)** **NOT POSSIBLE**
  ASC system cannot serve 2 quays within the available 650 m terminal depth .

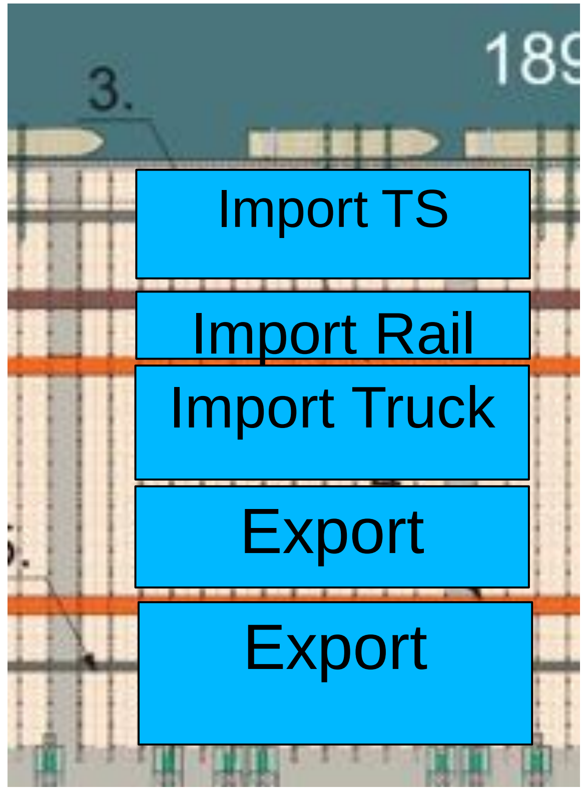
- **System B (Automated)**
  OHBC system with independent upper/lower crane and ALV for Waterside operation. Truck handled directly. Rail handled by integrated OHBC/Railcrane. Wide Span cranes serving the barges and feeders

- **System C (Manual)** **NOT POSSIBLE**
  SC system cannot serve 2 quays within the available 650 m terminal depth .

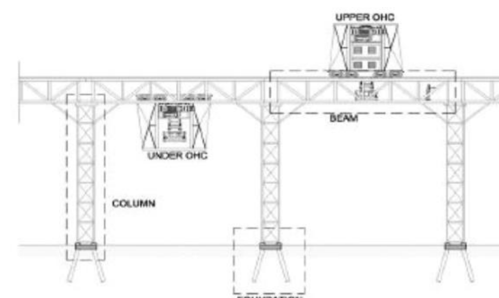
Detailed Assumptions Terminal 2

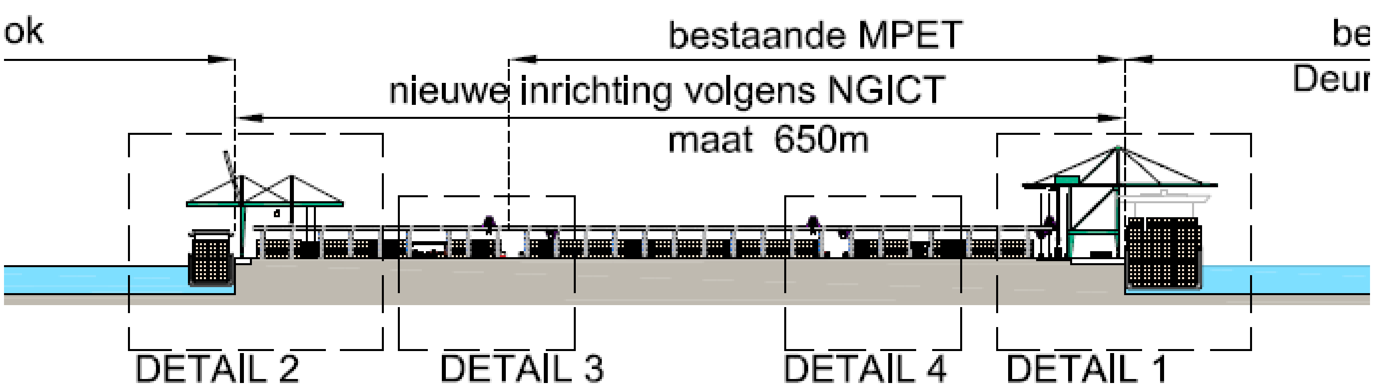
General assumptions			Terminal 2				
					productivity		
QC					35	cmph	
Railcrane					25	cmph	
Deepsea quay		2450	m	19			
Barge/Feeder quay		2300	m	14			
# deepsea berths		6					
# QC		29			1015	cmph	Waterside peak
# BFC		24			840	cmph	Waterside peak
total # of QC		53			1855	cmph	Total
# RC		2			50	cmph	Rail peak
TEU-factor		1.7					
Throughput per berth		deepsea	1,000,000	TEU	588,235	containers	
Total throughput		deepsea	6,000,000	TEU	3,529,412	containers	
Transshipment		60%	3,600,000	TEU	2,117,647	containers	
Bargevolume		25%	600,000	TEU	352,941	containers	
Railvolume		15%	360,000	TEU	211,765	containers	
Truckvolume		60%	1,440,000	TEU	847,059	containers	
Total volume DS + TS			9,600,000	TEU	5,647,059	containers	
Total volume quay			10,200,000	TEU	6,000,000	containers	
Gate opening hours p/d			14	hr	weekdays	260	days p/y
Peakfactor Gate		1.40					
Peak hour trucks					326	cmph	
Mean Dwelltime		5	days				
Stacking height yard		5	OHBC				
Maximum density		80%					
Peakfactor yard		1.25					
TEU visits per slot		46.72	yard				
Total required TEU slots		128,425	TEU				

Example Terminal System B

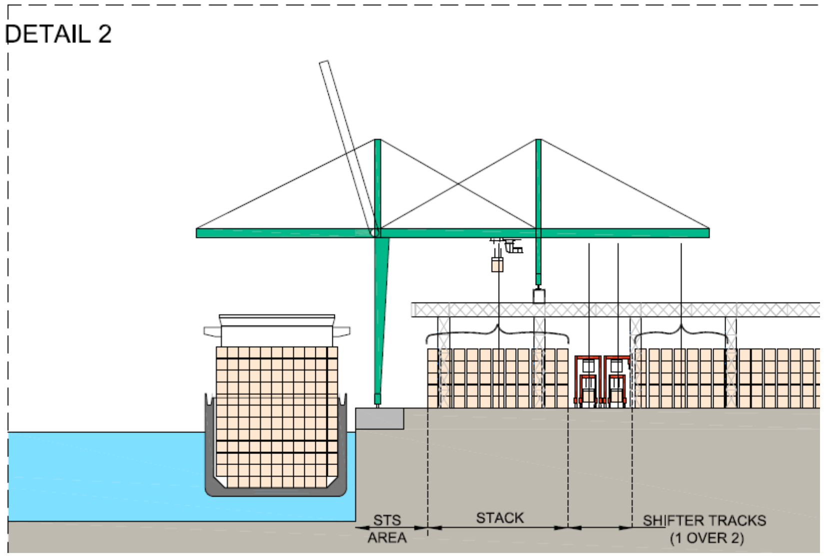


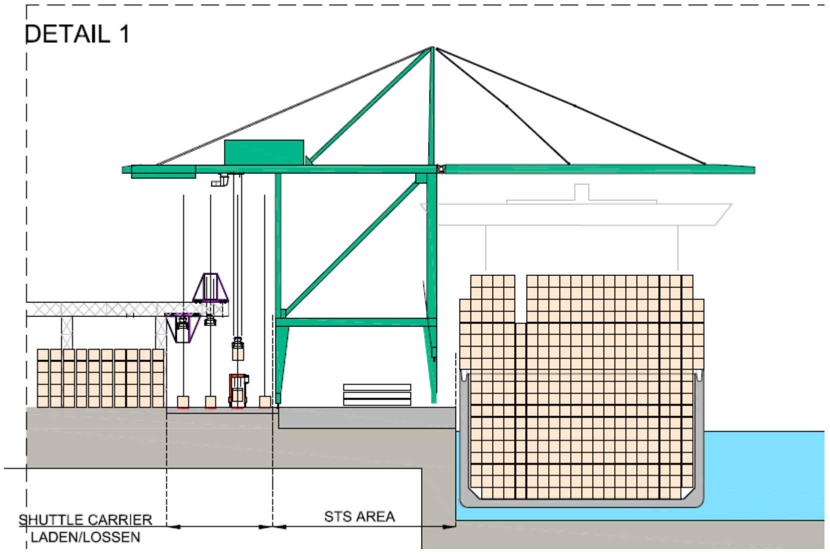
The support structure consists out of modular steel columns and girders which make phased extension of terminals possible. Conservation up to 40 years without high maintenance costs is possible.





Example Terminal SYSTEM B





Main Characteristics SYSTEM B

- OHBC blocks perpendicular to the quay
- End loaded for quay and rail
- 2 lanes in the yard for handling trucks
- 2 OHBC's per block, 1 upper and 1 lower, independent crossing
- 4-TEU wide , 5 high, container long , block width 30 m
- Total number of OHBC blocks: 78 (= 2340 m)
- HTS quay: ALV full electric, 1 over 1
- Average in/out handlings waterside: 20 cmph
- Average in/out handlings landside: 18 cmph
- Average OHBC productivity: 22 cmph
- Percentage housekeeping moves: 40%
- Average ALV productivity quay 12 cmph (incl. twin-carry)
- Rail crane directly served by OHBC 20 cmph

Performance Terminal 2 NGICT

Yard Design		Dual OHBC/ALV				
Stack	Dual OHBC				20	cmph
HTS Quay	ALV, 1 over 1				12	cmph
HTS Truck	direct by OHBC				18	cmph
Mean OHBC productivity (including housekeeping)					22	cmph
Percentage housekeeping moves					40%	
Block width dimensions					30	m
# blocks					78	
# of OHBC's					156	
Stack capacity					140,400	TEU slots
Stack capacity					6,559,488	TEU /yr
Landside handling capacity					1,404	cmph
Waterside handling capacity					1,560	cmph
Total handling capacity					2,964	cmph
Total OHBC moves per year					9,882,353	p/y
Total handlings per OHBC					63,348	p/y
# of ALV, 1 over 1		Waterside			85	
# of special NGICT railcranes					2	
length of rail					404	m
total length of rail					62.9	km
width yard area					2,340.0	m
Total yard area					85	ha
Throughput yard					113,487	TEU/ha/yr
Width quay area					100	m
Total terminal depth					504	m
Total terminal area					123	ha
Throughput per ha					77,823	TEU/ha/yr

Solid Port SOLUTIONS

CAPEX Terminal 2 NGICT

NGICT

Prices		Numbers		CAPEX in M euro
	euro	B		B
ALV, 1 over 1 Elec	€ 1,000,000	85		85
Railcrane NGICT	€ 1,800,000	2		4
OHBC, 30 m	€ 1,400,000	156		218
KM Rail OHBC	€ 4,500,000	63		283
Civil Infra per ha	€ 1,000,000	123		123
			Total	713

OPEX Terminal 2 NGICT

OPEX per move & per hour					Numbers
		per container	cmph	per hr	B
ALV with OHBC		€ 2.33	12	€ 28.0	3,529,412
RC NGICT		€ 2.00	20	€ 40.0	211,765
OHBC		€ 0.91	22	€ 20.0	9,882,353
Landlease		€ 100,000.00	ha		123
Price per handling: labor + energy + tyres + M&R					

Total OPEX in Euro x 1000		
		B
ALV with OHBC		8,235
RC NGICT		424
OHBC		8,984
Landlease		12,336
	Total	29,979

KPI's Terminal 2

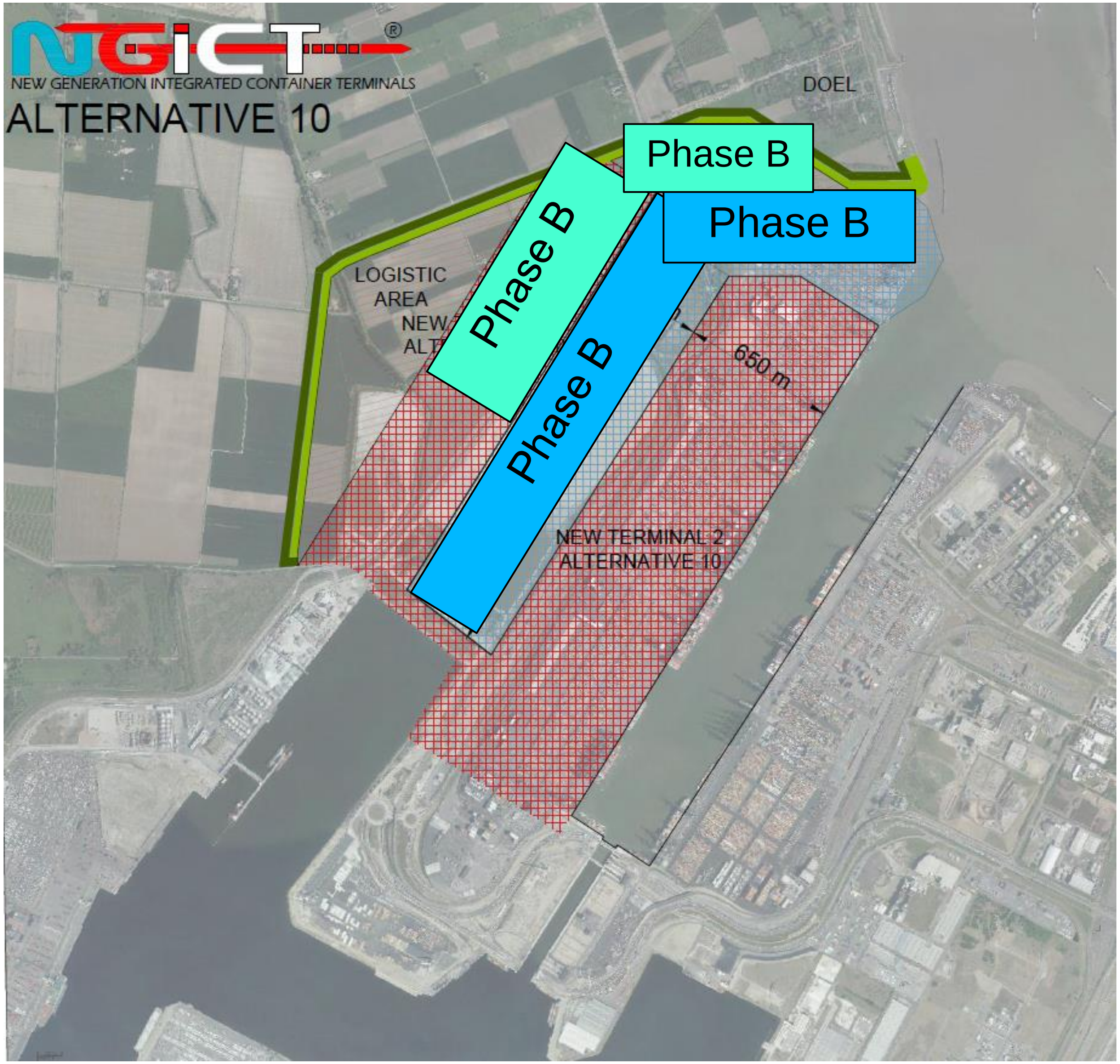
60%	Transshipment		
	KPI per year	OHBC	Required
	Deepsea volume	6,000,000	6,000,000
	TS volume	3,600,000	3,600,000
	Total volume	9,600,000	9,600,000
	TEU slots	140,400	128,425
	TEU/ha	77,823	
	TEU/ha yard only	113,487	
	TEU/ m quay	2,021	
	TEU/ QC	181,132	
	TEU/ yardcrane	107,692	

Construction Phasing

Phase A (2019 – 2020)

Construction Quaywall
Open Doeldok West

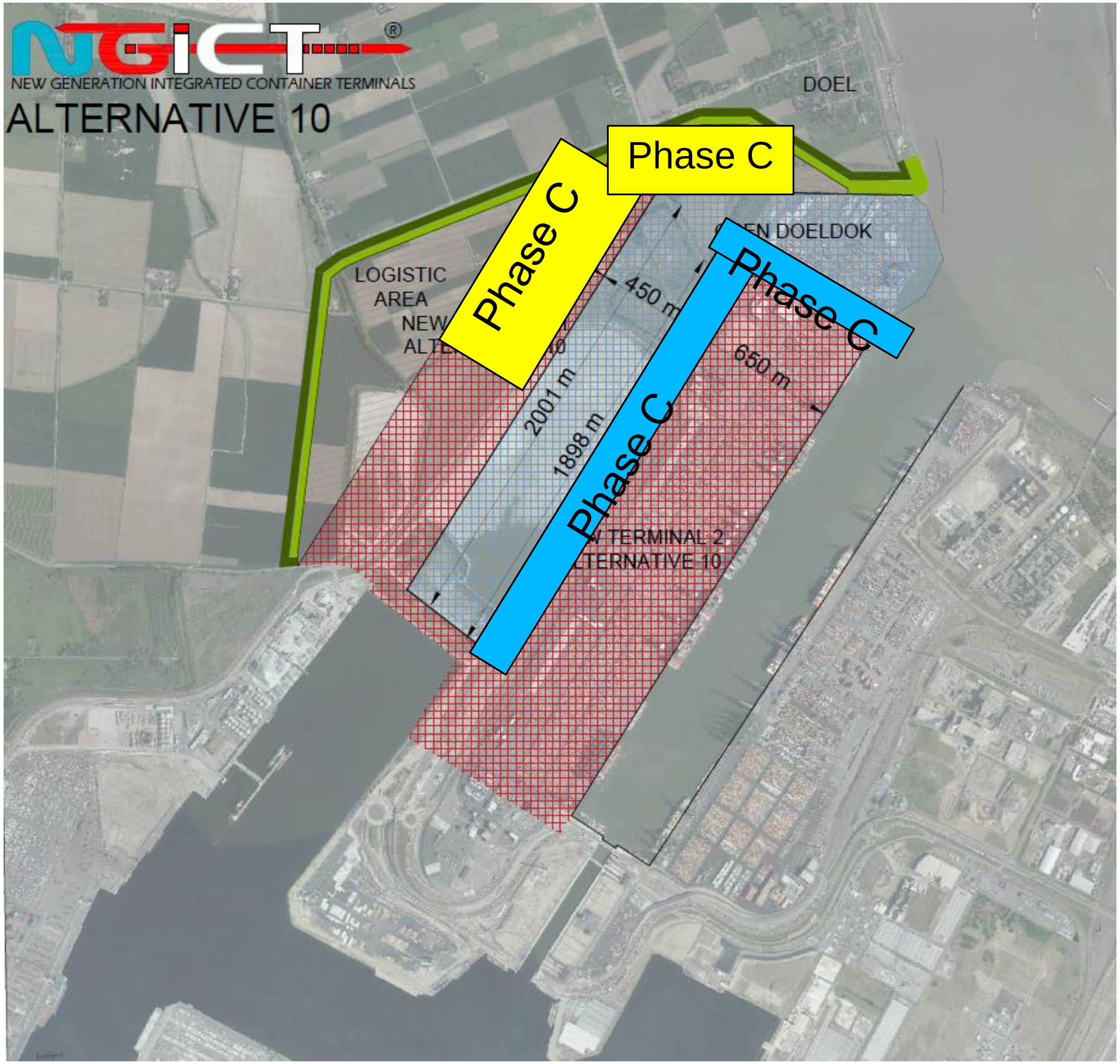
Construction Phasing



Phase B (2021 – 2022)

-Dredging Open Doeldok
-Construction T 1 phase 1

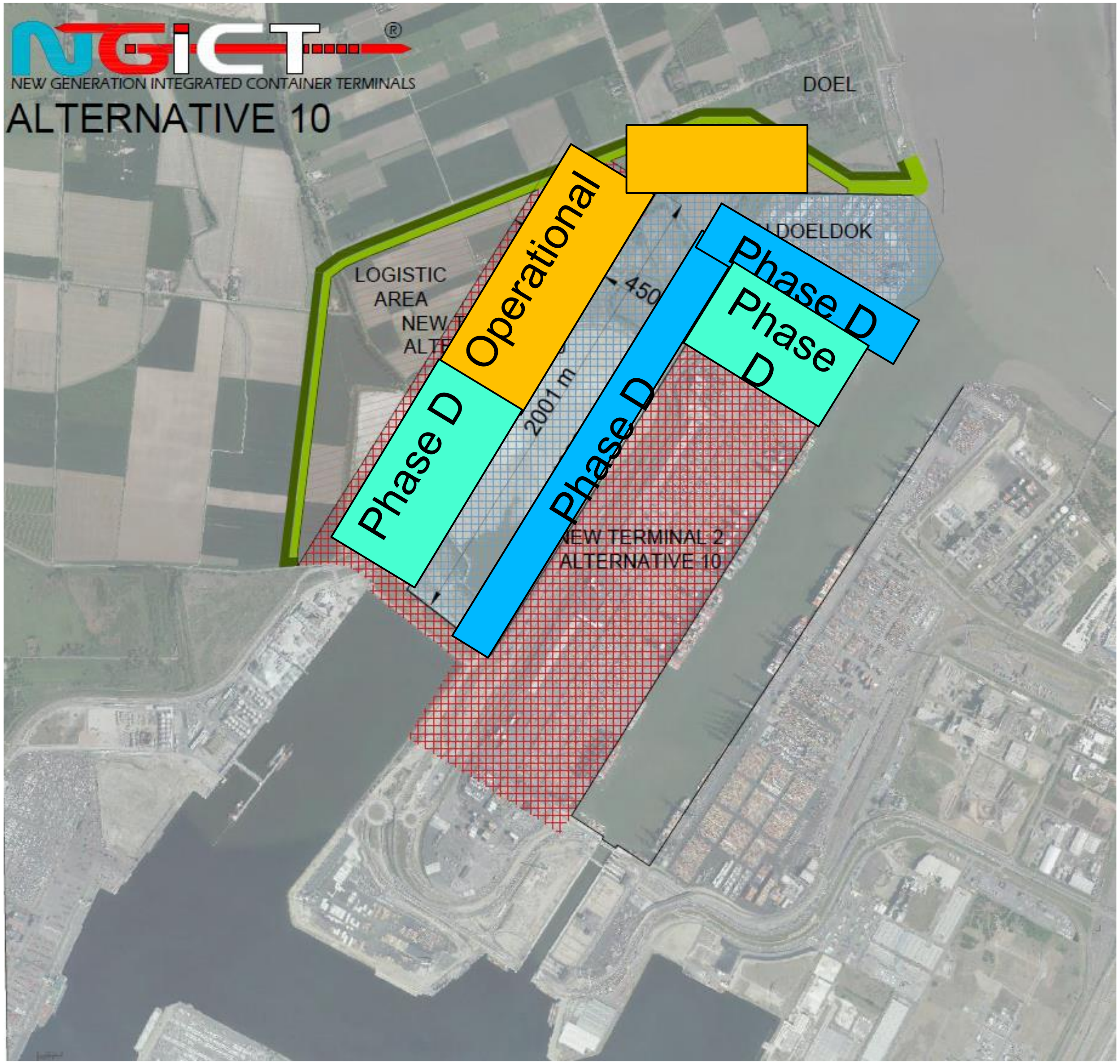
Construction Phasing



Phase C 2023

-Opening T 1 phase 1
-Construction Quaywall
Open Doeldok Oost / Noord

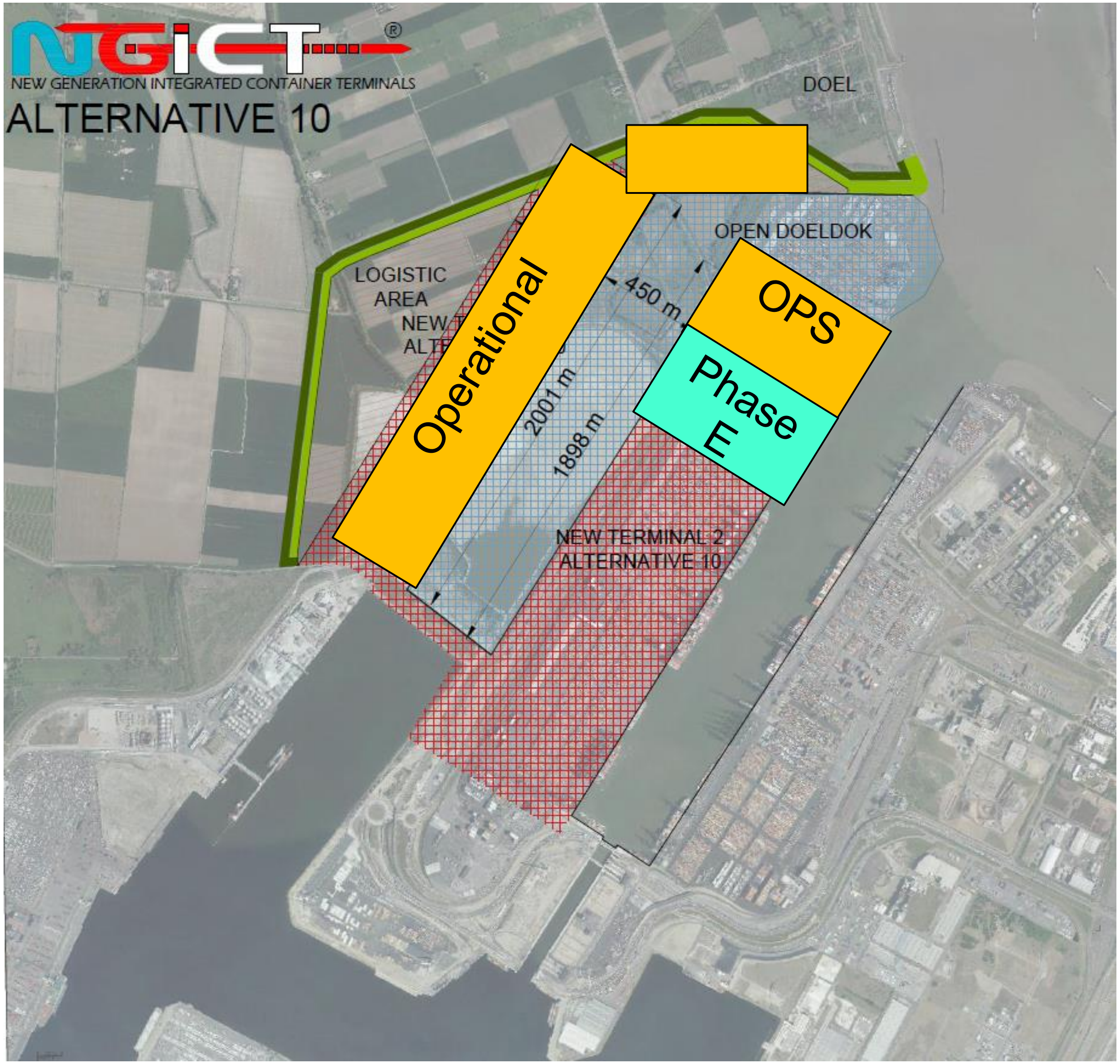
Construction Phasing



Phase D 2024

-(Temporary) Volume transfer MPET to T 1
-Construction T 1 phase 2
-Finalizing dredging
-Start Modification T2 berth 1

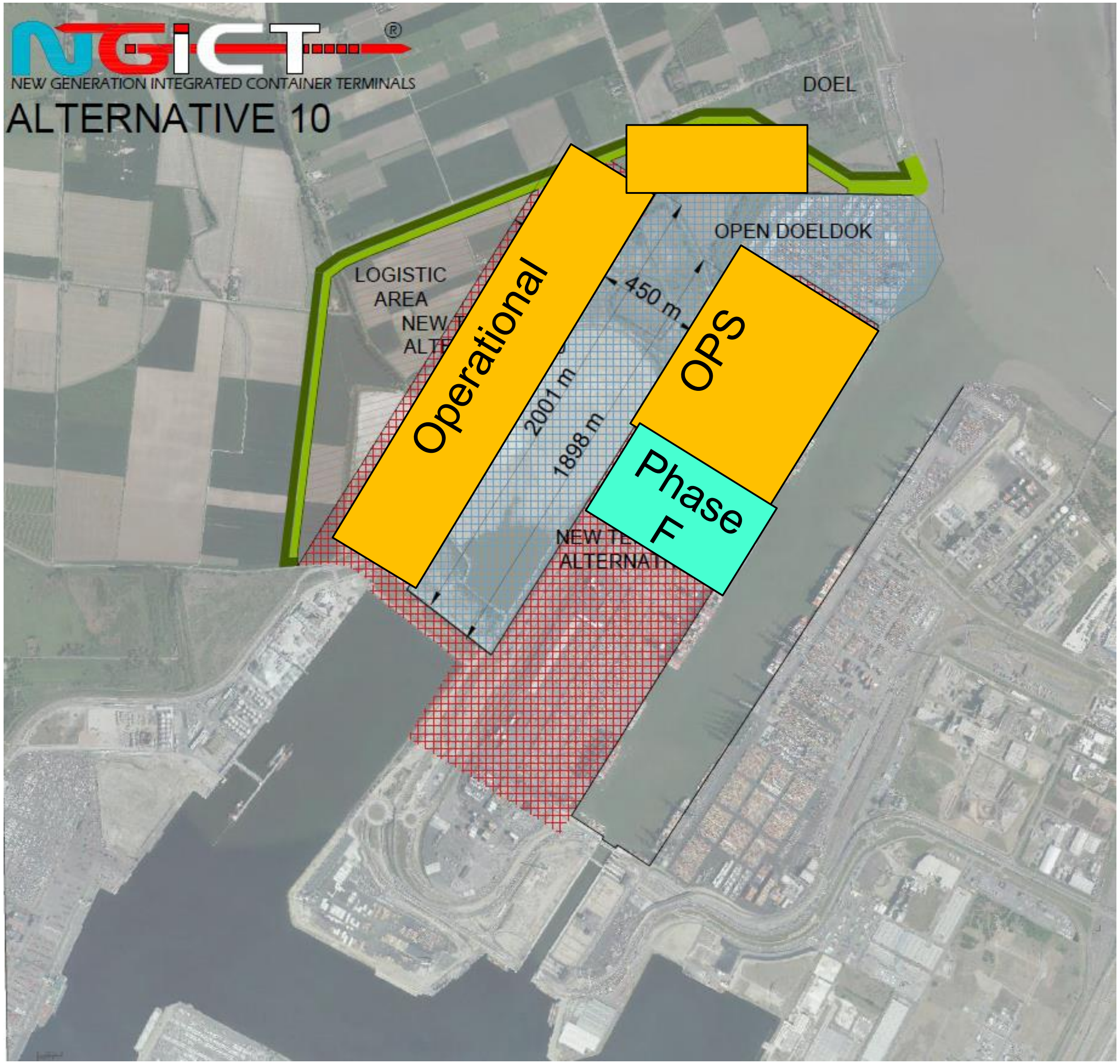
Construction Phasing



Phase E 2025

-Modification T2 berth 2

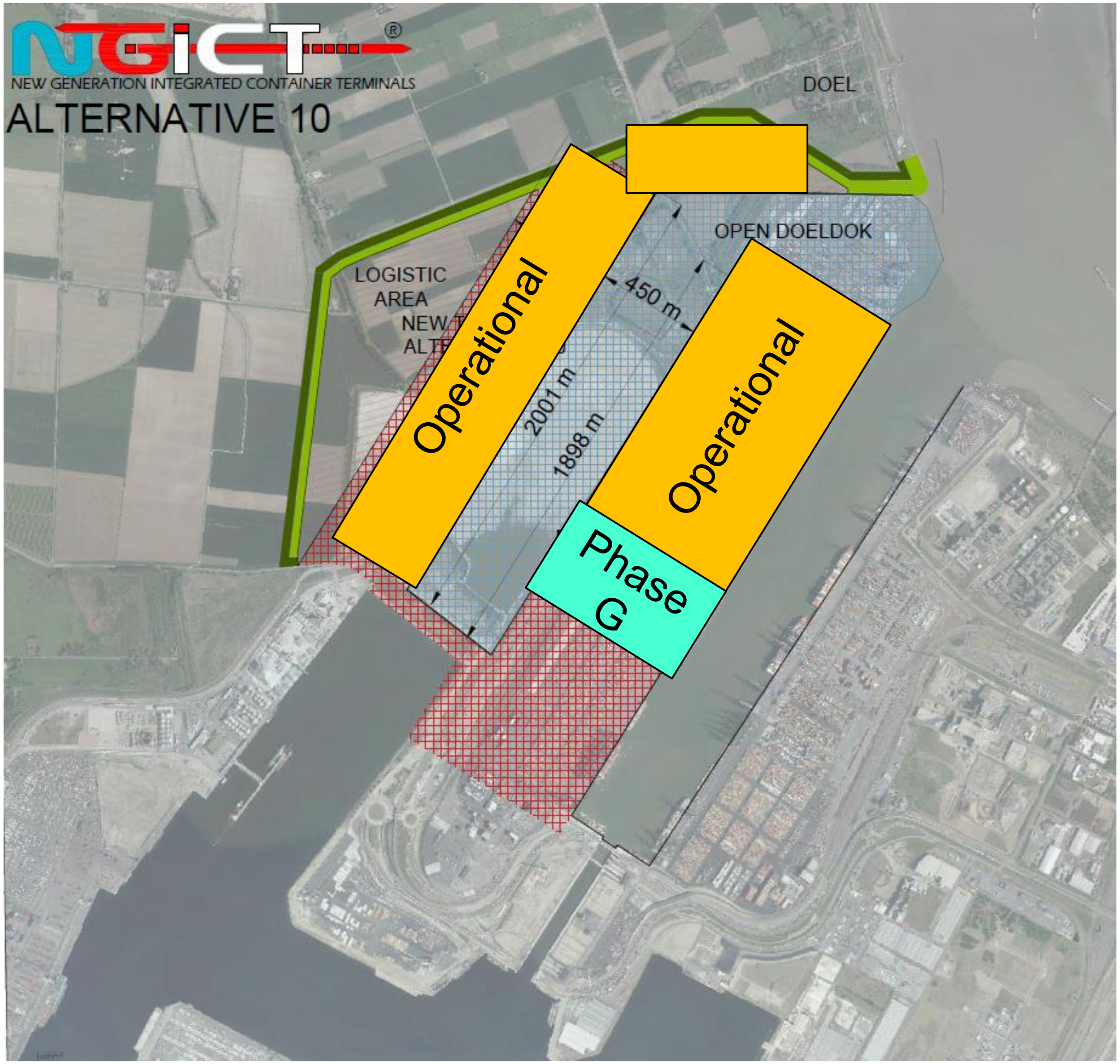
Construction Phasing



Phase F 2026

-Modification T2 berth 3

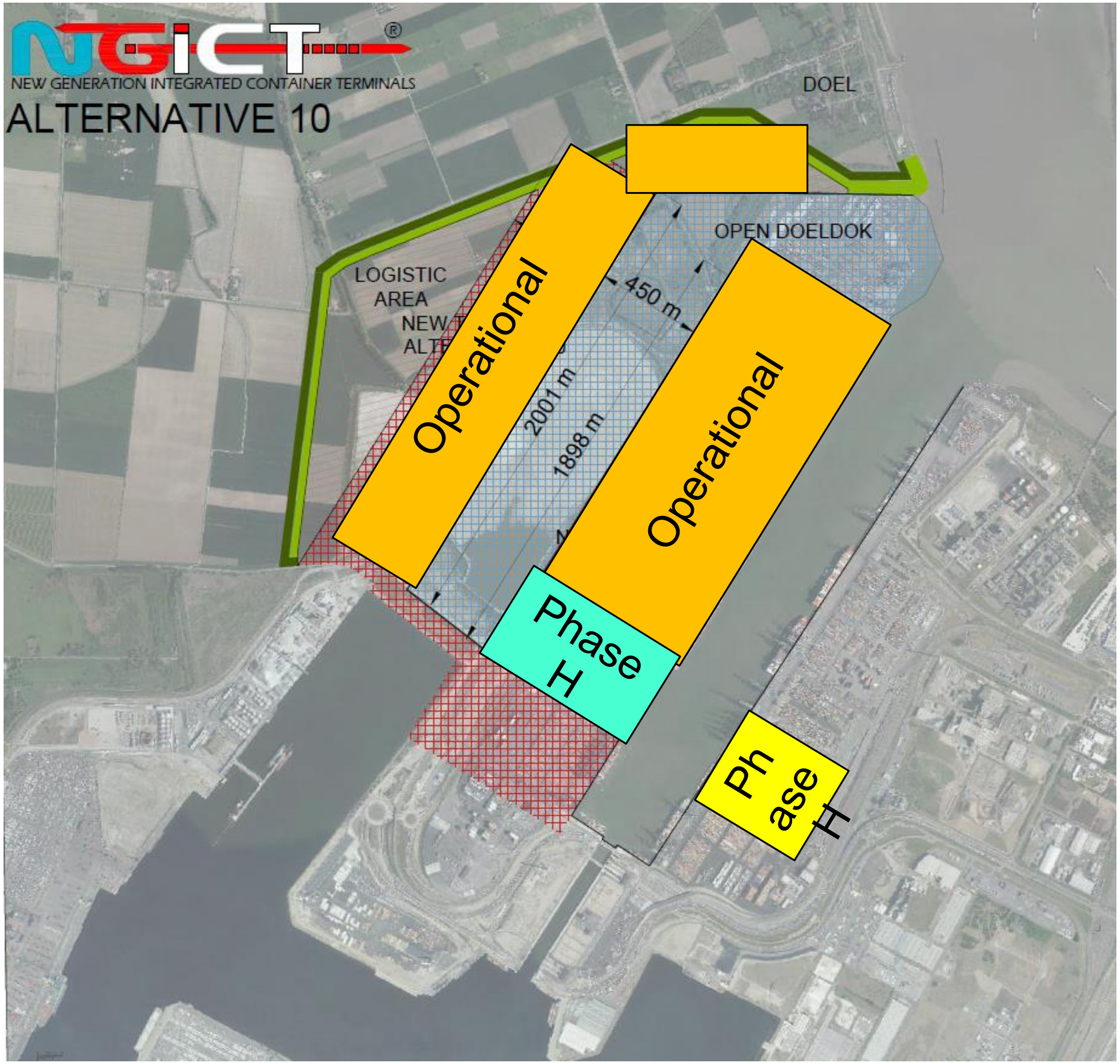
Construction Phasing



Phase G 2027

- Modification T2 berth 4

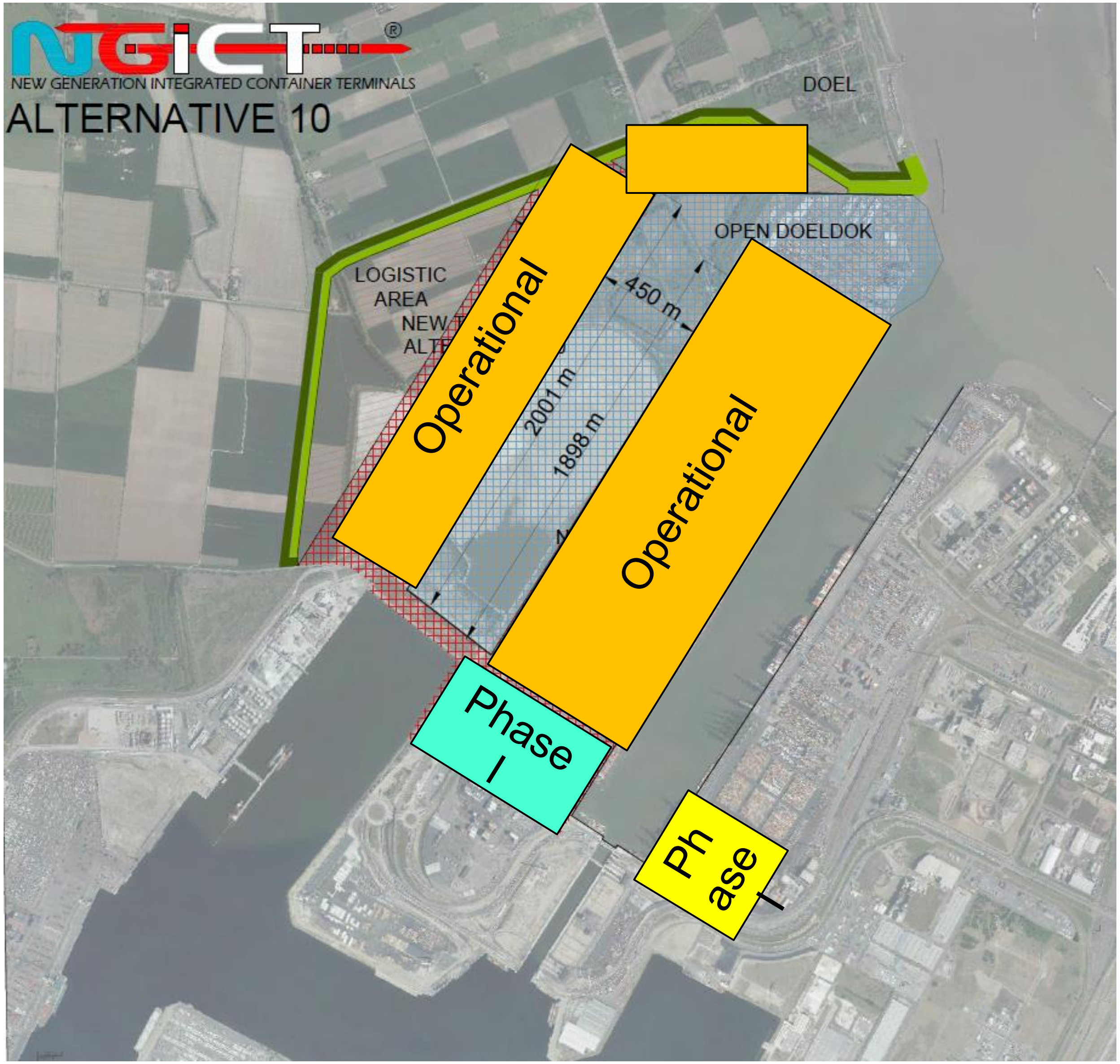
Construction Phasing



Phase H 2028

- Modification T2 berth 5
- Transfer volume MPET
- Deurganckdok oost phase 1

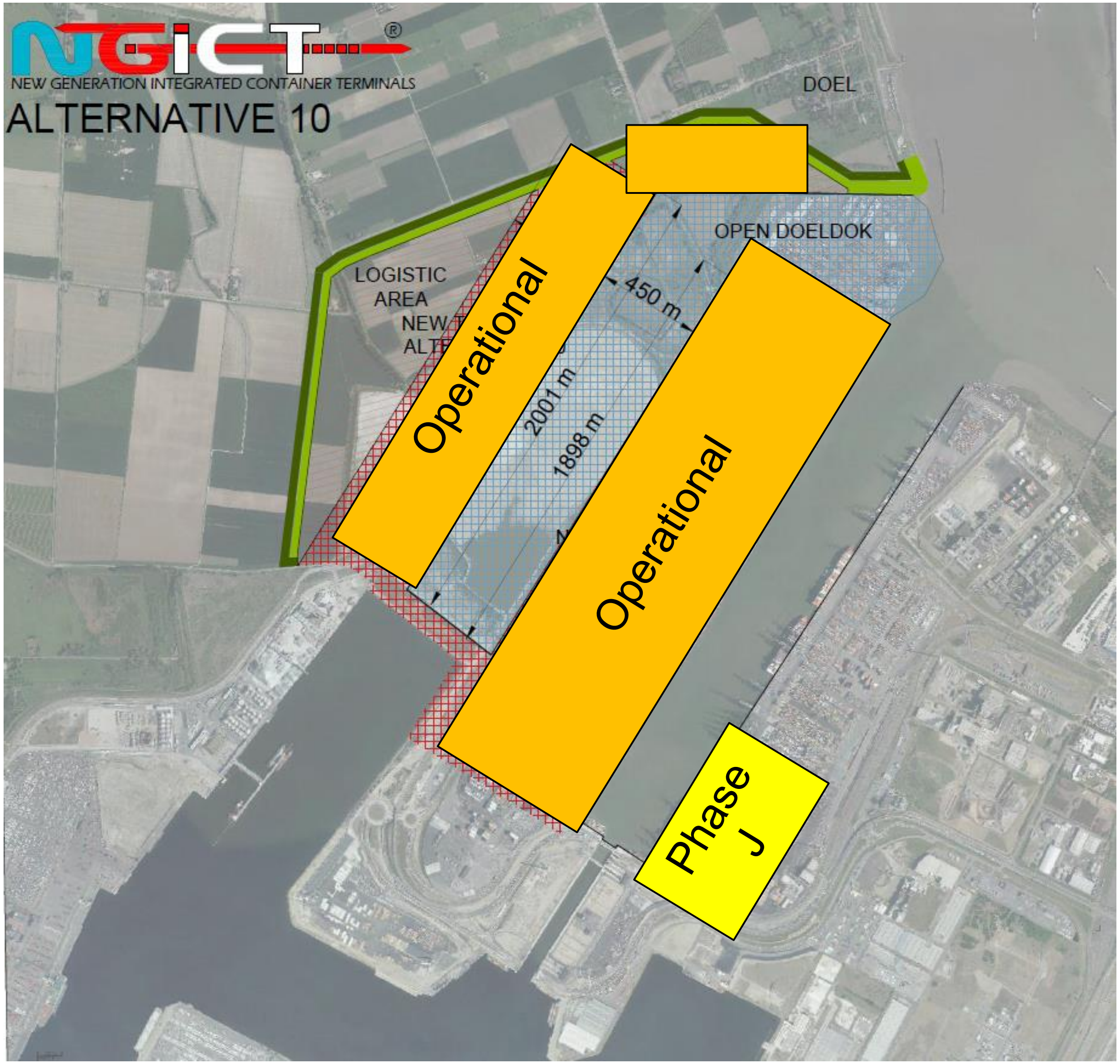
Construction Phasing



Phase I 2029

- Modification T2 berth 6
- Transfer volume MPET
- Deurganckdok oost phase 2

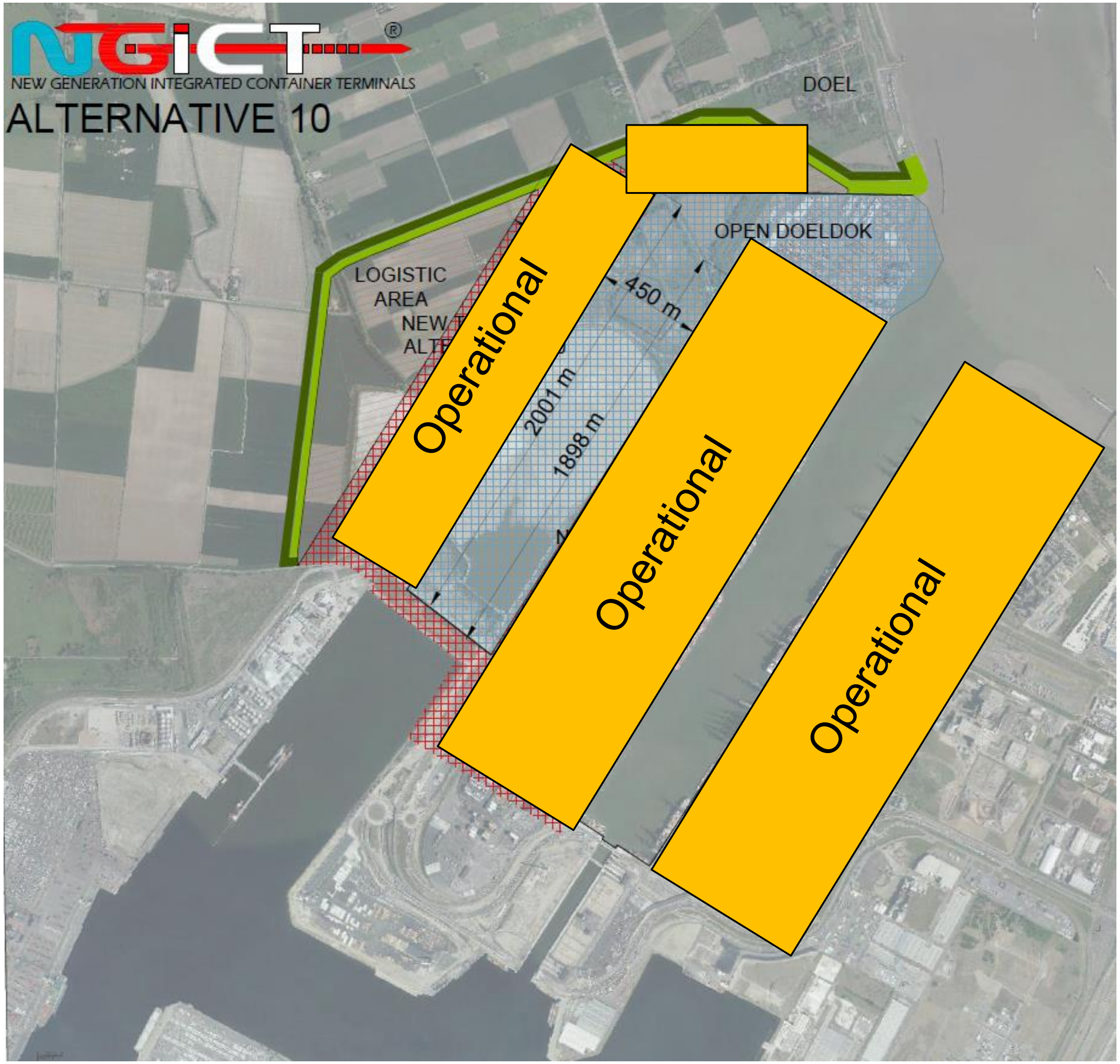
Construction Phasing



Phase J 2030

- Construction expansion AWG

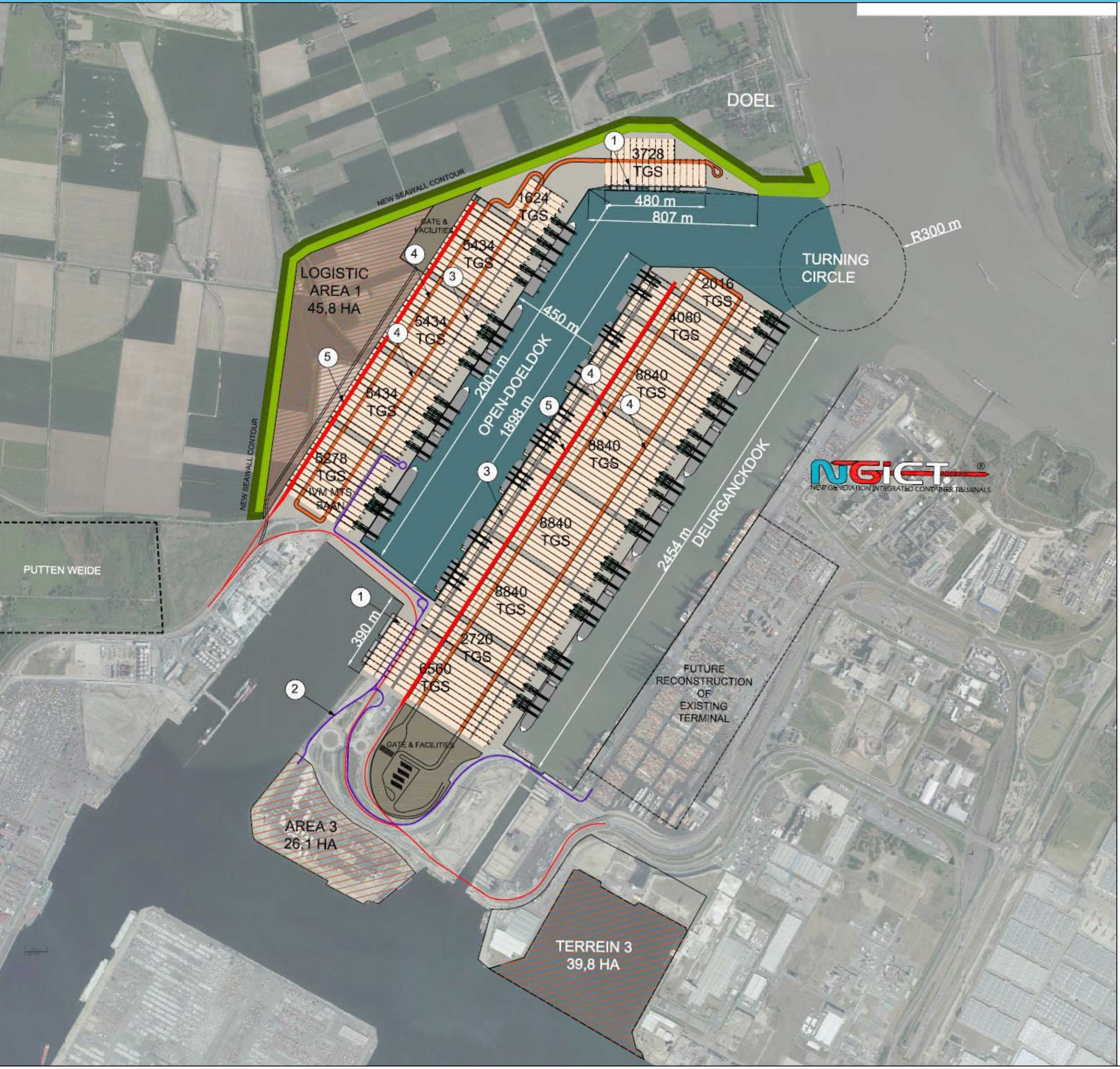
Construction Phasing



Phase K 2031

- Completion
- Total capacity 18 M TEU

End phase



NEW GENERATION INTEGRATED CONTAINER TERMINALS

1. Barge terminal
2. CER
3. 2x (1 over 2) shifter tracks
4. Truck lanes laden & lossen
5. 4 spoorbanen laden & lossen