CONCLUSIONS OF MULTIPLE COMPARISON BETWEEN NGICT - OHBC AND ARMG (ASC) AND STRADDLE CARRIER IN STACK OPERATIONS ON DEEPSEA CONTAINER TERMINALS

CONFIDENTIAL

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Explication abbreviations

ASC	= Automated Stacking Crane (= ARMG)
ARMG	= Automated Rail Mounted Gantry crane (= ARMG)
STS	= Ship to Shore crane (= Quay Crane)
SHC	= Shuttle Carrier (automated) (= ALV Automated Lifting Vehicle)
NGICT	= New Generation Integrated Container Terminal
OHBC	= Overhead Bridge Crane
cmph	= Container move per hour
SC	= Straddle Carrier
RC	= Rail Crane
ORC	= Overhead Rail Crane

Enclosures

SHORT SUMMARY OF CHAPTER 1, 2 AND 3

This study shows the results of a comparison between three systems stacking operations on deep sea container terminals regarding the investment costs, the operational costs and the productivity performance.
These systems are consecutively:
- a full straddle carrier operations;
- an ARMG configuration and;
- the new innovative NGICT-OHBC system.

The comparison is drawn up for terminal layouts T1, T2, T3, T4, T5 and T6 with only truck handling (chapter 1) at the land side and terminal layouts T7, T8, T9, T10, T11 and T12 (chapter 2) with both truck handling as well train handling at the land side. All terminals without transshipment and without barge handling. For all terminals it is assumed that the quay length is 1.000 meter, so the conclusions can be easily projected proportionally to any other quay length.
In chapter 3 all conclusions are presented by means of bar charts.

In summary, it appears that the NGICT-system offers great advantages in all respects compared to the AMRG configuration and compared to a full straddle carrier operation. Even if there was no limitation of land occupation the following table clearly show all major advantages.

<u>Remark in advance</u>
All financial amounts in this study are based on as realistic assumptions as possible in order to be able to set up the comparisons.
The actual amounts are determined by the overall cost structure of a specific terminal. Each terminal is unique.

Comparison of the normative factors; only vessel to truck	OHBC	ARMG	SC
Subject	Average (T1 + T2)	Average (T3 + T4)	Average (T5 + T6)
Land occupation (hectare)	35,25 = 100%	42,85 = 122%	53,70 = 152%
Stack density Stack area + transfer area (TEU per hectare)	1.753 = 100%	1.302 = 74%	825 = 47%
Yearly throughput per hectare land occupation (TEU)	61.628 = 100%	48.036 = 78%	35.341 = 57%
Peak capacity yard handling on water side * (container moves per hour)	775 = 100%	468 = 60%	298 = 38%
Peak capacity yard handling on land side * (container moves per hour)	620 = 100%	312 = 50%	259 = 42%
Total investment costs (Euro) (x 1.000.000)	174 = 100%	216 = 124%	151 = 87%
Investment costs per TEU stack capacity (Euro)	3.750 = 100%	4.495 = 131%	3.718 = 99%
Investment costs per TEU thoughput per year (Euro)	80,36 = 100%	105,80 = 132%	82,96 = 103%
Operational costs per TEU throughput per year (Euro) (maximal performance)	11,67 = 100%	17,29 = 148%	31,65 = 271%

* If 2 containers at the same time inside the OHBC would be transported the handling capacity could be about 900 cmph.

Comparison of the normative factors; vessel to truck + train	OHBC	ARMG	SC
Subject	Average (T7 + T8)	Average (T9 + T10)	Average (T11 + T12)
Land occupation (hectare)	39,85 = 100%	51,0 = 128%	65,25 = 163%
Stack density Stack area + transfer area (TEU per hectare)	1.545 = 100%	1.070 = 69%	672 = 44%
Yearly throughput per hectare land occupation (TEU)	54.494 = 100%	40.368 = 74%	29.015 = 53%
Peak capacity yard handling on water side * (container moves per hour)	775 = 100%	468 = 60%	298 = 38%
Peak capacity yard handling on land side * (container moves per hour)	620 = 100%	312 = 50%	150 = 39%
Total investment costs (Euro) (x 1.000.000)	198 = 100%	249 = 126%	178 = 90%
Investment costs per TEU stack capacity (Euro)	4.260 = 100%	5.713 = 134%	4.418 = 104%
Investment costs per TEU thoughput per year (Euro)	91,04 = 100%	123 = 134%	95,03 = 104%
Operational costs per TEU throughput per year (Euro) (maximal performance)	13,78 = 100%	22,20 = 161%	34,26 = 248%

* If 2 containers at the same time inside the OHBC would be transported the handling capacity could be about 900 cmph.

The above comparison results are expressed in percentages because the absolute amounts as mentioned in chapter 3 depend on the individual and strategic cost price calculation model of each terminal operator separately.

CHAPTER 1

Deep sea terminal with only transfer from vessel to truck
(no rail terminal and no transshipment).

No trains
No barges
No transshipment

Terminals quay length of 1.000 m	Total land occupation	Equipment	Maximal annual throughput (TEU)
T1	38,4 hectare	OHBC	2.500.000
T2	32,1 hectare	OHBC	1.900.000
T3	38,4 hectare	ARMG	1.700.000
T4	47,3 hectare	ARMG	2.500.000
T5	44,5 hectare	SC	1.500.000
T6	63,0 hectare	SC	2.250.000

1.1 Design data (see figure 1) (Deep sea terminal with only transfer from vessel to truck; no rail and no transshipment)

			TERMINAL 1	TERMINAL 2	TERMINAL 3	TERMINAL 4	TERMINAL 5	TERMINAL 6
	Component		NGICT-OHBC	ALT. NGICT-OHBC	ARMG - 10 Wide	ARMG – 10 Wide	SC	SC
Dimensions and quantities	1	Total terminal area excluding in- and outgoing roads	38,40 hectare	32,1 hectare	38,4 hectare	47,3 hectare	44,5 hectare	63 hectare
	2	Total terminal width perpendicular to the quay excluding in- and outgoing roads	384 m	321 m	384 m	473 m	445 m	630 m
	3	Quay length	1.000 m	1.000 m	1.000 m	1.000 m	1.000 m	1.000 m
	4	Number of stack lanes	31	31	26	26	9,5 blocks	14 blocks
	5	C.t.c. width stack lanes	30,48 m	30,48 m	36,88 m (average)	36,88 m (average)	Not applicable	Not applicable
	6	Stacking height	5 layers	5 layers	5 layers	5 layers	3 layers	3 layers
	7	Stack lane length nett.	246 m	183 m	180 m	266 m	360 m	545 m
	8	Transfer width sea side	± 28 m	28 m	± 53 m	53 m	85 m	85 m
	9	Transfer width land side	± 25 m	± 25 m	± 68 m	± 68 m	Not applicable	Not applicable
	10	Total stack lane length including transfer areas	± 300 m	± 236 m	± 301 m	± 387 m	Not applicable	Not applicable
	11	Total width of stack area // quay	± 947 m	± 947 m	± 959 m	± 959 m	1.000 m	1.000 m
	12	Surface stack area nett.	246 x 947 = 232.962 m²	183 x 947 = 173.301 m²	180 x 959 = 172.620 m²	266 x 959 = 255.094	36 hectare	54,5 hectare
	13	Total stack capacity at 100% occupation	53.940 TEU	40.300 TEU	36.400 TEU	53.950 TEU	32.814 TEU	48.588 TEU
		Total stack capacity at 80% occupation	43.152 TEU	32.240 TEU	29.120 TEU	43.160 TEU (80%)	26.251 TEU	38.870 TEU
Equipment	14	Number of stack cranes per lane	2	2	2	2	75 SCs	106 SCs
	15	Transport device from STS area to stack area	SHC 1 over 1 (= ALV)	SHC 1 over 1 (= ALV)	SHC 1 over 1 (= ALV)	SHC 1 over 1 (= ALV)	75 SCs	SC
	16	Transfer device from SHC to stack (sea side)	OHBC	OHBC	ARMG (= ASC)	ARMG (= ASC)	SC	SC
	17	Transfer device from stack to truck (land side)	OHBC	OHBC	ARMG (= ASC)	ARMG (= ASC)	SC	SC
	18	Number of QCs	11	11	11	11	7	10
	19	Number of SHC per QC	2,7	2,7	2,7	2,7	Not applicable	Not applicable
Operational	20	Average occupation rate	80%	80%	80%	80%	80%	80%
	21	Average dwell time	6 days	6 days	6 days	6 days	6 day	6 days
	22	Annual throughput to be persued	2.500.000 TEU	1.900.000 TEU	1.700.000 TEU	2.500.000 TEU	1.500.000 TEU	2.250.000 TEU
	23	Operational time per year	360 days	360 days	360 days	360 days	360 days	360 days
	24	TEU factor	1,67	1,67	1,67	1,67	1,67	1,67

1.2 Requirements

1.2.1 Performance

All six terminal configurations must be able to deliver simultaneously:

Berth 1 (vessel 400 m long):
- Quay productivity (peak) 5.000 container moves in 24 hours.
- 6 STS cranes at the same time.
- Land side productivity trucks = 300 days x 14 hours = 4.200 hours / year.
  Peak factor gate = 1,4.

and
Berth 2 (vessel 400 m long):
- Quay productivity (peak) 4.000 container moves in 24 hours.
- 5 STS cranes at the same time.
- Land side productivity trucks = 300 days x 14 hours = 4.200 hours / year.
  Peak factor gate = 1,4.

For the whole terminal:
- Berth 1 + Berth 2 simultaneously.
- Quay productivity (peak) = 9.000 container moves in 24 hours.
- 11 STS cranes at the same time.
- Operational time: 360 days / year = 8.640 hours.
- Average stack occupation max. 80%.
- Average dwell time 6 days.
- Average quay occupation 60% x 8.640 = 5.184 hours / year.
- TEU – factor 1,67.

Productivity to be persued:
- Quay ± 2.400 TEU / m^1.
- Terminal surface ± 60.000 TEU / hectare.

1.2.2 Land occupation

Quay length 1.000 m.
Maximal available width of terminal = 400 m.
Maximal available terminal surface 40 hectare exclusive gates, offices, workshops, battery charging stations, gas-oil stations, empty depots, etc.

1.3 Equipment and process

In order to meet these performance requirements the following equipment will be installed.

1.3.1 Terminal 1. NGICT – OHBC 38,4 hectare (see figure 3)

- Number of STS cranes: 11.
- Average productivity of STS cranes = 35 cmph (= 58,45 TEU/h).
- Total productivity of 11 STS cranes in 24 hours can be 9.240 moves.
- Transport from STS cranes to yard by ALV (automated lifting vehicles 1 over 1).
- Average productivity of ALV = 12 cmph (including twin carry).
- Minimum number of ALV = 9.240 / (24 x 12) = 32.
- Stack operations by OBHC (1 upper + 1 under per stack lane).
- Number of stack lanes = 31.
- Number of OHBCs = 62.
- Productivity OHBC on waterside = 25 cmph.
- Productivity OHBC on landside = 20 cmph.
- Average quantity of housekeeping 35%.
- Effective average productivity per stack lane = 0,5 (25 + 20) = 22,5 cmph.
- Peak productivity over 15 stack lanes = 15 x 22,5 = 338 cmph x 24 h = 8.100 cmph (= > 5.000; sufficient).
- Peak productivity over whole terminal = 31 stack lanes x 22,5 = 698 cmph x 24 h = 16.740 cmph (= > 9.000; sufficient).
- Stack capacity 31 lanes x 87 rows x 4 TEU x 5 layers = 53.940 TEU (100%).
- Maximal density 80% = 43.152 TEU.
- TEU visits per slot per year; assumption: 46.
- Throughput = 46 x 53.940 = 2.481.240 TEU / year (= 1.485.772 moves).
- Quay productivity max. = 2.481 TEU / m^1.
- Surface productivity max. = 24.812.40 / 38.4 = 64.616 TEU / hectare (sufficient).
- Number of OHBC moves per year = (2 x 1.485.772) + (35% x 2.971.544) = 4.001.584 that means 64.703 moves per OHBC.
  Due to 35% housekeeping total OHBC moves = 62 x 1,35 x 23.964 = 2.005.787.

1.3.2 Terminal 2. NGICT – OHBC 32,1 hectare (see figure 4)

- Number of STS cranes: 11.
- Average productivity of STS cranes = 35 cmph (=58,45 TEU / h).
- Total productivity of 11 STS cranes in 24 hours can be 9.240 moves.
- Transport from STS cranes to yard by ALV (automated lifting vehicles 1 over 1).
- Average productivity of ALV = 12 cmph (including twin carry).
- Minimum number of ALV = 9.240 / (24 x 12) = 32.
- Stack operations by OBHC (1 upper + 1 under per stack lane).
- Number of stack lanes = 31.
- Number of OHBC = 62.
- Productivity OHBC on waterside = 25 cmph.
- Productivity OHBC on landside = 20 cmph.
- Average quantity of housekeeping 35%.

- Effective average productivity per stack lane = 0,5 (25 + 20) = 22,5 cmph.
- Peak productivity over 15 stack lanes = 15 x 22,5 = 338 cmph x 24 h = 8.100 cmph (= > 5.000; sufficient).
- Peak productivity over whole terminal = 31 stack lanes x 22,5 = 698 cmph x 24 h = 16.740 cmph (= > 9.000; sufficient).
- Stack capacity 31 lanes x 66 rows x 4 TEU x 5 layers = 40.920 TEU (100%).
- Maximal density 80% = 32.736 TEU.
- TEU visits per slot per year; assumption: 46.
- Throughput max. = 46 x 40.920 = 1.882.320 TEU / year (= 1.127.138 moves).
- Quay productivity max. = 1.882 TEU / m^1 (not sufficient).
- Surface productivity max. = 1.882.320 / 31.2 = 60.330 TEU / hectare (sufficient).
- Number of OHBC moves per year = (2 x 1.127.138) + (35% x 2.254.276) = 3.043.273 that means 49.085 moves per OHBC.

1.3.3 Terminal 3. ASC (= ARMG) 38,4 hectare (see figure 5)

- Number of STS cranes: 11.
- Average productivity of STS cranes = 35 cmph.
- Total productivity of 11 STS cranes in 24 hours can be 9.240 cm.
  Transport from STS cranes to yard by ALV (automated lifting vehicles 1 over 1).
- Average productivity of ALV = 12 cmph (including twin carry).
- Minimum number of ALV = 9.240 / (24 x 12) = 32.
  Stack operations by 2 ARMGs per stack lane (ARMG's – 10 wide).
- Number of stack lanes = 26.
- Number of ARMGs = 52.
- Productivity ARMG on waterside = 18 cmph (historical data).
- Productivity ARMG on landside = 12 cmph (historical data).
- Average quantity of housekeeping 100%.
- Effective average productivity per stack lane = 0,5 (18 + 12) = 15 cmph.
- Peak productivity over 13 stack lanes = 13 x 15 = 195 cmph x 24 h = 4.680 cmph (= < 5.000; not sufficient).
- Peak productivity over 26 stack lanes = 26 x 15 = 390 cmph x 24 h = 9.360 cmph (> 9.000; sufficient).
- Stack capacity 26 x 10 x 14 x 2 x 5 = 36.400 TEU.
- Maximal density 80% = 29.120 TEU.
- TEU visits per slot assumption: 46.
- Max throughput = 46 x 36.400 = 1.674.400 TEU / year (= 1.002.634 moves).
- Quay productivity max. = 1.674 TEU / m^1 (not sufficient).
- Surface productivity max. = 1.674.400 / 38.4 = 43.604 TEU / hectare (not sufficient).
- Total ARMG moves per year = (2 x 1.002.634) + (100% x 2.005.268) = 4.010.356 including 100% housekeeping, that means 77.136 moves per ARMG.

Note: The yard system cannot meet the requested peak performance for berth 1.
The surface productivity does not meet the requested performance (< 60.000 TEU / hectare).
The quay productivity) does not meet the requested performance (< 2.400 TEU / m^1).

1.3.4 Terminal 4. ASC (= ARMG) 47,3 hectare (see figure 6)

- Number of STS cranes: 11.
- Average productivity of STS cranes = 35 cmph.
- Total productivity of 11 STS cranes in 24 hours can be 9.240 cm.
- Transport from STS cranes to yard by ALV 1 over 1.
- Average productivity of ALV = 12 cmph (including twin carry).
- Minimum number of ALV = 9.240 / (24 x 12) = 32.
- Stack operations by 2 ARMGs per stack lane (RMGs – 10 wide).
- Number of stack lanes = 26.
- Number of ARMG = 52.
- Productivity ARMG on waterside = 18 cmph (historical data).
- Productivity ARMG on landside = 12 cmph (historical data).
- Average quantity of housekeeping 100%.
- Effective average productivity per stack lane = 0,5 (18 + 12) = 15 cmph.
- Peak productivity over 14 stack lanes = 13 x 15 = 195 cmph x 24 h = 4.680 cmph (= < 5.000; not sufficient).
- Peak productivity over 26 stack lanes = 26 x 15 = 390 cmph x 24 h = 9.360 cmph (= > 9.000; sufficient).
- Stack capacity 26 x 20,75 x 10 rows x 5 layers x 2 TEU = 53.950 TEU (100% occupation).
- Maximal density 80% = 43.160 TEU.
- TEU visits per slot assumption 46.
- Max throughput = 46 x 53.950 = 2.481.700 TEU / year (= 1.486.048 moves).
- Quay productivity max. = 2.482 TEU / m^1.
- Surface productivity max. = 2.481.700 / 47.3 = 52.467 TEU / hectare (not sufficient).
- Number of ARMG moves per year = (2 x 1.486.048) + (100% x 2.972.096) = 5.944.192 including 100% housekeeping, that means 114.311 moves per ARMG.

Remarks: The yard system cannot meet the requested peak performance for berth 1.
The surface productivity does not meet the requested performance.
The quay productivity does not meet the requested performance.

1.3.5 Terminal 5. Full Straddle Carrier operation 45,5 hectare (see figure 7)

Number of STS cranes = 7.
Average productivity of STS cranes = 35 cmph.
Total productivity of 7 STS cranes in 24 hours can be 5.880 cm.
Transport from STS cranes to yard by SC 1 over 3.
Transport from yard to truck by SC 1 over 3.
Average productivity of SC seaside = 7 cmph (including twin carry).
Average productivity of SC landside = 7 cmph (including twin carry).
Minimum number of SCs seaside must be 5.880 / (24 x 7) = 35.
Minimum number of SCs per STS crane = 5.
Average quantity of housekeeping = 25%.
Number of SCs landside must be 32.
Effective average productivity of SCs = 0,5 (7 + 7) = 7,0 cmph.

Peak productivity over 1 berth = 6 x 35 x 24 h = 5.040.
Number of SC for housekeeping = 8.
Total number of SCs = 35 + 30 + 8 = 75.
Total number of moves is (2 x 909.230) + (25% x 1.818.460) = 2.273.075 that means 30.308 moves per SC (= 4.330 hour per SC).
Stack capacity = 33.009 TEU (100% occupation).
Maximal density 80% = 26.407 TEU.
TEU visits per slot assumption 46.
Maximal throughput = 46 x 33.009 = 1.518.414 TEU / year (= 909.230 moves).
Quay productivity maximal = 1.518 TEU / m^1 (not sufficient).
Surface productivity maximal = 1.518.414 / 44,5 = 34.122 TEU / hectare (not sufficient).
Yard productivity per year = 1.518.414 / 36,0 = 42.178 TEU / hectare.

Remarks: The full SC operations can neither meet the requirements in respect to available land occupation nor the requirements in respect to productivity performances.

1.3.6 Terminal 6. Full Straddle Carrier operation 63,0 hectare (see figure 8)

Number of STS cranes = 10.
Average productivity of STS cranes = 35 cmph.
Total productivity of 10 STS cranes in 24 hours can be 8.400 cm.
Transport from STS cranes to yard by SC 1 over 3.
Transport from yard to truck by SC 1 over 3.
Average productivity of SC seaside = 7 cmph (including twin carry).
Average productivity of SC landside = 7 cmph (including twin carry).
Minimum number of SCs seaside must be 8.400 / (24 x 7) = 50.
Minimum number of SCs per STS crane = 5.
Average quantity of housekeeping = 25%.
Number of SCs landside must be 44.
Effective average productivity of SCs = 0,5 (7 + 7) = 7,0 cmph.
Peak productivity over 1 berth = 6 x 35 x 24 h = 5.040.
Number of SC for housekeeping = 12.
Total number of SCs = 50 + 44 + 12 = 106.
Total handlings of 106 SCs estimated on approximately (2 x 1.379.174) + (25% x 2.758.347) = 3.447.934, that means 35.528 moves per SC (= 4.647 hour per SC).
Stack capacity = 50.070 TEU (100% occupation).
Maximal density 80% = 40.056 TEU.
TEU visits per slot assumption 46.
Maximal throughput = 46 x 50.070 = 2.303.220 TEU / year (= 1.379.174 moves)
Quay productivity maximal = 2.303 TEU / m^1.
Surface productivity maximal = 2.303.220 / 63 = 36.559 TEU / hectare (not sufficient).
Yard productivity maximal = 2.303.220 / 54,5 = 42.261 TEU / hectare.

Remarks: The full SC operations can neither meet the requirements in respect to available land occupation nor the requirements in respect to productivity performances.

1.4 Investment costs (only for stack operations)

1.4.1 General

Before we reach the stage of realistic cost estimates, in this first version of the feasibility study we explain our calculation system as follows.
The goal of the cost estimates in general is:

1. Determining the magnitude of the investment involved with the realization of a terminal according to the NGICT concept (at this moment, only for the stack area).
2. Drawing up a ‘strategic instrument’ for the decisions to be made with regard to the configuration, the measurements, the phasing and the level of automation with which the ultimate price level can be adjusted.
3. Estimating the operational costs for the OHBC configuration.
4. Estimating the operational costs for the ARMG configuration.
5. Estimating the operational costs for the SC configuration.

As regards the amounts mentioned hereafter, we point out that these can only be used combined with the below-mentioned margins. The accuracy of a cost estimate depends on the extent to which the plan is finalised (from rough to fine).

In drawing up such an estimate, we make a distinction between the following accuracies for each phase:

1. **Basic research (feasibility study):**
   Rough estimate of the investments;
   accuracy margins: - or + 25%.
2. Preliminary design:
   Assessment of the building costs;
   accuracy margins: - or + 20%.
3. Final design:
   Estimate of the various building elements;
   accuracy margins: - or + 15%.
4. Specifications:
   Cost estimate based on the specifications; in this stage, all quantities are known;
   accuracy margins: - or + 10% (market influences).

Despite these margins, this will hardly affect the mutual comparison.

Furthermore, we point out that all amounts are exclusive of VAT and are based on the price level of 1 January 2020 in Western Europe.

1.4.2 Comparison of the investment costs considering the following components

NGICT-OHBC	ARMG	STRADDLE CARRIER
For T1 and T2	For T3 and T4	For T5 and T6
Steel construction of support structure inclusive conservation	Rail on concrete sleepers	-
Foundation of support structure (piled foundation)	Foundation of sleepers on compacted underground layers	-
Electrical installation inclusive distribution	Electrical installation inclusive distribution	Electrical installation inclusive distribution
Civil works stack area + transfer areas	Civils works stack area + service areas + transfer areas	Civil works stack area + transfer areas
OHBCs	ARMGs	SCs
Spreaders, headblocks, rotators	Spreaders, headblocks, rotators	Spreaders and headblocks

1.12 Operational costs of the stack operations for T1, T2, T3, T4, T5 and T6

1.12.1 Principle

The most important purpose of these calculations is to show the differences in operational costs between these six configurations as a percentage.
Not to determine the actual costs!
The estimated investment amounts as mentioned in resume in paragraph 1.11 will be used for drawing up the exploitation calculation.
Considering a margin on the investment amounts, in this phase that margin also needs to be applied to the exploitation calculation. ‘From rough to fine’ is also applicable here, depending on the reliability of the assumptions and principles.
Furthermore, the technical standards and quality considerations also determine the life span and the maintenance needs of each part of the project.
The accuracy of the calculation must evolve from rough estimate to solid price on which the exploitation estimate can be determined.
After all, the assumed degree of accuracy has hardly any influence on the comparisons.

All operational costs as mentioned hereafter are exclusive:
- management costs
- property taxes
- administration costs
- charge for quay occupation by vessels
- variable costs for service to vessels
- extra costs for reefers
- costs for inspection of containers
- costs for gate moves
- hatch cover moves
- charge for entrance external vehicles to the yard

and
- surcharge for profit and risk.

1.12.2 Contingencies

In view of program and specification changes, there is a risk that during the further process of the project realization, price increases which exceed the average cost index. This risk and the financial consequences are NOT taken into account in this calculation.

1.12.3 Yearly costs

1.12.3.1 Expenses

The yearly costs necessary for drawing up the exploitation estimate consist of both fixed and variable cost categories.

The fixed costs mentioned hereafter in 1, 2 and 3 are being identified:
The costs mentioned in 4 and 5 will be more or less equal for all four concepts

1. Depreciation (write-off).
2. Rent quay and terrain (or long lease).
3. Reservation major maintenance.
4. Management costs (not taken into account).
5. Property taxes (not taken into account).

The following variable costs are being taken into account to show the differences between the six concepts:

1. Regular maintenance.
2. Insurances.
3. Energy costs.
4. Interest costs and repayment.
5. Labour costs.

1.12.4 Fixed costs (only for stack operations)

1.12.4.1 Depreciation (write-off costs)

Depreciation of the investment costs needs to take place over the life span of the various parts of the project. The life span meant is the technical life span. For the mechanical parts a life span of 25 years is assumed, for the electromechanical parts of the project, a life span of 20 years. For the life span of the static parts, also 40 years is assumed. For spreaders, head blocks and rotator is assumed 10 years.

1.12.4.2 Rent quay and terrain (or long lease)

These costs are also taken into account in this calculation model. Because only the costs of the stack operations are being considered. Only the required surface occupation for stack area and transfer area are taken into account.

1.12.4.3 Reservation major maintenance

For the costs needed for major maintenance, a reservation needs to be made yearly. Major maintenance means corrective or malfunction maintenance, as well as the costs of periodic inspections.

1.12.4.4 Management costs

This comprises the costs of the administration involved in operating the container terminal. Besides the cost administration, the administration also comprises the periodic customer invoicing.
The costs associated with the administration and invoicing are not taken into account in this calculation because the stack operations will only represent a small part of the total management costs and will not have important effect on the comparison.

1.12.5 Variable costs (only for stack operations)

1.12.5.1 Regular maintenance

Regular maintenance is carried out preventively. The costs for regular maintenance are assumed at 1,0% per year for OHBC and 1,2% per year for ARMG terminal. For SC terminals due to tires 2,5% per SC.

1.12.5.2 Insurances

The costs for insurances are assumed at 0,5% per year. The insurances need to at least cover fire risks of the various electromechanical components, as well as the support structure. To what extent it is practical and possible to entirely or partially cover the risk of consequential damages caused by interruptions in the energy supply, needs to be further investigated. The various risks need to be evaluated during the final design phase.

1.12.5.3 Energy costs

Note: Of course, the differences in energy costs are large worldwide and therefore in this study only intended as a comparison between the different terminal models.

The energy costs of the NGICT-OHBC system deviate considerably from the conventional ARMG-system due to the much lower own weight.

Based on detailed calculations we assume the following energy costs per yard layout.

Terminal 1: NGICT – OHBC (38,4 hectare)
€ 0,40 per move
Terminal 2: NGICT – OHBC (32,1 hectare)
€ 0,40 per move
Terminal 3: ARMG (38,4 hectare)
€ 0,93 per move
Terminal 4: ARMG (47,3 hectare)
€ 0,93 per move
Terminal 5: SC (45,5 hectare) (75 SCs)
Total handlings = 2.273.075 inclusive 25% housekeeping
Average 7 handlings per hour → 324.725 hour; per SC 4.330 hour / year.
Assume 30 litre diesel oil per km à € 0,95 / litre → € 28,50 / hour x 4.330
= € 123.405,00 per SC.
Total 75 SCs x € 123.405,00 = € 9.255.375,00.
Terminal 6: SC (63,0 hectare) (106 SCs)
Total handlings = 3.447.934 moves inclusive 25% housekeeping.
Average 7 handlings per hour → 492.562 hour; per SC = 4.647 hour / year.
Assume 30 litre diesel oil per km à € 0,95 / litre → € 28,50 / hour x 4.647
= € 132.440,00 per SC.
Total 106 SC x € 132.440,00 = € 14.038.587,00.

1.12.5.4 Interest costs

Assuming that the total project investment needs to be borrowed on the open market, with repayment and interest costs, we calculate the effect this has on the operational costs as follows. In this calculation model, we assume monthly payment of a fixed amount, as shown in the table below. This is not the most favourable calculation method, so the actual costs will be somewhat lower.

Interest rate 1,5% / Repayment 25 years	**TERMINAL 1** NGICT – OHBC (38,4 hectare)	**TERMINAL 2** NGICT – OHBC (32,1 hectare)	**TERMINAL 3** ARMG (38,4 hectare)	**TERMINAL 4** ARMG (47,3 hectare)
Total investment	€ 183.473.080,00	€ 165.159.540,00	€ 209.049.200,00	€ 211.587.490,00
Total interest over 25 years	€ 35.777.250,00	€ 32.206.110,00	€ 40.764.594,00	€ 43.209.560,00
Total paid over 25 years	€ 219.250.330,00	€ 197.356.650,00	€ 249.813.794,00	€ 264.797.050,00
Total costs per year	€ 8.770.013,00	€ 7.894.266,00	€ 9.992.552,00	€ 10.591.882,00

Interest rate 1,5% / Repayment 25 years	**TERMINAL 5** SC (45,5 hectare)	**TERMINAL 6** SC (63,0 hectare)
Total investment	€ 123.980.000,00	€ 177.725.000,00
Total interest over 25 years	€ 24.176.100,00	€ 34.656.375,00
Total paid over 25 years	€ 148.156.100,00	€ 212.381.375,00
Total costs per year	€ 5.926.244,00	€ 8.495.255,00

1.12.5.5 Labour costs (for OHBC and ARMG)

Note: Of course, the differences in labour costs are large worldwide and therefore in this study only intended as a comparison between the different terminal models.

For the operations within the stack area, we only consider the actions to be performed within the stack itself. So the supply and the transport of the containers by ship and the costs of the STS cranes and the costs of the SHCs are left out of consideration. However the stack operations will be fully automated we add still a certain amount of labour costs to execute regular checks and regular modifications in programming. We assume an average cost of € 0,10 per move.

1.12.5.6 Labour costs (for stack operations only) for full SC operation

Terminal 5: Total hours per SC per year = 4.330.
For 75 SC is that 334.750 hour / year.
Assume labour (driver)costs = € 50,00 / hour → € 16.237.500,00.
Terminal 6: Total hours per SC = 4.647 hour per year.
For 106 SC is that 492.562 hour.
Assume labour (driver)costs = € 50,00 / hour → € 24.629.100,00.

CHAPTER 2

Deep sea terminal with transfer from vessel to truck and train (no transshipment).

No transshipment
No barges

Terminals quay length of 1.000 m	Total land occupation	Equipment	Maximal annual throughput (TEU)
T7	42,9 hectare	OHBC	2.500.000
T8	36,8 hectare	OHBC	1.900.000
T9	46,8 hectare	ARMG	1.700.000
T10	55,2 hectare	ARMG	2.500.000
T11	56,0 hectare	SC	1.500.000
T12	74,5 hectare	SC	2.250.000

2.1 Design data (see figure 9 and 10)

			TERMINAL 7	TERMINAL 8	TERMINAL 9	TERMINAL 10	TERMINAL 11	TERMINAL 12
	Component		**NGICT-OHBC**	**NGICT-OHBC**	**ARMG - 10 Wide**	**ARMG – 10 Wide**	**SC**	**SC**
Dimensions and quantities	1	Total terminal area excluding in- and outgoing roads	42,9 hectare	36,8 hectare	46,8 hectare	55,2 hectare	56,0 hectare	74,5 hectare
	2	Total terminal width perpendicular to the quay excluding in- and outgoing roads	428 m	368 m	468 m	552 m	560 m	745 m
	3	Quay length	1.000 m	1.000 m	1.000 m	1.000 m	1.000 m	1.000 m
	4	Number of stack lanes	31	31	26	26	9,5 blocks	14 blocks
	5	C.t.c. width stack lanes	30,48 m	30,48 m	36,88 m (average)	36,88 m (average)	Not applicable	Not applicable
	6	Stacking height	5 layers	5 layers	5 layers	5 layers	3 layers	3 layers
	7	Stack lane length nett.	241 m	181 m	180 m	264 m	360 m	545 m
	8	Transfer width sea side	± 28 m	28 m	± 53 m	53 m	85 m	85 m
	9	Transfer width land side truck	± 25 m	± 25 m	± 68 m	± 68 m	Not applicable	Not applicable
	10	Transfer width land side train	48 m	48 m	85 m	85 m		
	11	Total stack lane length including transfer areas	± 344 m	± 283 m	± 386 m	± 470 m	Not applicable	Not applicable
	12	Total width of stack area // quay	± 947 m	± 947 m	± 959 m	± 959 m	1.000 m	1.000 m
	13	Surface stack area nett.	344 x 947 = 325.768 m^2	283 x 947 = 268.001 m^2	386 x 959 = 370.174 m^2	266 x 959 = 255.094	36 hectare	54,5 hectare
	14	Total stack capacity at 100% occupation	53.940 TEU	40.300 TEU	36.400 TEU	53.950 TEU	32.814 TEU	48.588 TEU
	15	Total stack capacity at 80% occupation	43.152 TEU	32.240 TEU	29.120 TEU	43.160 TEU (80%)	26.251 TEU	38.870 TEU
Equipment	16	Number of stack cranes per lane	2	2	2	2	75 SCs	106 SCs
	17	Transport device from STS area to stack area	SHC 1 over 1 (= ALV)	SHC 1 over 1 (= ALV)	SHC 1 over 1 (= ALV)	SHC 1 over 1 (= ALV)	SCs	SC
	18	Transfer device from SHC to stack (sea side)	OHBC	OHBC	ARMG (= ASC)	ARMG (= ASC)	SC	SC
	19	Transfer device from stack to truck (land side)	OHBC	OHBC	ARMG (= ASC)	ARMG (= ASC)	SC	SC
	20	Transfer from stack to train	OHBC	OHBC	SHC 1 over 1	SHC 1 over 1	SC	SC
	21	Number of QCs	11	11	11	11	7	10
	22	Number of SHC per QC	2,7	2,7	2,7	2,7	Not applicable	Not applicable
Operational	23	Average occupation rate	80%	80%	80%	80%	80%	80%
	24	Average dwell time	6 days	6 days	6 days	6 days	6 day	6 days
	25	Annual throughput to be persued	2.500.000 TEU	1.900.000 TEU	1.700.000 TEU	2.500.000 TEU	1.500.000 TEU	2.250.000 TEU
	26	Operational time per year	360 days	360 days	360 days	360 days	360 days	360 days
	27	TEU factor	1,67	1,67	1,67	1,67	1,67	1,67

2.2 Requirements

2.2.1 Performance

All six terminal configurations must be able to deliver simultaneously:

Berth 1 (vessel 400 m long):
- Quay productivity (peak) 5.000 container moves in 24 hours.
- 6 STS cranes at the same time.
- Land side productivity (peak) trucks = 160 cmph.
- Land side productivity (peak) train = 60 cmph.

Berth 2 (vessel 400 m long):
- Quay productivity (peak) 4.000 container moves in 24 hours.
- 5 STS cranes at the same time.
- Land side productivity (peak) trucks = 120 cmph.
- Land side productivity (peak) train = 60 cmph.

For the whole terminal:
- Berth 1 + Berth 2 simultaneously.
- Quay productivity (peak) = 9.000 container moves in 24 hours.
- 11 STS cranes at the same time.
- Operational time: 360 days / year = 8.640 hours.
- Average stack occupation max. 80%.
- Average dwell time 6 days.
- Average quay occupation 60% x 8.640 = 5.184 hours / year.
- TEU – factor 1,67.
- Throughput truck terminal 70%.
- Throughput train terminal 30%.

Productivity to be persued:
- Quay ± 2.400 TEU / m^1.
- Terminal surface ± 60.000 TEU / hectare.

2.2.2 Land occupation

Quay length 1.000 m.
Maximal available width of terminal = 450 m.
Maximal available terminal surface 45 hectare exclusive gates, offices, workshops, battery charging stations, gas-oil stations, empty depots, charging stations, etc.

2.3 Equipment and process

In order to meet these performance requirements the following equipment will be installed.

2.3.1 Terminal 7. NGICT – OHBC 42,9 hectare inclusive rail terminal (see figure 11)

- Number of STS cranes: 11.
- Average productivity of STS cranes = 35 cmph (= 58,45 TEU/h).
- Total productivity of 11 STS cranes in 24 hours can be 9.240 moves.
- Transport from STS cranes to yard by ALV (automated lifting vehicles 1 over 1).
- Average productivity of ALV = 12 cmph (including twin carry).
- Minimum number of ALV = 9.240 / (24 x 12) = 32.
- Stack operations by OBHC (1 upper + 1 under per stack lane).
- Number of stack lanes = 31.
- Number of OHBCs = 62.
- Productivity OHBC on waterside = 25 cmph.
- Productivity OHBC on landside = 20 cmph.
- Average quantity of housekeeping 35%.
- Effective average productivity per stack lane = 0,5 (25 + 20) = 22,5 cmph.
- Peak productivity over 15 stack lanes = 15 x 22,5 = 338 cmph x 24 h = 8.100 cmph (= > 5.000; sufficient for 1 berth).
- Peak productivity over whole terminal = 31 stack lanes x 22,5 = 698 cmph x 24 h = 16.740 cmph (= > 9.000; sufficient).
- Stack capacity 31 lanes x 87 rows x 4 TEU x 5 layers = 53.940 TEU (100%).
- Maximal density 80% = 43.152 TEU.
- TEU visits per slot per year; assumption: 46.
- Throughput = 46 x 53.940 = 2.481.240 TEU / year (= 1.485.772 moves).
- Quay productivity max. = 2.481 TEU / m^1.
- Surface productivity max. = 24.812.40 / 38.4 = 64.616 TEU / hectare (sufficient).
- Number of OHBC moves per year = (2 x 1.485.772) + (35% x 2.971.544) = 4.001.584 moves. That means 64.703 moves per OHBC.
- Train handling = 25% direct by OHBCs + 75% by ORCs.
- Number of ORC (overhead rail cranes) = 6.
- Productivity truck terminal 70% x 2.481.240 TEU = 1.736.868 TEU / year = 1.040.041 moves.
- Productivity rail terminal = 30% x 2.481.240 TEU = 744.372 TEU = 445.732 moves.
- Productivity per ORC = 445.732 / 6 = 74.289 moves per crane.
- Average productivity per ORC = 20 cmph.
- Operational time of ORC = 74.289 / 20 = 3.714 hour per year.

2.3.2 Terminal 8. NGICT – OHBC 36,8 hectare inclusive rail terminal (see figure 12)

- Number of STS cranes: 11.
- Average productivity of STS cranes = 35 cmph (=58,45 TEU / h).
- Total productivity of 11 STS cranes in 24 hours can be 9.240 moves.

- Transport from STS cranes to yard by ALV (automated lifting vehicles 1 over 1).
- Average productivity of ALV = 12 cmph (including twin carry).
- Minimum number of ALV = 9.240 / (24 x 12) = 32.
- Stack operations by OBHC (1 upper + 1 under per stack lane).
- Number of stack lanes = 31.
- Number of OHBC = 62.
- Productivity OHBC on waterside = 25 cmph.
- Productivity OHBC on landside = 20 cmph.
- Average quantity of housekeeping 35%.
- Effective average productivity per stack lane = 0,5 (25 + 20) = 22,5 cmph.
- Peak productivity over 15 stack lanes = 15 x 22,5 = 338 cmph x 24 h = 8.100 cmph (= > 5.000; sufficient).
- Peak productivity over whole terminal = 31 stack lanes x 22,5 = 698 cmph x 24 h = 16.740 cmph (= > 9.000; sufficient).
- Stack capacity 31 lanes x 66 rows x 4 TEU x 5 layers = 40.920 TEU (100%).
- Maximal density 80% = 32.736 TEU.
- TEU visits per slot per year; assumption: 46.
- Throughput max. = 46 x 40.920 = 1.882.320 TEU / year (= 1.127.138 moves).
- Quay productivity max. = 1.882 TEU / m^1 (not sufficient).
- Surface productivity max. = 1.882.320 / 31.2 = 60.330 TEU / hectare (sufficient).
- Number of OHBC moves per year = (2 x 1.127.138) + 35% x 2.254.276) = 3.043.273 that means 49.085 moves per OHBC.
- Train handling = 25% direct by OHBCs + 75% by ORCs.
- Number of ORC (overhead rail cranes) = 6.
- Productivity truck terminal 70% x 1.882.320 = 1.317.624 TEU per year = 788.996 moves per year.
- Productivity rail terminal = 30% x 1.882.320 = 564.696 TEU per year = 338.141 moves per year.
- Productivity per ORC = 338.141 / 6 = 56.357 moves per year.
- Average productivity per ORC = 20 cmph.
- Operational time of ORC = 56.357 / 20 = 2.818 hour per year.

2.3.3 Terminal 9. ASC (= ARMG) 46,8 hectare inclusive rail terminal (see figure 13)

- Number of STS cranes: 11.
- Average productivity of STS cranes = 35 cmph.
- Total productivity of 11 STS cranes in 24 hours can be 9.240 cm.
  Transport from STS cranes to yard by ALV (automated lifting vehicles 1 over 1).
- Average productivity of ALV = 12 cmph (including twin carry).
- Minimum number of ALV = 9.240 / (24 x 12) = 32.
  Stack operations by 2 ARMGs per stack lane (ARMGs – 10 wide).
- Number of stack lanes = 26.
- Number of ARMGs = 52.
- Productivity ARMG on waterside = 18 cmph (historical data).
- Productivity ARMG on landside = 12 cmph (historical data).
- Average quantity of housekeeping 100%.
- Effective average productivity per stack lane = 0,5 (18 + 12) = 15 cmph.

- Peak productivity over 13 stack lanes = 13 x 15 = 195 cmph x 24 h = 4.680 cmph (= < 5.000 not sufficient).
- Peak productivity over 26 stack lanes = 26 x 15 = 390 cmph x 24 h = 9.360 cmph (> 9.000; sufficient).
- Stack capacity 26 x 10 x 14 x 2 x 5 = 36.400 TEU.
- Maximal density 80% = 29.120 TEU.
- TEU visits per slot assumption: 46.
- Max throughput = 46 x 36.400 = 1.674.400 TEU / year (= 1.002.634 moves).
- Quay productivity max. = 1.674 TEU / m^1 (not sufficient).
- Surface productivity max. = 1.674.400 / 38.4 = 43.604 TEU / hectare (not sufficient).
- Total ARMG moves per year = (2 x 1.002.634) + (100% x 2.005.268) = 4.010.356 moves including 100% housekeeping.

Note: The yard system cannot meet the requested peak performance for berth 1.
The surface productivity does not meet the requested performance (< 60.000 TEU / hectare).
The quay productivity) does not meet the requested performance (< 2.400 TEU / m^1).

- Train handling = transport from truck transfer positions to train by SC 1 over 3.
- Train workload 30% of 1.674.400 TEU = 502.320 TEU / year = 300.790 moves per year.
- Number of RC (rail cranes) = 3.
- Productivity per RC = 300.790 / 3 = 100.263 moves.
- Productivity per RC = 20 cmph.
- Operational time per RC = 100.263 / 20 = 5.013 hour per year.
- Workload of SCs = 300.790 moves per year.
- Average productivity of SC = 7 cmph.
- If number of SCs is 10 than the operational time per SC = 300.790 / (10 x 7) = 4.297 hour per year.

2.3.4 Terminal 10. ASC (= ARMG) 55,2 hectare inclusive rail terminal (see figure 14)

- Number of STS cranes: 11.
- Average productivity of STS cranes = 35 cmph.
- Total productivity of 11 STS cranes in 24 hours can be 9.240 cm.
- Transport from STS cranes to yard by ALV 1 over 1.
- Average productivity of ALV = 12 cmph (including twin carry).
- Minimum number of ALV = 9.240 / (24 x 12) = 32.
- Stack operations by 2 ARMGs per stack lane (ARMGs – 10 wide).
- Number of stack lanes = 26.
- Number of ARMG = 52.
- Productivity ARMG on waterside = 18 cmph (historical data).
- Productivity ARMG on landside = 12 cmph (historical data).
- Average quantity of housekeeping 100%.
- Effective average productivity per stack lane = 0,5 (18 + 12) = 15 cmph.

- Peak productivity over 13 stack lanes = 13 x 15 = 195 cmph x 24 h = 4.680 cmph (= < 5.000; not sufficient).
- Peak productivity over 26 stack lanes = 26 x 15 = 390 cmph x 24 h = 9.360 cmph (= > 9.000; sufficient).
- Stack capacity 26 x 415 = 53.950 TEU (100% occupation).
- Maximal density 80% = 43.160 TEU.
- TEU visits per slot assumption 46.
- Max throughput = 46 x 53.950 = 2.481.700 TEU / year (= 1.486.048 moves).
- Quay productivity max. = 2.482 TEU / m^1.
- Surface productivity max. = 2.481.700 / 47.3 = 52.467 TEU / hectare (not sufficient).
- Number of ARMG moves per year = (2 x 1.486.048) + (100% x 2.972.096) = 5.944.192 moves including 100% housekeeping.

Remarks: The yard system cannot meet the requested peak performance for berth 1.
The surface productivity does not meet the requested performance.
The quay productivity does not meet the requested performance.

- Terminal handling = transport from truck transfer positions to train by SC 1 over 3.
- Total workload for train = 30% x 2.481.700 = 744.510 TEU per year = 445.814 moves per year.
- Number of RCs = 3.
- Required productivity per RC = 445.814 / 3 = 148.604 moves per year.
- Average productivity per RC = 20 cmph.
- Operational time per RC = 148.604 / 20 = 7.430 hour (= 86% of 8.640 hour).

Note: 86% of the operational time per year cannot be performed so the workload for train has to be reduced to 20% and 80% for trucks. Then the operational time per RC will be 4.953 hour (= 57%).
Workload for SCs is then 20% x 2.481.700 = 496.340 TEU per year = 297.209 moves. If number of SC is 10 and average productivity = 7 cmph then the operational time will be 297.209 / (10 x 7) = 4.246 hour per year.

2.3.5 Terminal 11. Full Straddle Carrier operation 56,0 hectare inclusive rail terminal (see figure 15)

Number of STS cranes = 7.
Average productivity of STS cranes = 35 cmph.
Total productivity of 7 STS cranes in 24 hours can be 5.880 cm.
Transport from STS cranes to yard by SC 1 over 3.
Transport from yard to truck by SC 1 over 3.
Average productivity of SC seaside = 7 cmph (including twin carry).
Average productivity of SC landside = 7 cmph (including twin carry).
Minimum number of SCs seaside must be 5.880 / (24 x 7) = 35.
Minimum number of SCs per STS crane = 5.
Average quantity of housekeeping = 25%.

Number of SCs landside must be 32.
Effective average productivity of SCs = 0,5 (7 + 7) = 7,0 cmph.
Peak productivity over 1 berth = 6 x 35 x 24 h = 5.040.
Number of SC for housekeeping = 8.
Total number of SCs = 35 + 30 + 8 = 75.
Total number of moves is (2 x 909.230) + (25% x 1.818.460) = 2.273.075 moves.
That means 30.308 moves per SC (= 4.330 hour per SC per year).
Stack capacity = 33.009 TEU (100% occupation).
Maximal density 80% = 26.407 TEU.
TEU visits per slot assumption 46.
Maximal throughput = 46 x 33.009 = 1.518.414 TEU / year (= 909.230 moves).
Quay productivity maximal = 1.518 TEU / m^1 (not sufficient).
Surface productivity maximal = 1.518.414 / 44,5 = 34.122 TEU / hectare
(not sufficient).
Yard productivity per year = 1.518.414 / 36,0 = 42.178 TEU / hectare.

Remarks: The full SC operations can neither meet the requirements in respect to available land occupation nor the requirements in respect to productivity performances.

Train handling to be persued 30% of 1.518.414 = 455.524 TEU per year = 272.789 moves per year.
Truck handing 70% x 1.518.414 = 1.062.890 TEU per year = 636.461 moves per year.
Due to the increased travel distance to the rail terminal the number of SCs will be increased from 75 to 85.
The workload for the destinated SCs to the rail terminal would be 272.789 / 10 = 27.279 moves.
The operational time will be 27.279 / 7 cmph = 3.897 hour per year.
Total moves SC = (2.273.075 + 272.789) = 2.545.864 inclusive rail terminal.

2.3.6 Terminal 12. Full Straddle Carrier operation 74,5 hectare inclusive rail terminal (see figure 16)

Number of STS cranes = 10.
Average productivity of STS cranes = 35 cmph.
Total productivity of 10 STS cranes in 24 hours can be 8.400 cm.
Transport from STS cranes to yard by SC 1 over 3.
Transport from yard to truck by SC 1 over 3.
Average productivity of SC seaside = 7 cmph (including twin carry).
Average productivity of SC landside = 7 cmph (including twin carry).
Minimum number of SCs seaside must be 8.400 / (24 x 7) = 50.
Minimum number of SCs per STS crane = 5.
Average quantity of housekeeping = 25%.
Number of SCs landside must be 44.
Effective average productivity of SCs = 0,5 (7 + 7) = 7,0 cmph.
Peak productivity over 1 berth = 6 x 35 x 24 h = 5.040.

Number of SC for housekeeping = 12.
Total number of SCs = 50 + 44 + 12 = 106.
Total number of moves is (2 x 1.379.174) + (25% x 2.758.347) = 3.447.934 moves.
That means 35.528 moves per SC (= 4.647 hour per SC).
Stack capacity = 50.070 TEU (100% occupation).
Maximal density 80% = 40.056 TEU.
TEU visits per slot assumption 46.
Maximal throughput = 46 x 50.070 = 2.303.220 TEU / year (= 1.379.174 moves)
Quay productivity maximal = 2.303 TEU / m^1.
Surface productivity maximal = 2.303.220 / 63 = 36.559 TEU / hectare
(not sufficient).
Yard productivity maximal = 2.303.220 / 54,5 = 42.261 TEU / hectare.

Remarks: The full SC operations can neither meet the requirements in respect to available land occupation nor the requirements in respect to productivity performances.

Train handling to be persued 30% of 2.303.220 = 690.966 TEU per year = 413.752 moves per year.
Truck handing 70% of 2.303.220 = 1.612.254 TEU per year = 965.422 moves per year.
Due to the increased travel distance to the rail terminal the number of SCs will be increased from 106 to 120.
The workload for the destinated SCs to the rail terminal would be 413.752 / 14 = 29.554 moves.
The operational time will be 29.554 / 7 cmph = 4.222 hour per year.
Total moves inclusive rail terminal = (3.447.934 + 413.752) = 3.861.686.

2.4 Investment costs (for stack operations + truck handling + train handling)

2.4.1 General

Before we reach the stage of realistic cost estimates, in this first version of the feasibility study we explain our calculation system as follows.
The goal of the cost estimates in general is:

1. Determining the magnitude of the investment involved with the realization of a terminal according to the NGICT concept (at this moment, only for the stack operations + truck handling + train handling).
2. Drawing up a ‘strategic instrument’ for the decisions to be made with regard to the configuration, the measurements, the phasing and the level of automation with which the ultimate price level can be adjusted.
3. Estimating the operational costs for the OHBC configuration.
4. Estimating the operational costs for the ARMG configuration.
5. Estimating the operational costs for the SC configuration.

As regards the amounts mentioned hereafter, we point out that these can only be used combined with the below-mentioned margins. The accuracy of a cost estimate depends on the extent to which the plan is finalised (from rough to fine).

In drawing up such an estimate, we make a distinction between the following accuracies for each phase:

1. **Basic research (feasibility study):**
   Rough estimate of the investments;
   accuracy margins: - or + 25%.
2. Preliminary design:
   Assessment of the building costs;
   accuracy margins: - or + 20%.
3. Final design:
   Estimate of the various building elements;
   accuracy margins: - or + 15%.
4. Specifications:
   Cost estimate based on the specifications; in this stage, all quantities are known;
   accuracy margins: - or + 10% (market influences).

Despite these margins, this will hardly affect the mutual comparison.

Furthermore, we point out that all amounts are exclusive of VAT and are based on the price level of 1 January 2020 in Western Europe.

2.4.2 Comparison of the investment costs considering the following components

NGICT-OHBC	ARMG	STRADDLE CARRIER
For T1 and T2	For T3 and T4	For T5 and T6
Steel construction of support structure inclusive conservation	Rail on concrete sleepers	-
Foundation of support structure (piled foundation)	Foundation of sleepers on compact underground layers	-
Electrical installation inclusive distribution	Electrical installation inclusive distribution	Electrical installation inclusive distribution
Civil works stack area + transfer areas	Civils works stack area + service areas + transfer areas	Civil works stack area + transfer areas
OHBCs	ARMGs	SCs
Spreaders, headblocks, rotators	Spreaders, headblocks, rotators	Spreaders and headblocks
Extra for T7 and T8	Extra for T9 and T10	Extra for T11 and T12
Railway tracks inside stack area inclusive foundation	Railway tracks inclusive foundation	Railway tracks inclusive foundation
Additional steel structure	Additional foundation for rail cranes	Additional foundation for rail cranes
Overhead rail cranes over railway tracks	Rail cranes over rail way tracks	Rail cranes over railway tracks
-	Straddle carriers dedicated to railway process	Straddle carrier dedicated to railway process

2.12 Operational costs of the stack operations (inclusive transfer operations at the land side for T7, T8, T9, T10, T11 and T12

2.12.1 Principle

The most important purpose of these calculations is to show the differences in operational costs between these six configurations as a percentage.
Not to determine the actual costs!
The estimated investment amounts as mentioned in the resume on page 51 will be used for drawing up the exploitation calculation.
Considering a margin on the investment amounts, in this phase that margin also needs to be applied to the exploitation calculation. ‘From rough to fine’ is also applicable here, depending on the reliability of the assumptions and principles.
Furthermore, the technical standards and quality considerations also determine the life span and the maintenance needs of each part of the project.
The accuracy of the calculation must evolve from rough estimate to solid price on which the exploitation estimate can be determined.
After all, the assumed degree of accuracy has hardly any influence on the comparisons.

All operational costs as mentioned hereafter are exclusive:
- management costs
- property taxes
- administration costs
- charge for quay occupation by vessels
- variable costs for service to vessels
- extra costs for reefers
- costs for inspection of containers
- costs for gate moves
- hatch cover moves
- charge for entrance external vehicles to the yard

and
- surcharge for profit and risk.

2.12.2 Contingencies

In view of program and specification changes, there is a risk that during the further process of the project realization, price increases which exceed the average cost index. This risk and the financial consequences are NOT taken into account in this calculation.

2.12.3 Yearly costs

2.12.3.1 Expenses

The yearly costs necessary for drawing up the exploitation estimate consist of both fixed and variable cost categories.

The fixed costs mentioned hereafter in 1, 2 and 3 are being identified:
The costs mentioned in 4 and 5 will be more or less equal for all four concepts
1. Depreciation (write-off).
2. Rent quay and terrain (or long lease).
3. Reservation major maintenance.
4. Management costs (not taken into account).
5. Property taxes (not taken into account).

The following variable costs are being taken into account to show the differences between the six concepts:
1. Regular maintenance.
2. Insurances.
3. Energy costs.
4. Interest costs and repayment.
5. Labour costs.

2.12.4 Fixed costs (for stack operations and transfer operations at the land side)

2.12.4.1 Depreciation (write-off costs)

Depreciation of the investment costs needs to take place over the life span of the various parts of the project. The life span meant is the technical life span. For the mechanical parts a life span of 25 years is assumed, for the electromechanical parts of the project, a life span of 20 years. For the life span of the static parts, also 40 years is assumed. For spreaders, head blocks and rotator is assumed 10 years.

2.12.4.2 Rent quay and terrain (or long lease)

These costs are also taken into account in this calculation model. Because only the costs of the stack and transfer on the land side operations are being considered. So, only the required surface occupation for stack area and transfer area are taken into account.

2.12.4.3 Reservation major maintenance

For the costs needed for major maintenance, a reservation needs to be made yearly. Major maintenance means corrective or malfunction maintenance, as well as the costs of periodic inspections.

2.12.4.4 Management costs

This comprises the costs of the administration involved in operating the container terminal. Besides the cost administration, the administration also comprises the periodic customer invoicing.
The costs associated with the administration and invoicing are not taken into account in this calculation because the stack operations will only represent a small part of the total management costs and will not have important effect on the comparison.

2.12.5 Variable costs (only for stack operations)

2.12.5.1 Regular maintenance

Regular maintenance is carried out preventively. The costs for regular maintenance are assumed at 1,0% per year for OHBC and 1,2% per year for ARMG terminal. For SC terminals due to tires 2,5% per SC.

2.12.5.2 Insurances

The costs for insurances are assumed at 0,5% per year. The insurances need to at least cover fire risks of the various electromechanical components, as well as the support structure. To what extent it is practical and possible to entirely or partially cover the risk of consequential damages caused by interruptions in the energy supply, needs to be further investigated. The various risks need to be evaluated during the final design phase.

2.12.5.3 Energy costs

Note: Of course, the differences in energy costs are large worldwide and therefore in this study only intended as a comparison between the different terminal models.

The energy costs of the NGICT-OHBC system deviate considerably from the conventional ARMG-system due to the much lower own weight.

Based on detailed calculations we assume the following energy costs per yard layout.

Terminal 7: NGICT – OHBC (42,9 hectare)
OHBC costs € 0,45 per move (for a length of the rail of ± 345 m)
ORC costs € 0,90 per move
Terminal 8: NGICT – OHBC (36,8 hectare)
OHBC costs € 0,45 per move (for a length of the rail of ± 285 m)
ORC costs € 0,90 per move
Terminal 9: ARMG (46,8 hectare)
ARMG costs € 0,93 per move (for a length of the rail of ± 246 m)
SC for transport from stack area to railway terminal assume € 4,50 per move
RC (rail crane) assume € 2,00 per move
Terminal 10: ARMG (55,2 hectare)
ARMG costs € 0,93 per move (for a length of the rail of ± 246 m)
SC for transport from stack area to railway terminal assume € 4,50 per move
RC (rail crane) assume € 2,00 per move
Terminal 11: SC (56,0 hectare)
SC costs € 4,50 per move
RC costs € 2,00 per move
Terminal 12: SC (74,5 hectare)
SC costs € 4,50 per move
RC costs € 2,00 per move

2.12.5.4 Interest costs

Assuming that the total project investment needs to be borrowed on the open market, with repayment and interest costs, we calculate the effect this has on the operational costs as follows. In this calculation model, we assume monthly payment of a fixed amount, as shown in the table below. This is not the most favourable calculation method, so the actual costs will be somewhat lower.

	TERMINAL 7	**TERMINAL 8**	**TERMINAL 9**	**TERMINAL 10**
Interest rate 1,5% / Repayment 25 years	NGICT – OHBC (42,9 hectare)	NGICT – OHBC (36,8 hectare)	ARMG (46,8 hectare)	ARMG (55,2 hectare)
Total investment	€ 207.789.867,00	€ 188.073.005,00	€ 243.831.000,00	€ 255.009.300,00
Total interest over 25 years	€ 40.519.023,00	€ 36.674.236,00	€ 47.547.045,00	€ 49.726.813,00
Total paid over 25 years	€ 248.308.890,00	€ 224.736.992,00	€ 291.378.045,00	€ 304.736.113,00
Total costs per year	€ 9.932.356,00	€ 8.989.480,00	€ 11.655.122,00	€ 12.189.445,00

	TERMINAL 11	**TERMINAL 12**
Interest rate 1,5% / Repayment 25 years	SC (56,0 hectare)	SC (74,5 hectare)
Total investment	€ 149.690.000,00	€ 207.625.000,00
Total interest over 25 years	€ 29.189.550,00	€ 40.486.875,00
Total paid over 25 years	€ 178.879.550,00	€ 248.111.875,00
Total costs per year	€ 7.155.182,00	€ 9.924.475,00

2.12.5.5 Labour costs

Note: Of course, the differences in labour costs are large worldwide and therefore in this study only intended as a comparison between the different terminal models.

For the labour costs we consider both the stack operations as well the transfer operations at the land side for truck and train. The assumptions for the labour costs are as follows.

OHBC: However these operations will be fully automated we still add a certain amount of labour costs to execute regular checks and regular modifications in programming. We assume an average cost of € 0,10 per move.

ORC: The operation will take place by remote control.
One operator controles 3 ORCs.
Costs per hour € 40,00.
Costs per move € 40,00 / 20 = € 2,00.

ARMG: However these operations will be fully automated we still add € 0,10 per move for regular checks and modification of programming.

SC: This will be a manned operation.
The costs of the driver is € 50,00 per hour.
Costs per move € 50,00 / 7 = € 7,14.

RC: This will be a manned operation.
Each crane has a driver à € 40,00 per hour.
Costs per move € 40,00 / 20 = € 2,00.

CHAPTER 3

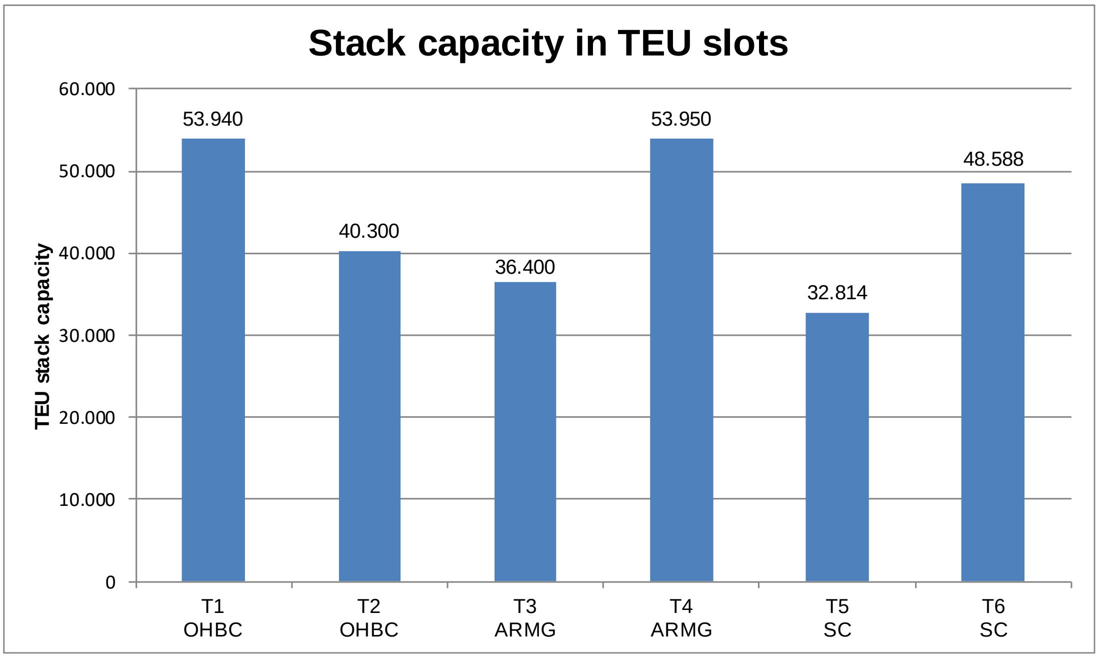
CONCLUSIONS

3.1 Terminals T1, T2, T3, T4, T5 and T6
3.2 Terminals T7, T8, T9, T10, T11 and T12

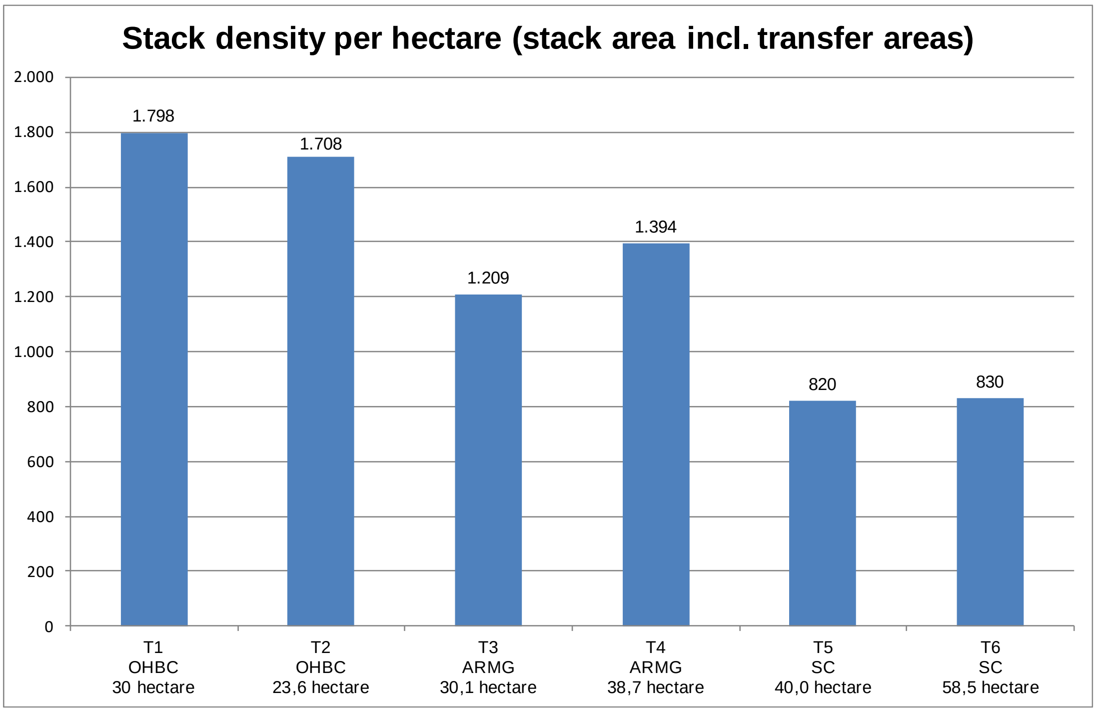
3.1 For container terminals with only ship to truck process applies for T1, T2, T3, T4, T5 and T6

3.1.1 Comparison performance

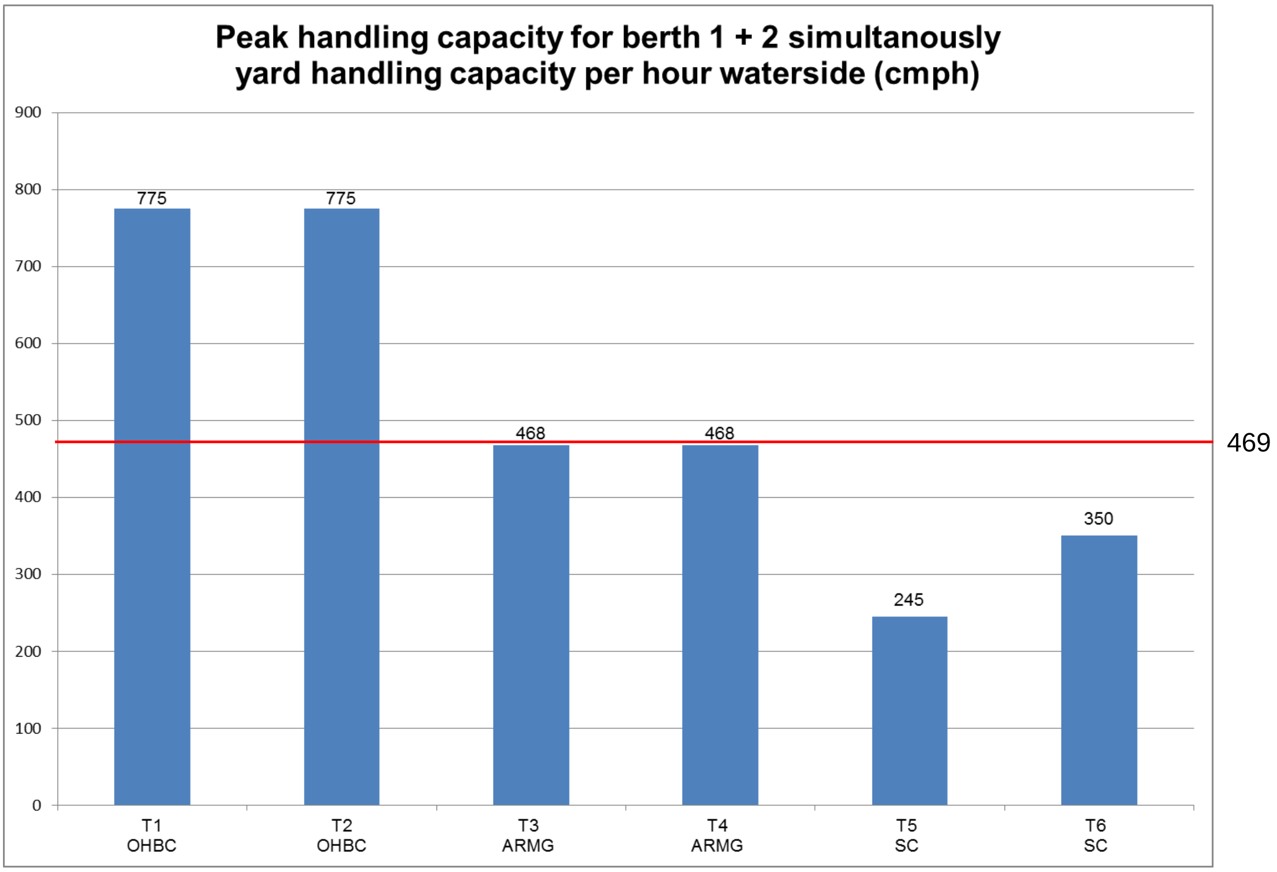
3.1.1.1 Stack capacity in TEU slots



3.1.1.2 Stack density per hectare (stack area incl. transfer areas)



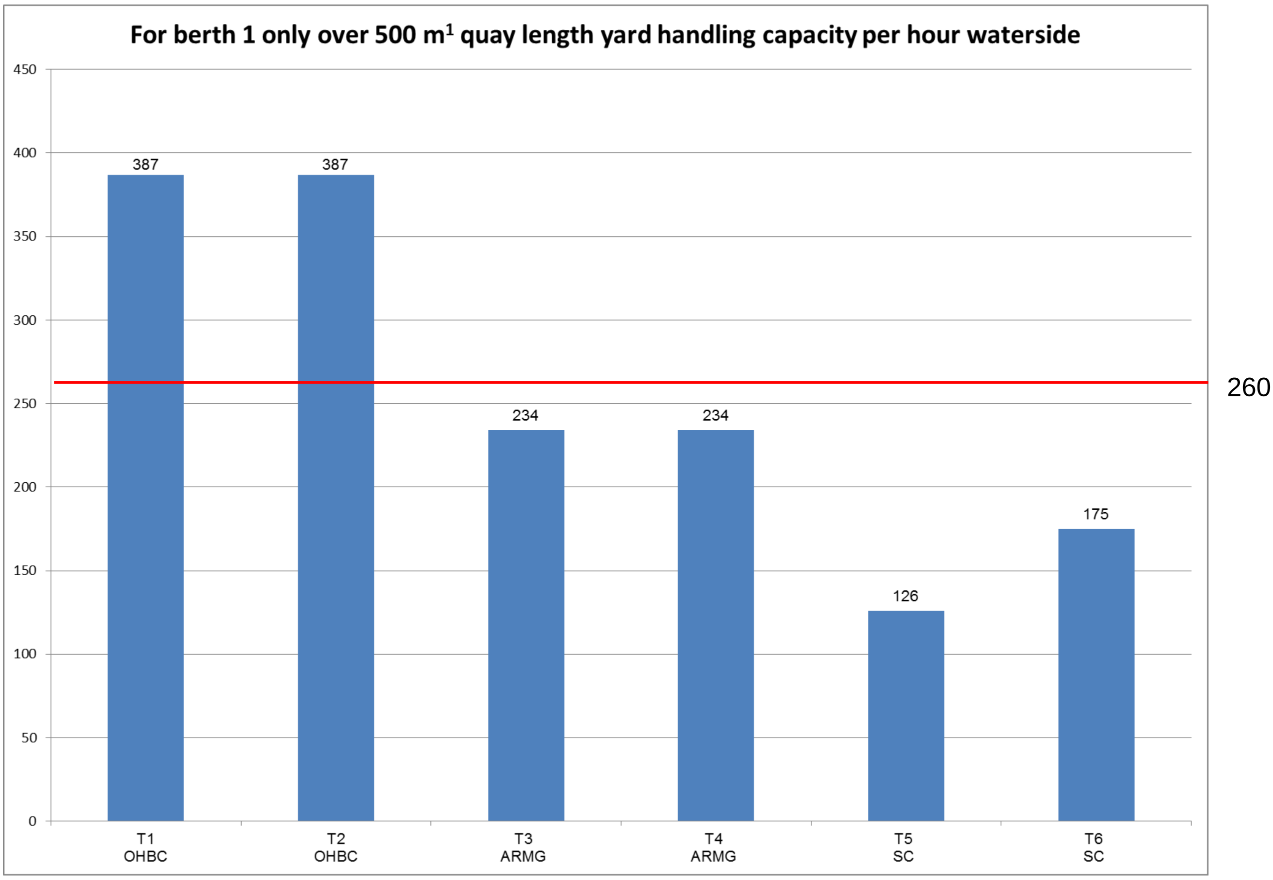
3.1.1.3 Peak handling capacity per hour waterside for whole terminal (quay length 1.000 m; 2 berths)



For the whole terminal
Requirement 9.000 container moves per 24 hour
Peak factor yard 1,25
9.000 / 24 x 1,25 = 469 cmph over 1.000 m quay length.

T1: 31 x 25 = 775 cmph (sufficient)
T2: 31 x 25 = 775 cmph (sufficient)
T3: 26 x 18 = 468 cmph (sufficient)
T4: 26 x 18 = 468 cmph (sufficient)
T5: 35 x 7 = 245 cmph (not sufficient)
T6: 50 x 7 = 350 cmph (not sufficient)

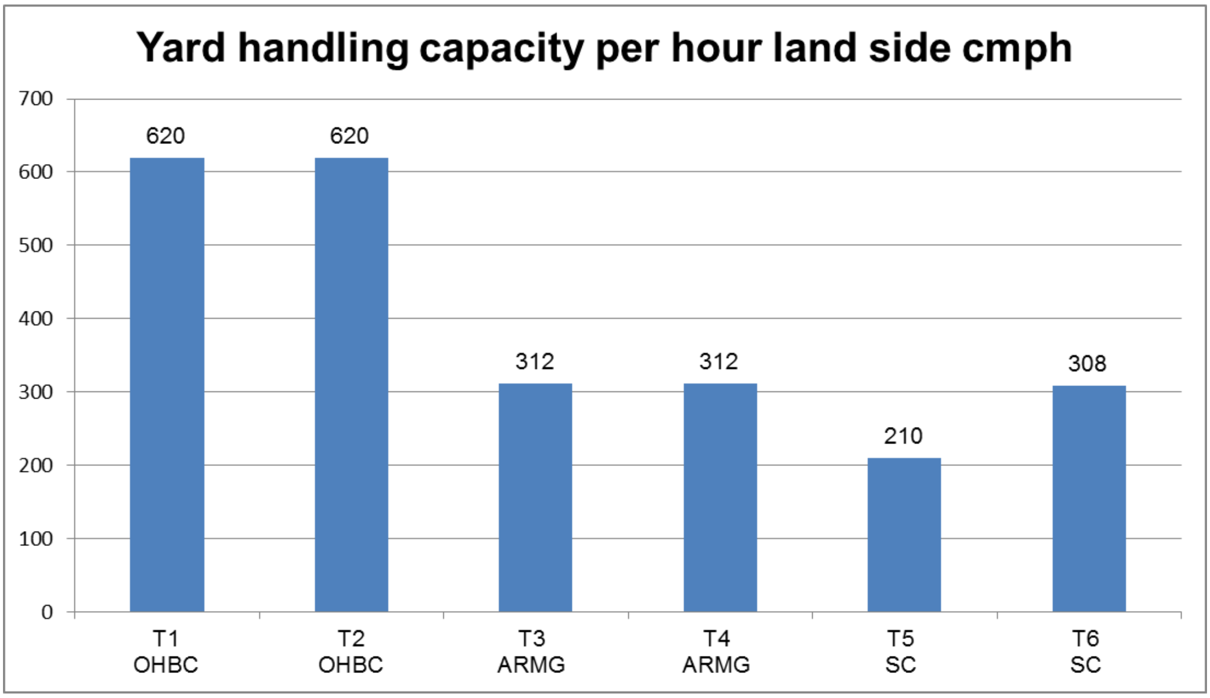
3.1.1.4 Peak handling capacity per hour waterside for 1 berth (quay length 500 m)



Requirement 5.000 container moves per 24 hour over 500 m^1 quay length
Peak factor 1,25
5.000 / 24 x 1,25 = 260 cmph.

T1: 15,5 x 25 = 387 cmph (sufficient)
T2: 15,5 x 25 = 387 cmph (sufficient)
T3: 13 x 18 = 234 cmph (not sufficient)
T4: 13 x 18 = 234 cmph (not sufficient)
T5: 18 x 7 = 126 cmph (not sufficient)
T6: 25 x 7 = 175 cmph (not sufficient)

3.1.1.5 Peak handling capacity per hour land side

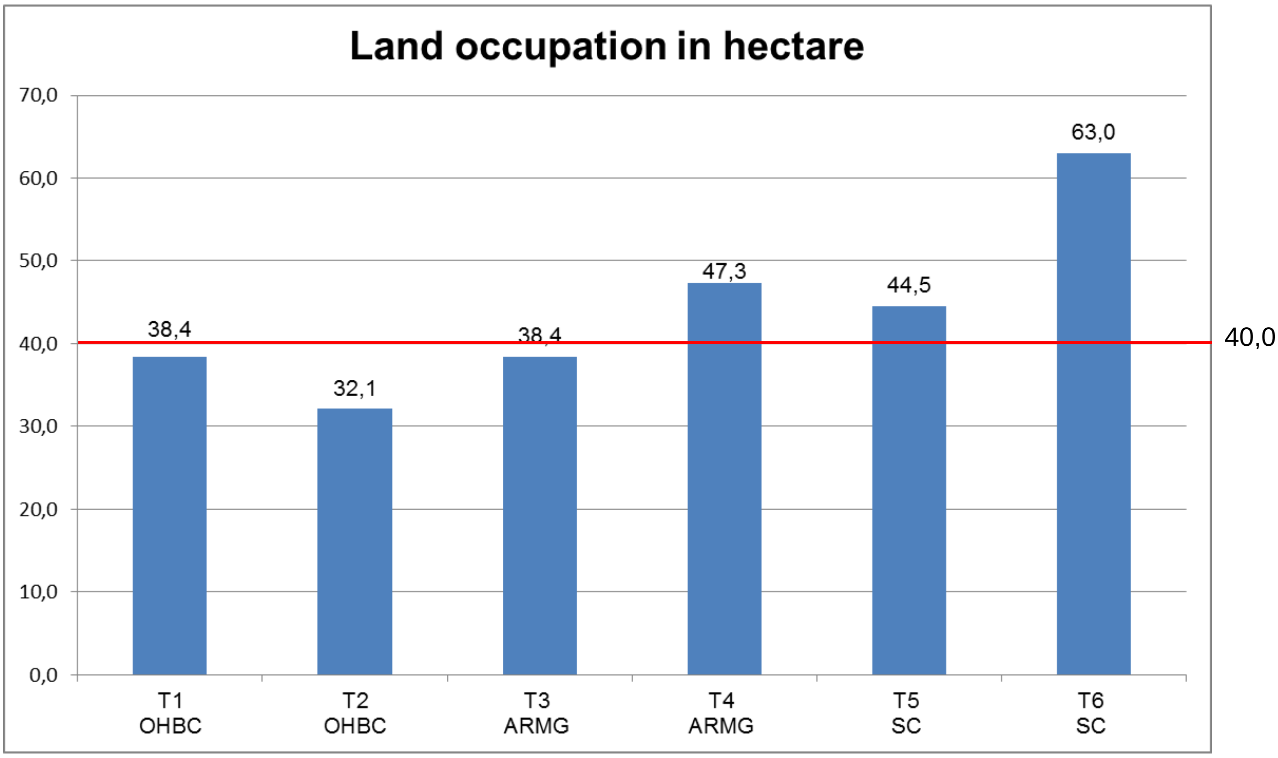


Requirement:

- Gate for trucks open 14 hours per day / 300 days per year. Total 4.200 hours.
- Peak factor yard = 1,4.

Terminal	Required capacity cmph x Peak factor	Actual capacity cmph	
T1	1.485.772 / 4.200 = 354 x 1,4 = 495	31 x 20 = 620	Sufficient
T2	1.127.138 / 4.200 = 268 x 1,4 = 375	31 x 20 = 620	Sufficient
T3	1.002.634 / 4.200 = 239 x 1,4 = 334	26 x 12 = 312	Not sufficient
T4	1.468.048 / 4.200 = 354 x 1,4 = 495	26 x 12 = 312	Not sufficient
T5	909.230 / 4.200 = 216 x 1,4 = 303	30 x 7 = 210	Not sufficient
T6	1.397.174 / 4.200 = 328 x 1,4 = 459	44 x 7 = 308	Not sufficient

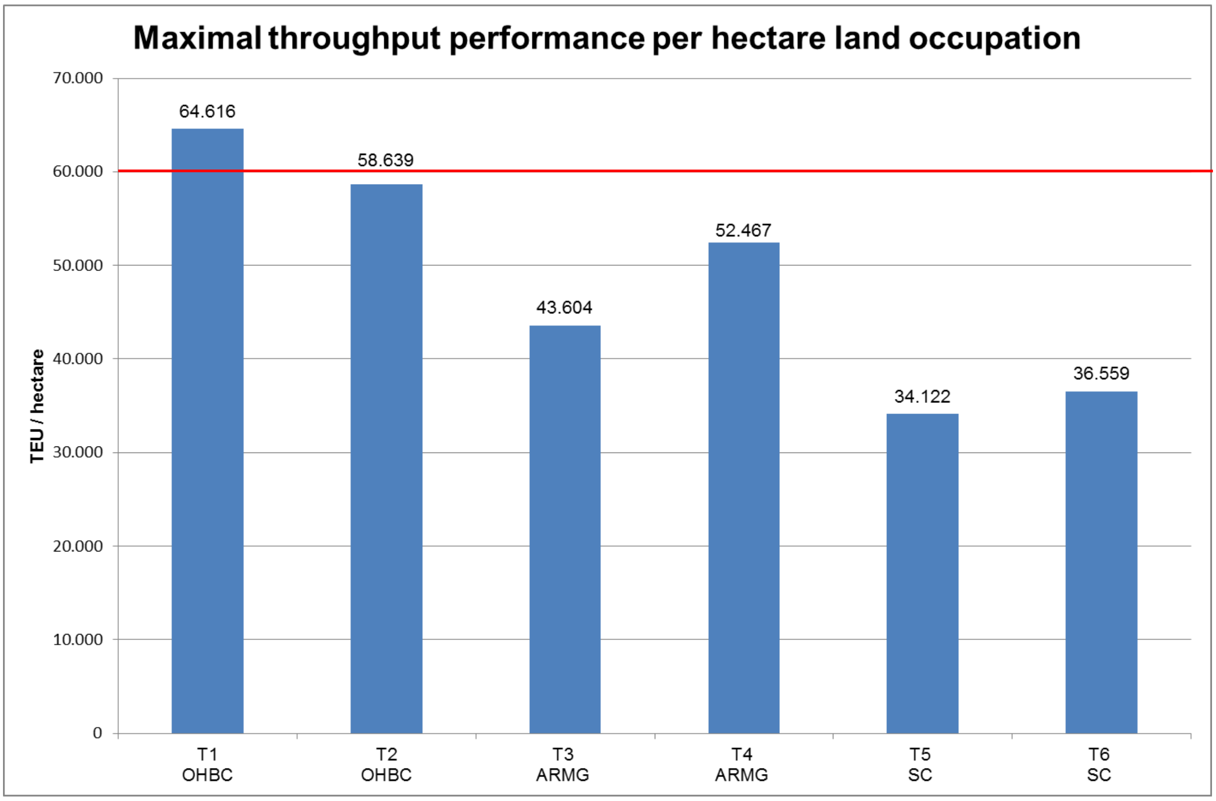
3.1.1.6 Land occupation in hectare



Available land surface = 40,0 hectare

Terminal	Land occupation		Surplus / Shortage + -
T1	38,4 hectare	Sufficient	+ 1,6 hectare
T2	32,1 hectare	Sufficient	+ 7,9 hectare
T3	38,4 hectare	Sufficient	+ 1,6 hectare
T4	47,3 hectare	Not sufficient	- 7,3 hectare
T5	44,5 hectare	Not sufficient	- 4,5 hectare
T6	63,0 hectare	Not sufficient	- 23,0 hectare

3.1.1.7 Throughput per m^2 land occupation

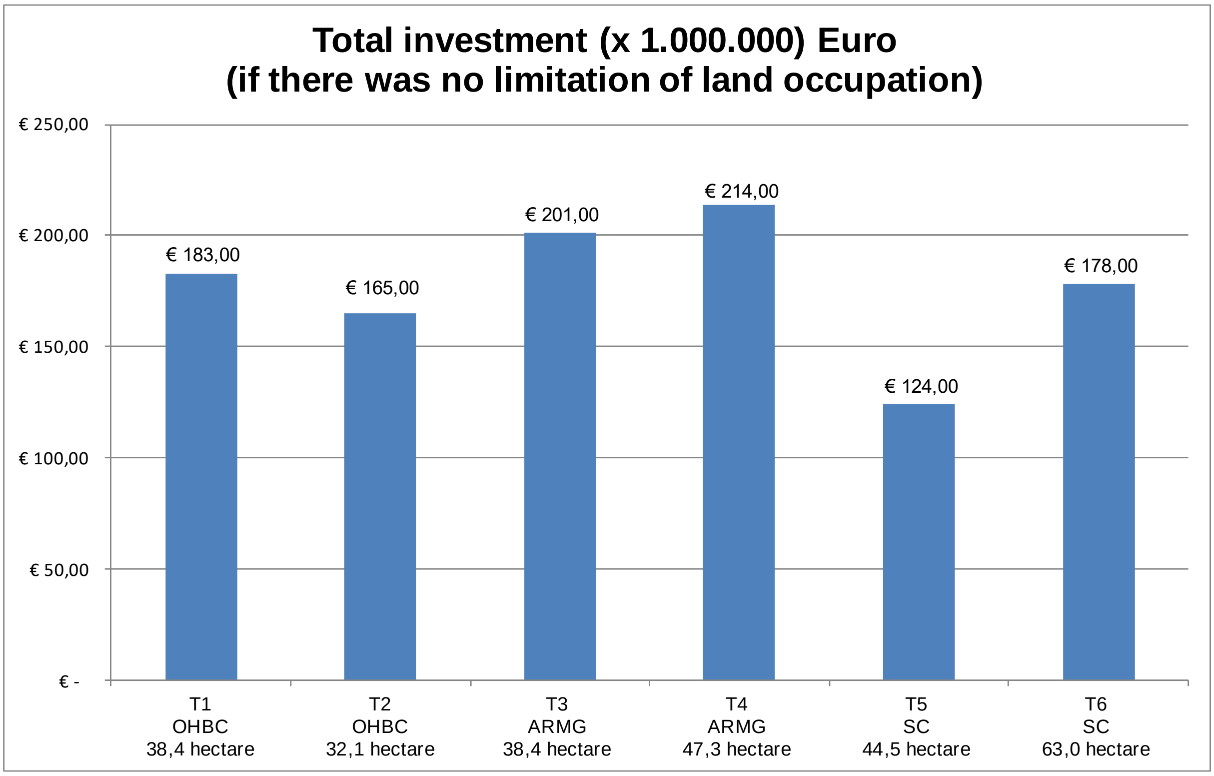


Required throughput per hectare per year = 60.000 TEU

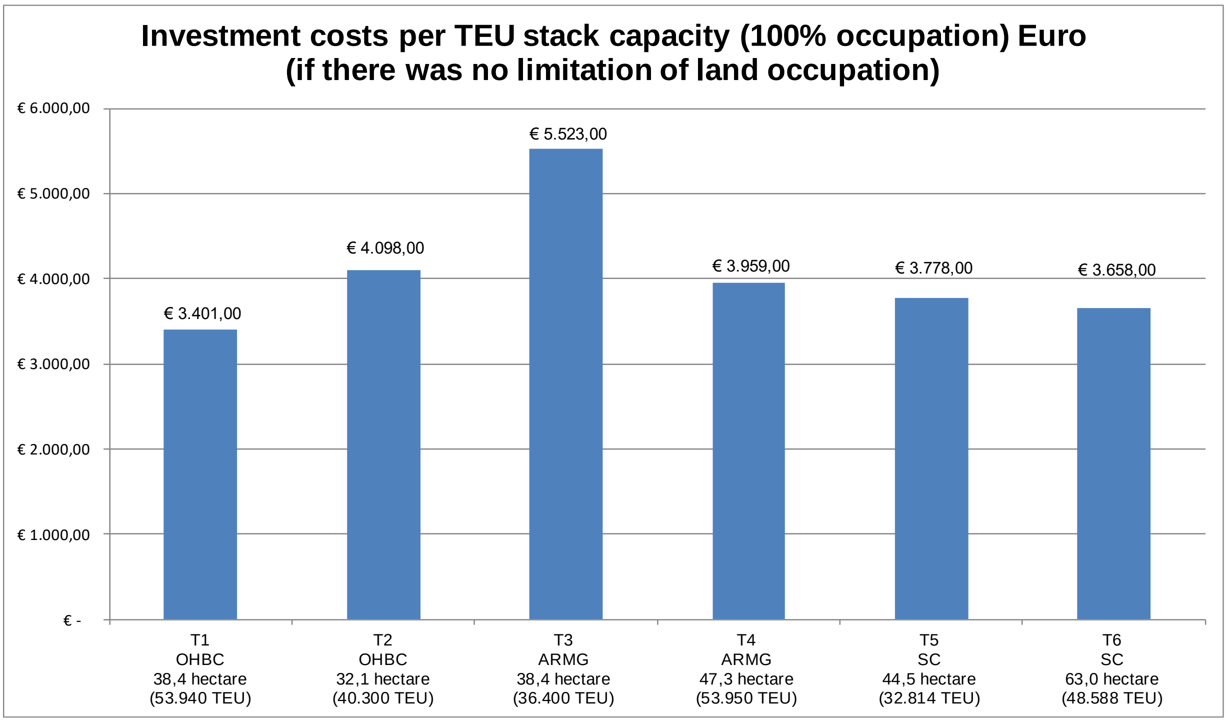
Terminal	Performance	
T1	2.481.240 / 38,4 = 64.616 TEU / hectare	Sufficient
T2	1.882.320 / 32,1 = 58.639 TEU / hectare	Almost sufficient
T3	1.674.400 / 38,4 = 43.604 TEU / hectare	Not sufficient
T4	2.481.700 / 47,3 = 52.467 TEU / hectare	Not sufficient
T5	1.518.414 / 44,5 = 34.122 TEU / hectare	Not sufficient
T6	2.303.220 / 63,0 = 36.559 TEU / hectare	Not sufficient

3.1.2 Comparison investment costs

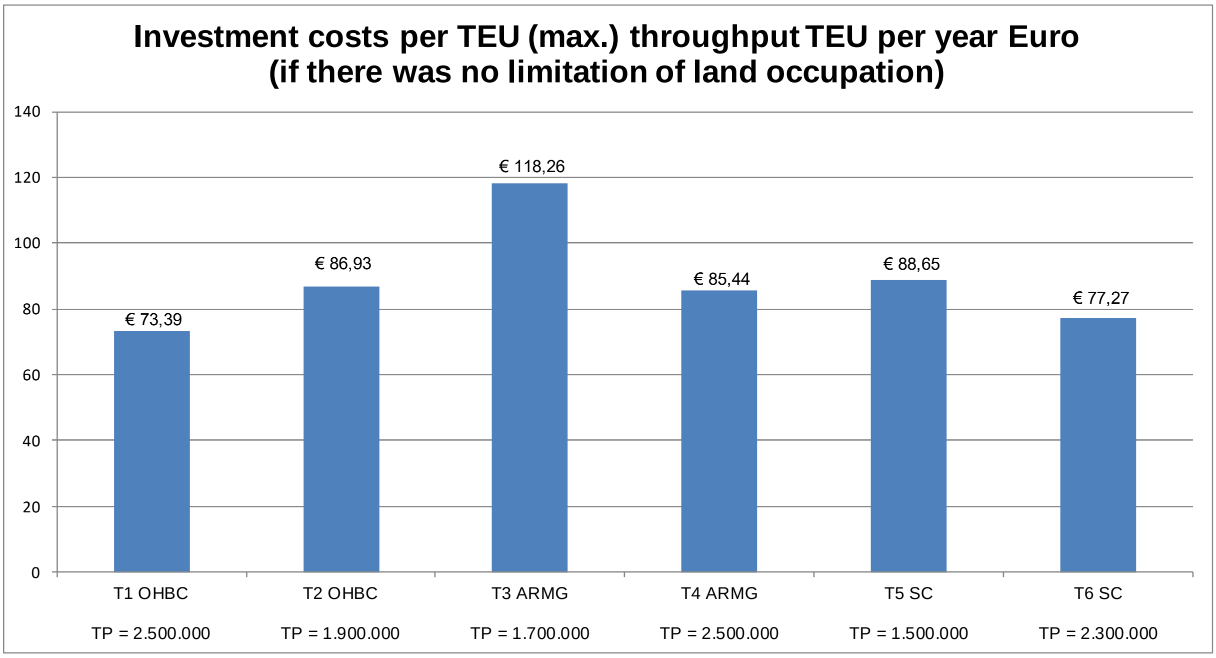
3.1.2.1 Investment costs T1, T2, T3, T4, T5 and T6



3.1.2.2 Investment costs T1, T2, T3, T4, T5 and T6 per TEU stack capacity

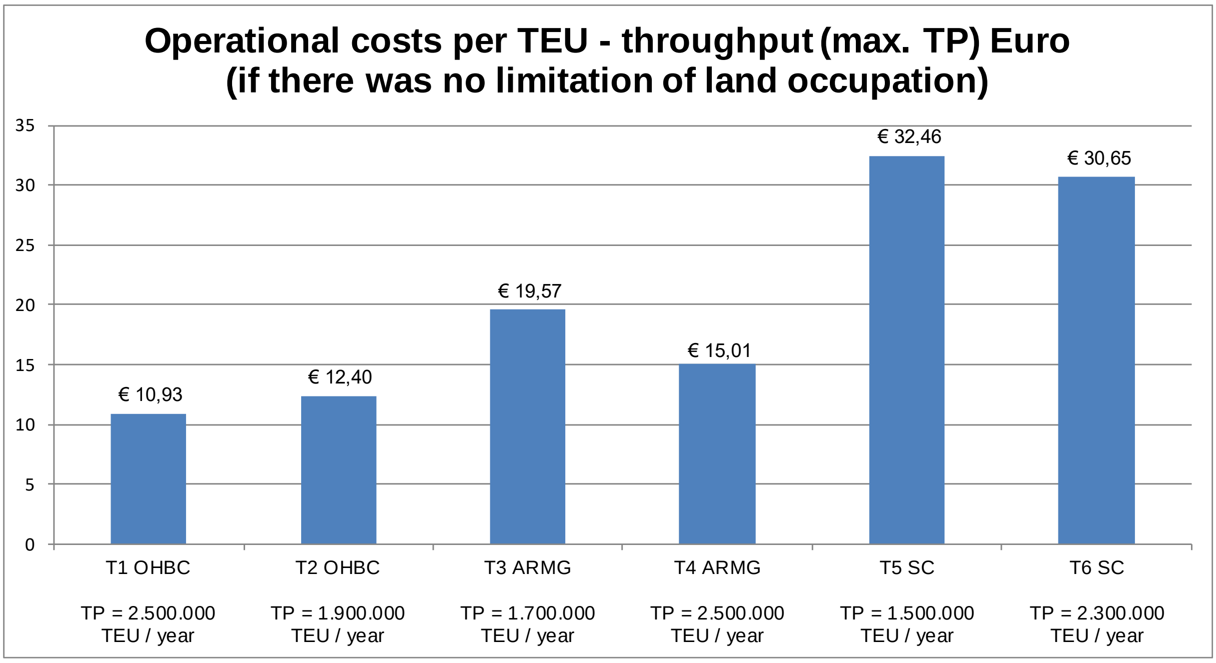


3.1.2.3 Investment costs T1, T2, T3, T4, T5 and T6 per TEU throughput



3.1.3 Comparison operational costs

3.1.3.1 Operational costs T1, T2, T3, T4, T5 and T6 per TEU throughput



3.1.3.2 Saving operational costs T1 versus T4

Comparison OHBC versus ARMG (T1 versus T4)
(if there was no limitation on available land occupation

TP per year TEU	Operational costs per TEU				Saving per year by OHBC	
	T4 ARMG 47,3 hectare		T1 OHBC 38,4 hectare			
2.500.000	€	15,01	€	10,93	€	10.200.000,00
2.250.000	€	16,42	€	11,97	€	10.012.500,00
2.000.000	€	18,16	€	13,36	€	9.600.000,00
1.750.000	€	20,41	€	15,16	€	9.187.500,00

3.1.3.3 Saving operational costs T2 versus T3

Comparison OHBC versus ARMG (T2 versus T3)
(if there was no limitation on available land occupation

TP per year TEU	Operational costs per TEU				Saving per year by OHBC	
	T3 ARMG 38,4 hectare		T2 OHBC 32,1 hectare			
1.750.000	€	19,00	€	13,47	€	9.677.500,00
1.500.000	€	21,87	€	15,61	€	9.390.000,00
1.250.000	€	25,90	€	18,56	€	9.175.000,00

3.1.3.4 Saving operational costs T1 versus T6

Comparison OHBC versus SC (T6 versus T1)
(if there was no limitation on available land occupation

TP per year TEU	Operational costs per TEU				Saving per year by OHBC	
	T6 SC 63,0 hectare		T1 OHBC 38,4 hectare			
2.500.000	€	30,00	€	10,93	€	46.675.000,00
2.250.000	€	31,34	€	11,97	€	43.582.500,00
2.000.000	€	33,01	€	13,36	€	39.300.000,00
1.750.000	€	35,15	€	15,16	€	34.982.500,00
1.500.000	€	38,01	€	17,55	€	30.690.000,00

3.1.3.5 Saving operational costs T2 versus T5

Comparison OHBC versus SC (T2 versus T5)
(if there was no limitation on available land occupation

TP per year TEU	Operational costs per TEU				Saving per year by OHBC	
	T5 SC 44,5 hectare		T2 OHBC 32,1 hectare			
1.750.000	€	30,22	€	13,47	€	29.312.500,00
1.500.000	€	32,46	€	15,61	€	25.275.000,00
1.250.000	€	35,08	€	18,56	€	20.650.000,00

3.1.3.6 Resume operational costs T1 to T6

	T1 OHBC (38,4 hectare)	T2 OHBC (21,1 hectare)	T3 ARMG (38,4 hectare)	T4 ARMG (47,3 hectare)	T5 SC (44,5 hectare)	T6 SC (63,0 hectare)
Total investments costs	€ 183.473.080,00	€ 165.159.540,00	€ 209.049.200,00	€ 221.587.490,00	€ 123.980.000,00	€ 177.725.000,00
Total operational costs per year	€ 27.122.948,00	€ 23.720.683,00	€ 33.242.732,00	€ 37.516.305,00	€ 48.700.539,00	€ 71.475.867,00
Thoughput in TEU / year						
2.500.000	***€ 10,93***			***€ 15,01***		***€ 30,00***
2.250.000	€ 11,97			€ 16,42		€ 31,34
2.000.000	€ 13,36	***€ 11,86***		€ 18,16		€ 33,01
1.750.000	€ 15,16	€ 13,47	***€ 19,00***	€ 20,41	***€ 30,22***	€ 35,15
1.500.000	€ 17,55	€ 15,61	€ 21,87	€ 23,40	€ 32,46	€ 38,01
1.250.000	€ 20,90	€ 18,56	€ 25,90		€ 35,08	
1.000.000			€ 30,31		€ 39,32	

The figures in red colour are above maximal performance.

3.1.3.7 Comparison of the normative factors between T1 to T6

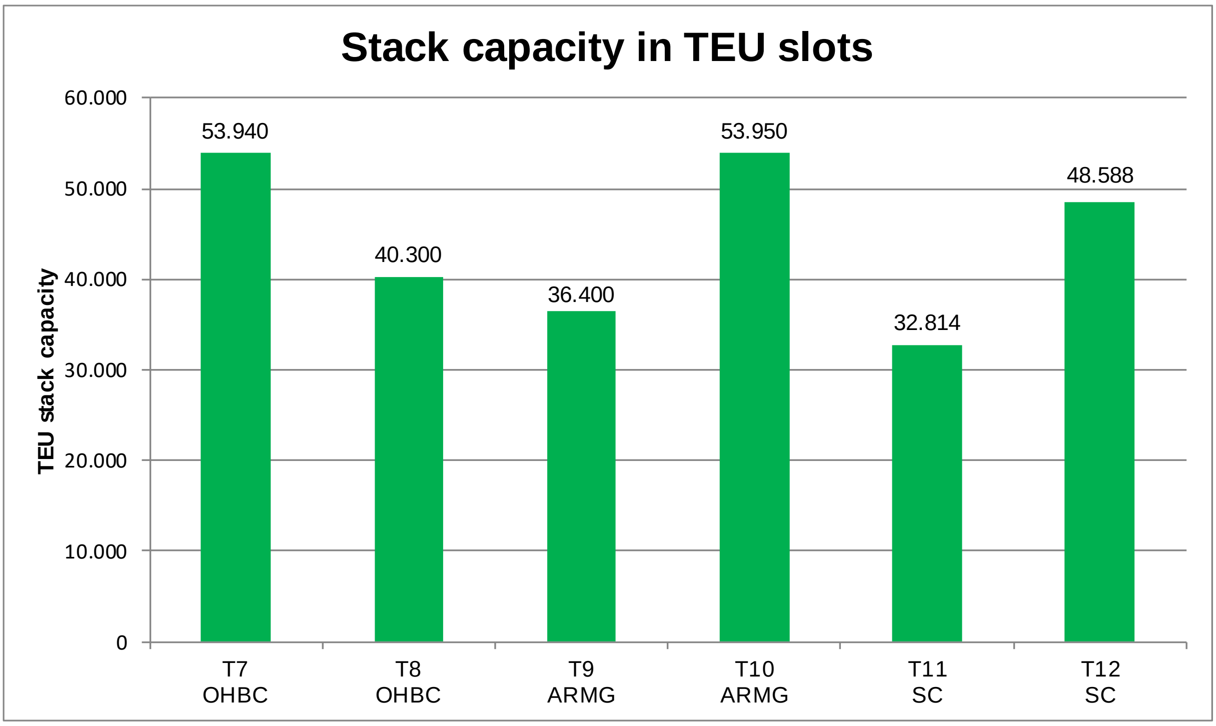
Subject	OHBC T1 + T2		ARMG T3 + T4		SC T5 + T6	
	Figures	Average (T1 + T2)	Figures	Average (T3 + T4)	Figures	Average (T5 + T6)
Stack density Stack area + transfer area (TEU per hectare)	T1 = 1.789 T2 = 1.708	1.753 = 100%	T3 = 1.209 T4 = 1.394	1.302 = 74%	T5 = 820 T56 = 830	825 = 47%
Yearly throughput per hectare land occupation (TEU)	T1 = 64.616 T2 = 58.639	61.628 = 100%	T3 = 43.604 T4 = 52.467	48.036 = 78%	T5 = 34.122 T6 = 36.559	35.341 = 57%
Peak capacity yard handling on water side * (container moves per hour)	T1 = 775 T2 = 775	775 = 100%	T3 = 468 T4 = 468	468 = 60%	T5 = 245 T6 = 350	298 = 38%
Peak capacity yard handling on land side * (container moves per hour)	T1 = 620 T2 = 620	620 = 100%	T3 = 312 T4 = 312	312 = 50%	T5 = 210 T6 = 308	259 = 42%
Total investment costs (Euro) (x 1.000.000)	T1 = 183 T2 = 165	174 = 100%	T3 = 209 T4 = 222	216 = 124%	T5 = 124 T6 = 178	151 = 87%
Investment costs per TEU stack capacity (Euro)	T1 = 3.401 T2 = 4.098	3.750 = 100%	T3 = 5.743 T4 = 4.107	4.925 = 131%	T5 = 3.778 T6 = 3.658	3.718 = 99%
Investment costs per TEU thoughput per year (Euro)	T1 = 73,79 T2 = 86,93	80,36 = 100%	T3 = 122,97 T4 = 88,63	105,8 = 148%	T5 = 88,65 T6 = 77,27	82,96 = 103%
Operational costs per TEU throughput per year (Euro) (maximal performance)	T1 = 10,93 T2 = 12,40	11,67 = 100%	T3 = 19,57 T4 = 15,01	17,29 = 148%	T5 = 32,46 T6 = 30,85	31,65 = 271%

* If 2 containers at the same time inside the OHBC would be transported the productivity could be about 900 cmph.

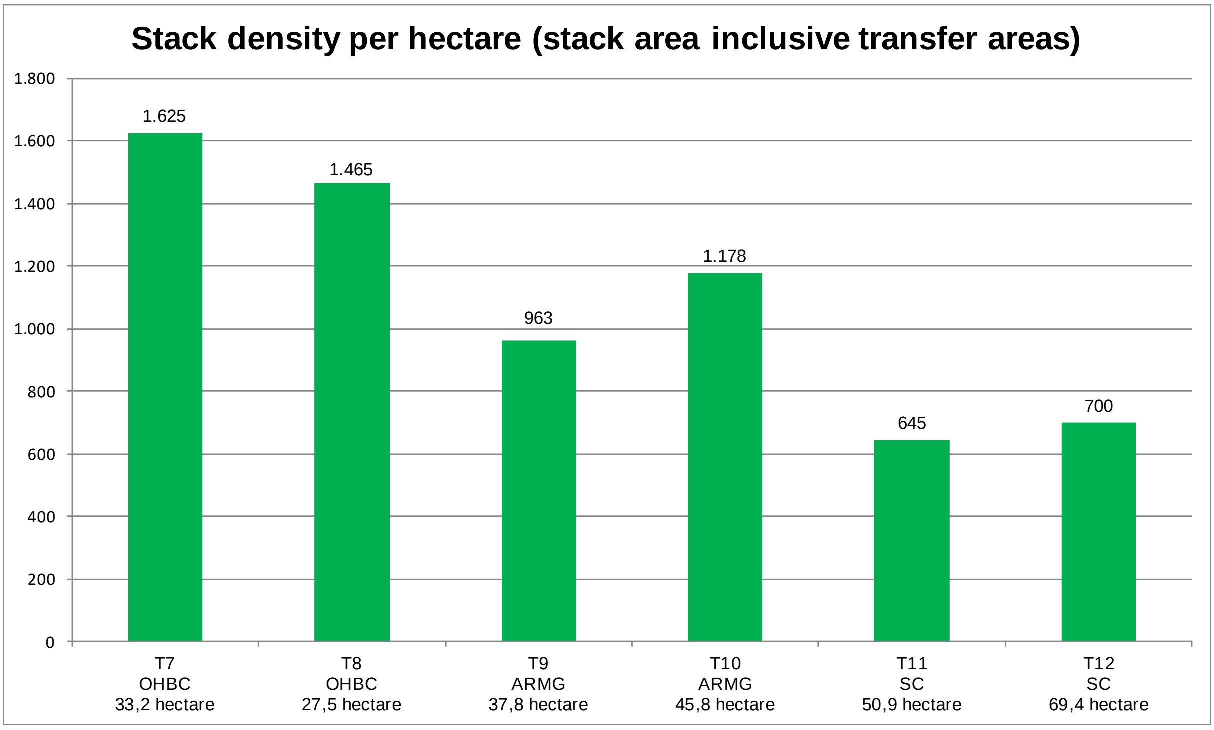
3.2 Applies for container terminals with ship to truck and train process for T7, T8, T9, T10, T11 and T12

3.2.1 Comparison performance

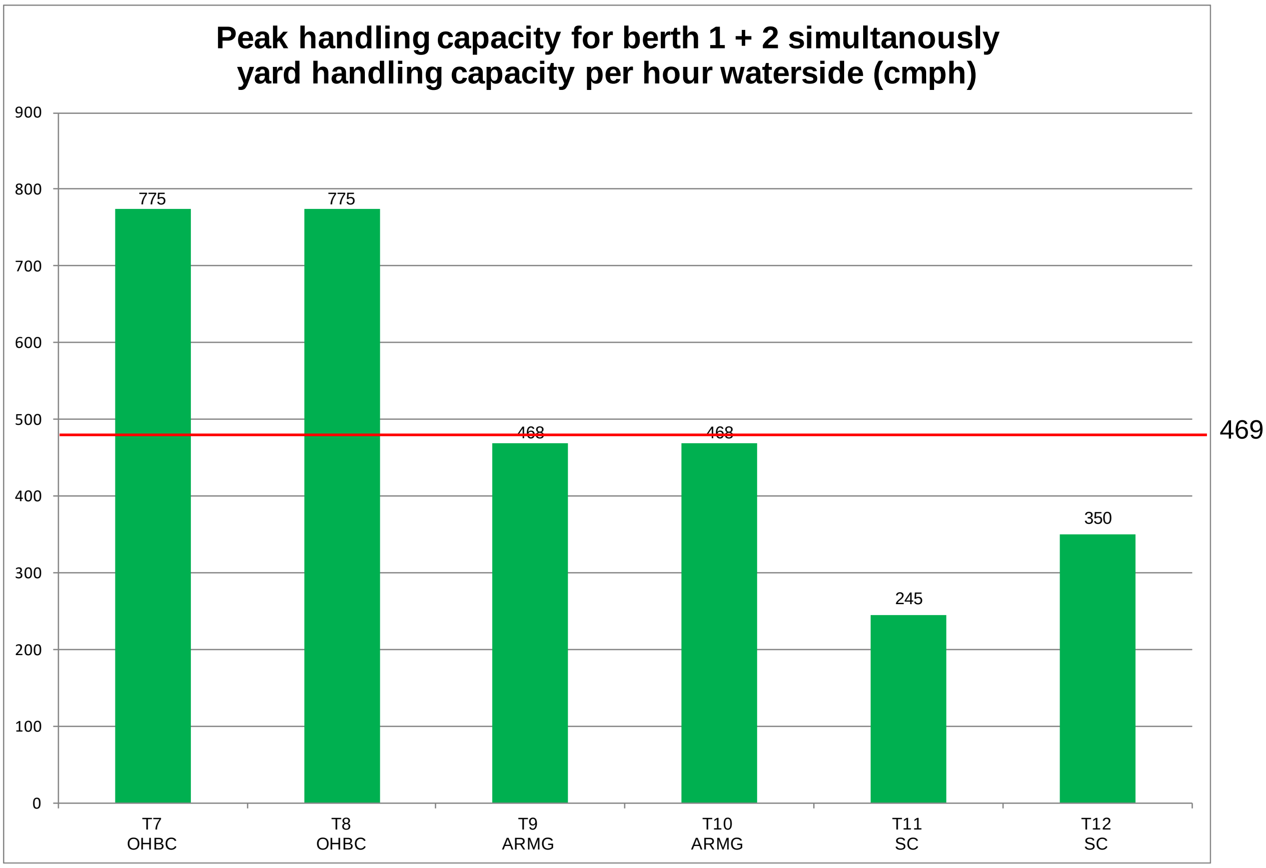
3.2.1.1 Stack capacity in TEU slots



3.2.1.2 Stack density in TEU per hectare



3.2.1.3 Peak handling capacity per hour waterside for whole terminal (quay length 1.000 m; 2 berths)

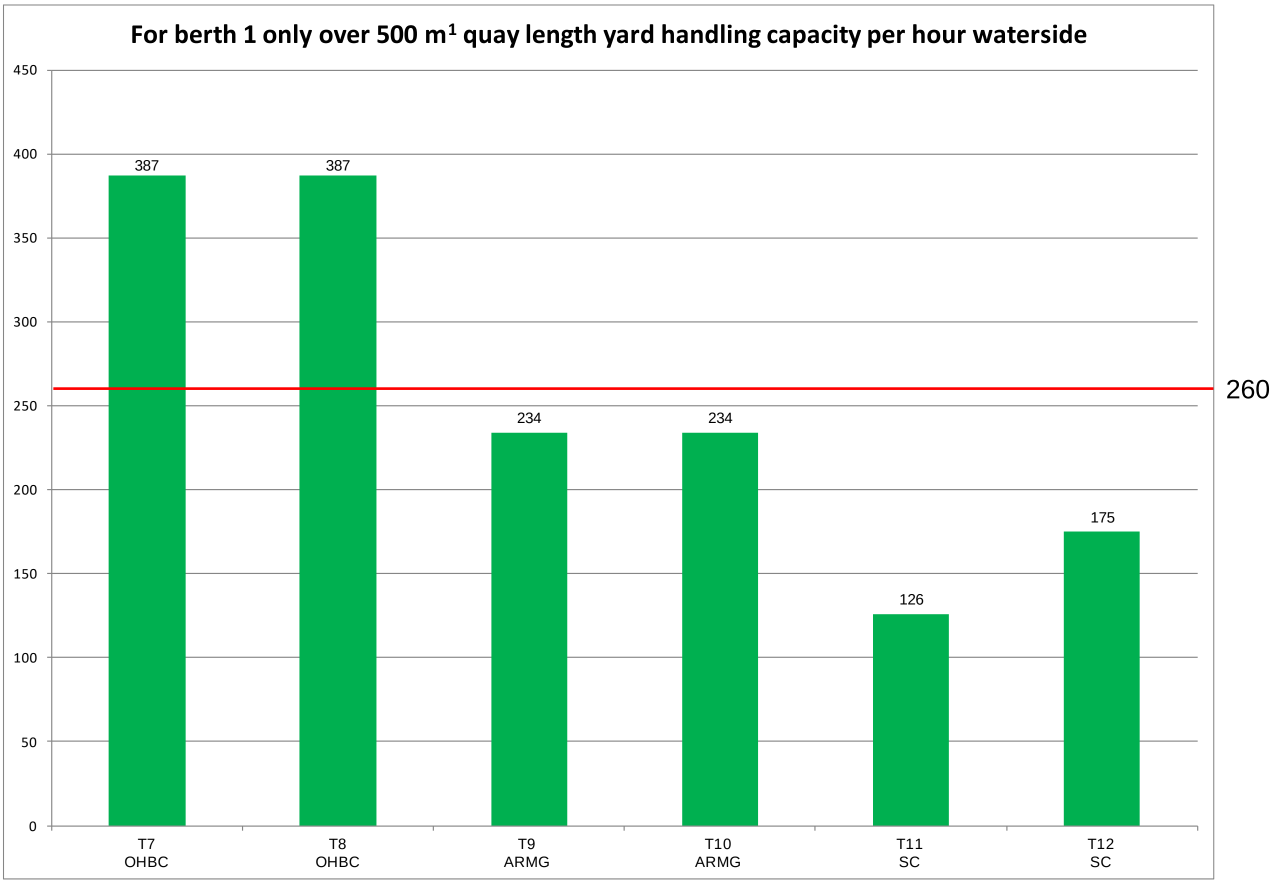


For the whole terminal

Requirement 9.000 container moves per 24 hour
Peak factor yard 1,25
9.000 / 24 x 1,25 = 469 cmph over 1.000 m quay length.

T7: 31 x 25 = 775 cmph (sufficient)
T8: 31 x 25 = 775 cmph (sufficient)
T9: 26 x 18 = 468 cmph (sufficient)
T10: 26 x 18 = 468 cmph (sufficient)
T11: 35 x 7 = 245 cmph (not sufficient)
T12: 50 x 7 = 350 cmph (not sufficient)

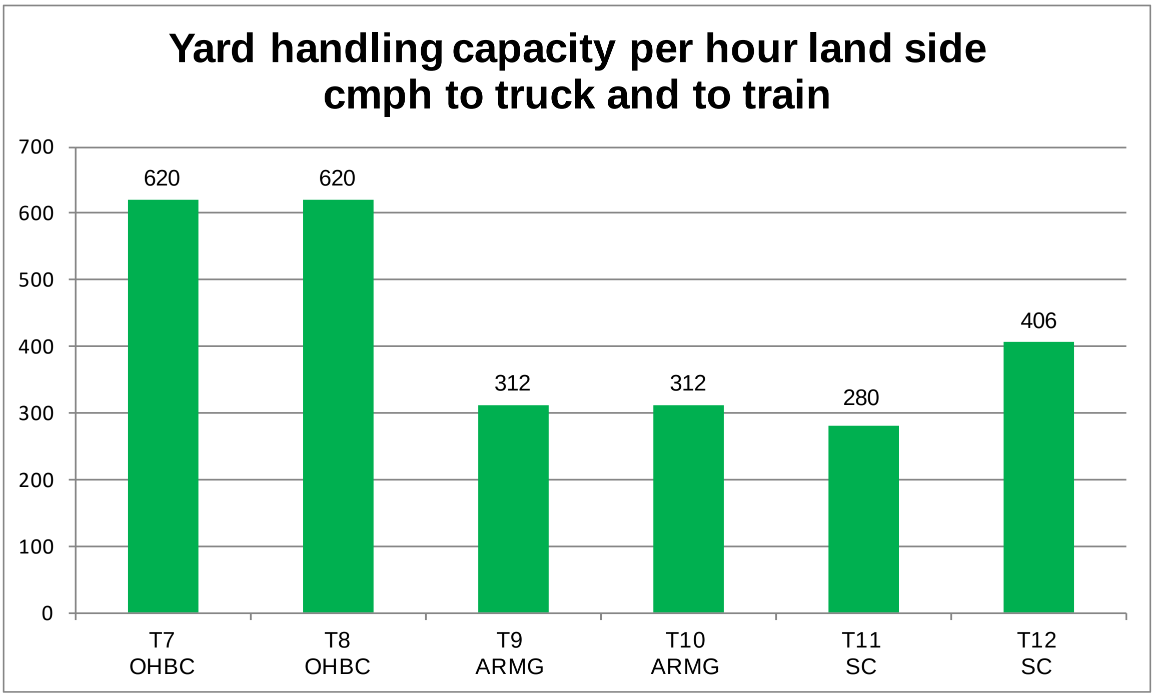
3.2.1.4 Peak handling capacity per hour waterside for 1 berth (quay length 500 m)



Requirement 5.000 container moves per 24 hour over 500 m^1 quay length
Peak factor 1,25
5.000 / 24 x 1,25 = 260 cmph.

T7: 15,5 x 25 = 387 cmph (sufficient)
T8: 15,5 x 25 = 387 cmph (sufficient)
T9: 13 x 18 = 234 cmph (not sufficient)
T10: 13 x 18 = 234 cmph (not sufficient)
T11: 18 x 7 = 126 cmph (not sufficient)
T12: 25 x 7 = 175 cmph (not sufficient)

3.2.1.5 Peak handling capacity per hour land side

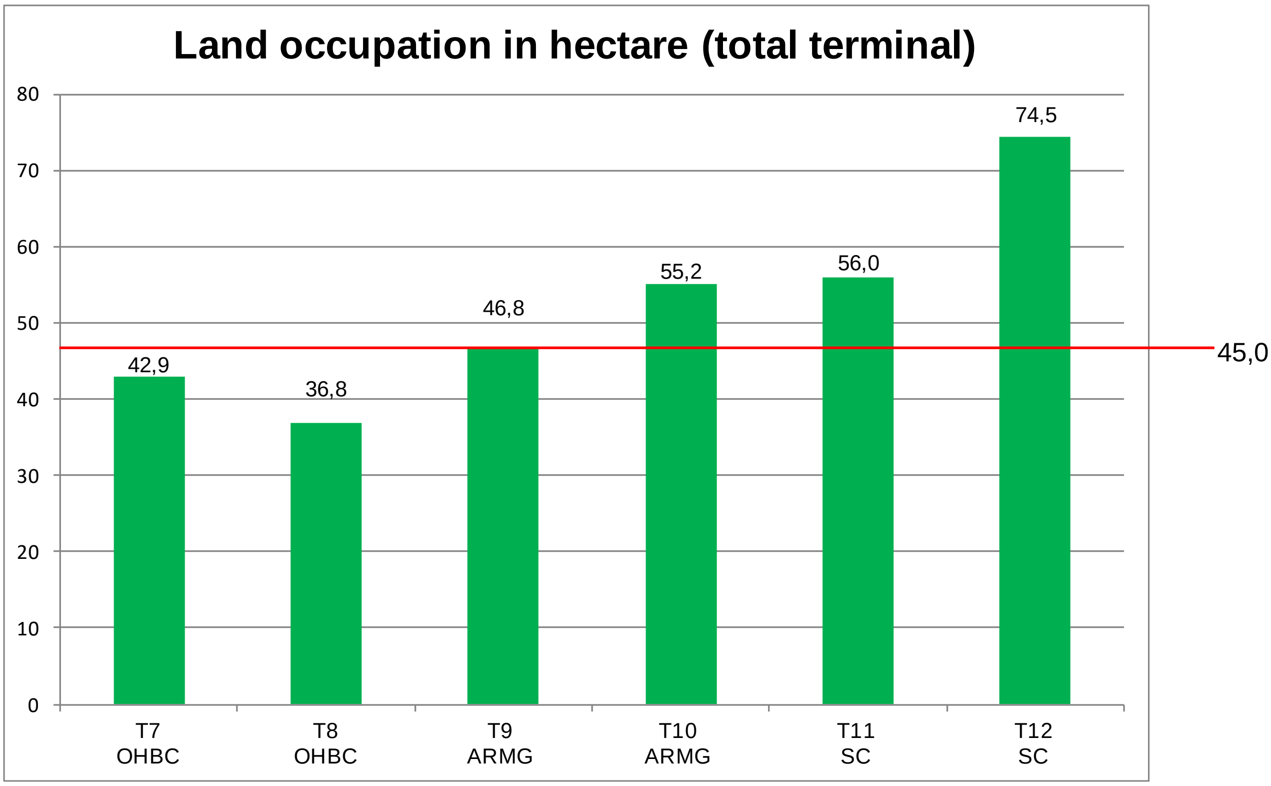


Requirement:
- Gate for trucks open 14 hours per day à 300 days per year. Total 4.200 hours.
- Gate for train open 24 hours per day à 300 days per year. Total 7.200 hours.
- Peak factor yard = 1,4.

Terminal	Required capacity cmph x Peak factor		Actual capacity cmph	
T7	1.485.772 / 4.200 = 354 x 1,4 = 495		31 x 20 = 620	Sufficient
T8	1.127.138 / 4.200 = 268 x 1,4 = 375		31 x 20 = 620	Sufficient
T9 Truck	70% x 1.002.634 / 4.200 = 167 x 1,4 = 234	293	26 x 12 = 312	Sufficient
T9 Train	30% x 1.002.634 / 7.200 = 42 x 1,4 = 59			
T10 Truck	70% x 1.468.048 / 4.200 = 245 x 1,4 = 342	428	26 x 12 = 312	Not sufficient
T10 Train	30% x 1.468.048 / 7.200 = 61 x 1,4 = 86			
T11 Truck	70% x 909.230 / 4.200 = 152 x 1,4 = 213	266	40 x 7 = 280	Sufficient
T11 Train	30% x 909.230 / 7.200 = 38 x 1,4 = 53			
T12 Truck	70% x 1.379.174 / 4.200 = 230 x 1,4 = 322	402	58 x 7 = 406	Sufficient
T12 Train	30% x 1.379.174 / 7.200 = 57 x 1,4 = 80			

Note: For T11 and T12 applies transfer to rail depot.

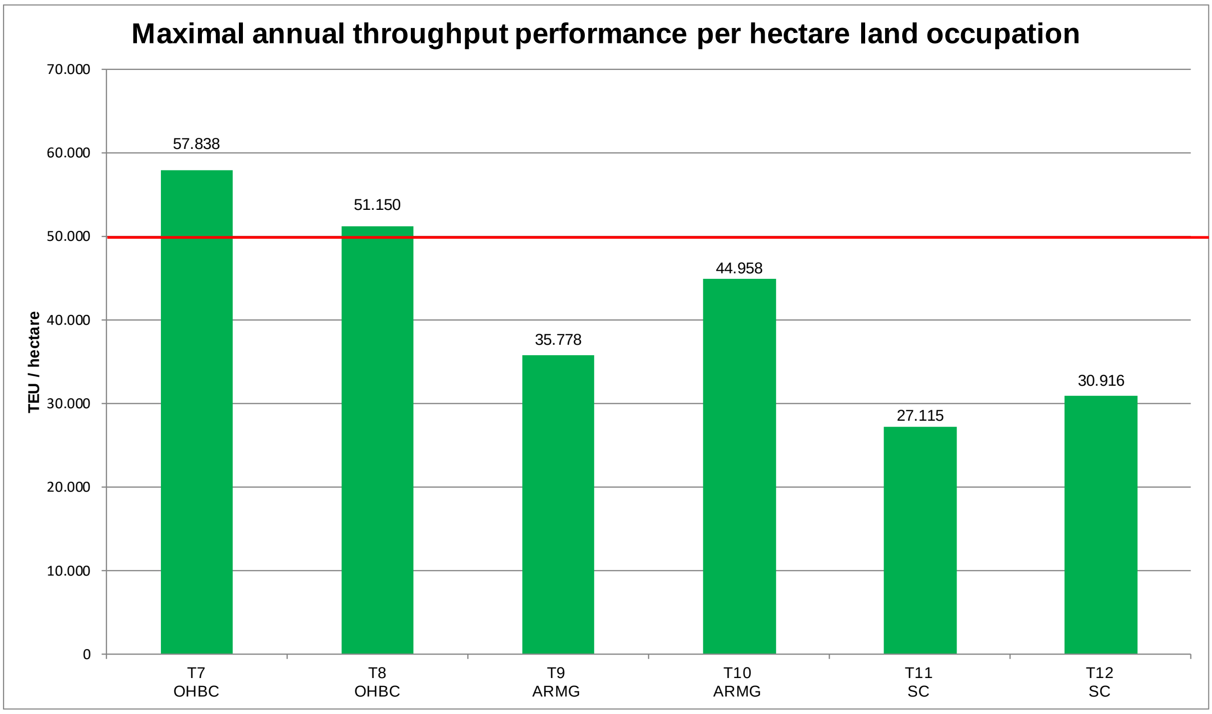
3.2.1.6 Land occupation in hectare



Available land surface = 45,0 hectare.

Terminal	Land occupation		Surplus / Shortage + -
T7	42,9 hectare	Sufficient	+ 2,1 hectare
T8	36,8 hectare	Sufficient	+ 8,2 hectare
T9	46,8 hectare	Sufficient	+ 1,8 hectare
T10	55,2 hectare	Not sufficient	- 10,2 hectare
T11	56,0 hectare	Not sufficient	- 11,0 hectare
T12	74,5 hectare	Not sufficient	- 29,5 hectare

3.2.1.7 Throughput per m^2 land occupation

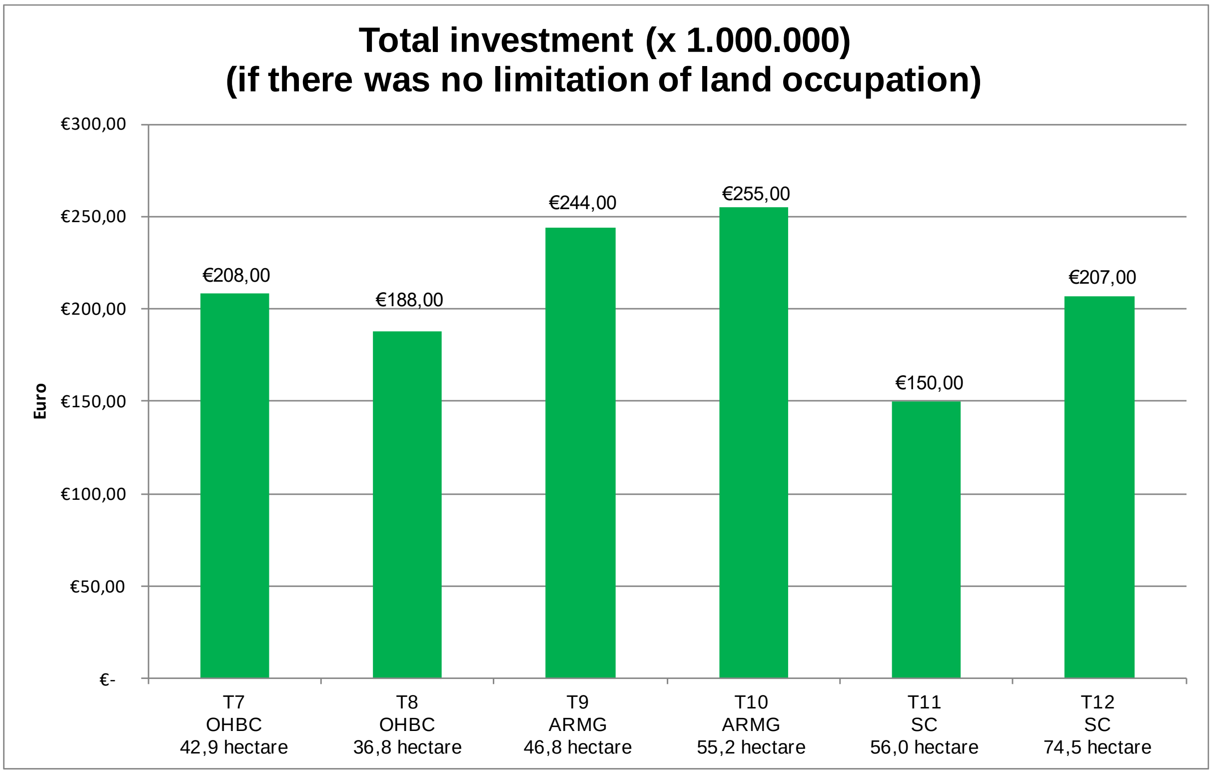


Required throughput per hectare per year = 60.000 TEU

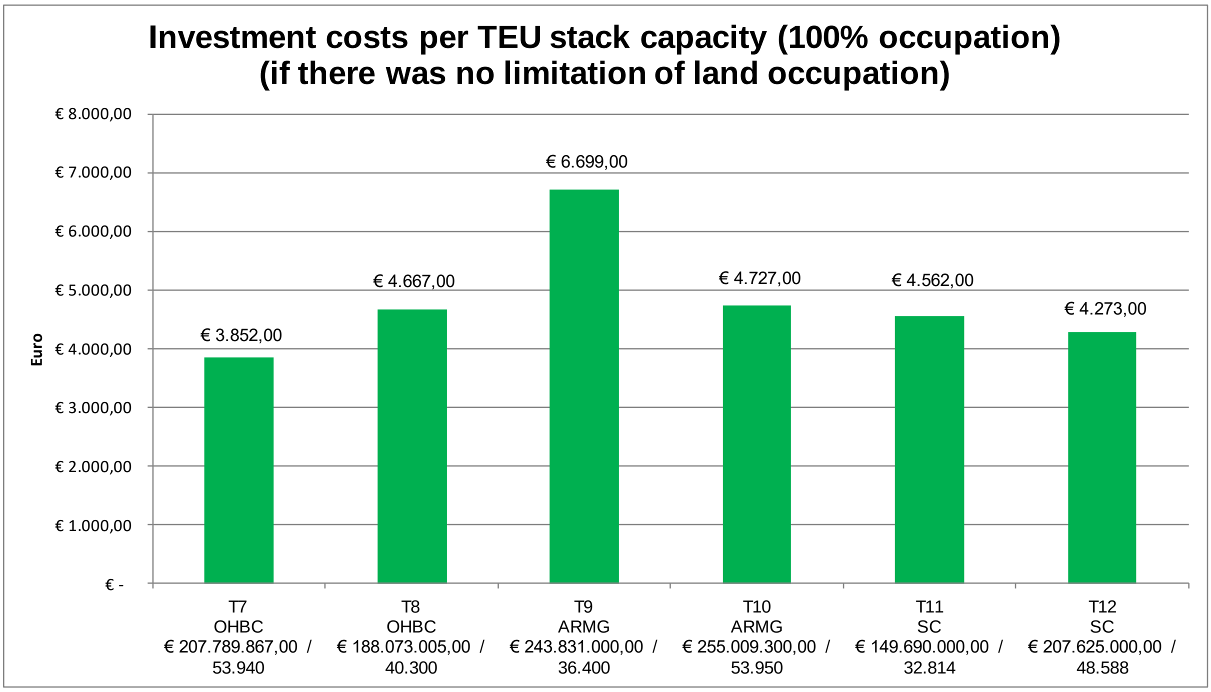
T7	2.481.240 / 42,9 = 57.838 TEU / hectare	Sufficient
T8	1.882.320 / 36,8 = 51.150 TEU / hectare	sufficient
T9	1.674.400 / 46,8 = 35.778 TEU / hectare	Not sufficient
T10	2.481.700 / 55,2 = 44.958 TEU / hectare	Not sufficient
T11	1.518.414 / 56,0 = 27.115 TEU / hectare	Not sufficient
T12	2.303.220 / 74,5 = 30.916 TEU / hectare	Not sufficient

3.2.2 Comparison investment costs

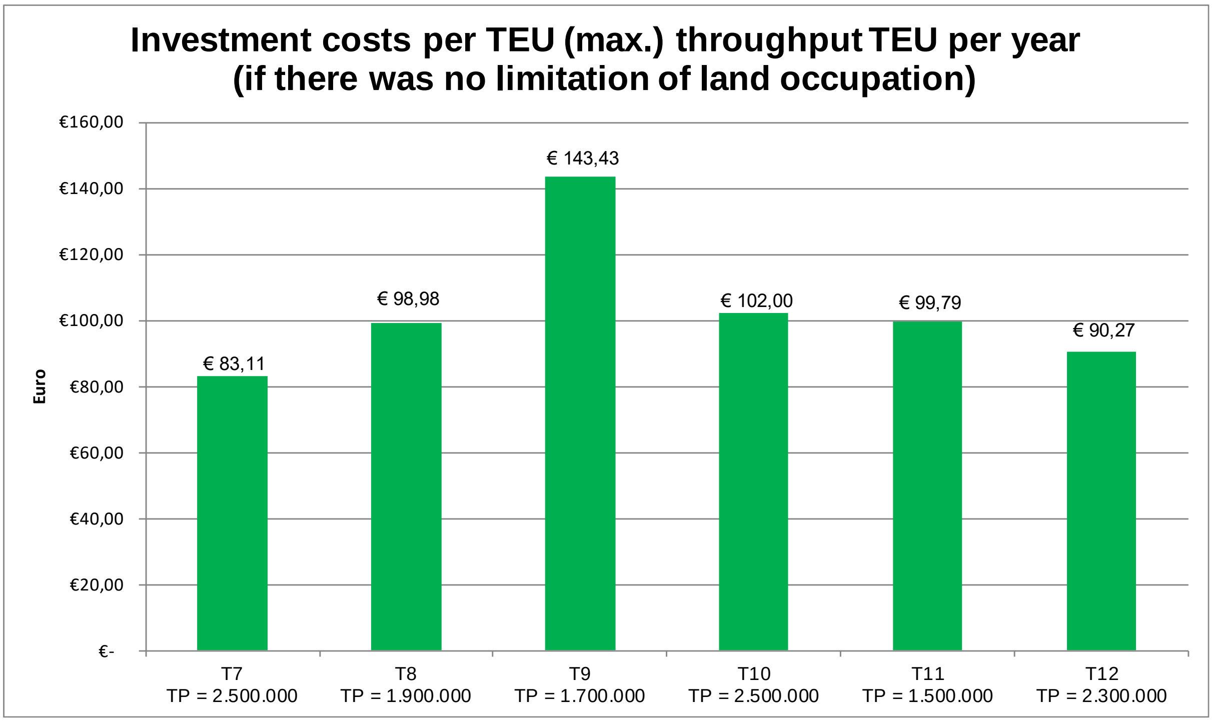
3.2.2.1 Investment costs T7, T8, T9, T10, T11 and T12



3.2.2.2 Investment costs T7, T8, T9, T10, T11 and T12 per TEU stack capacity

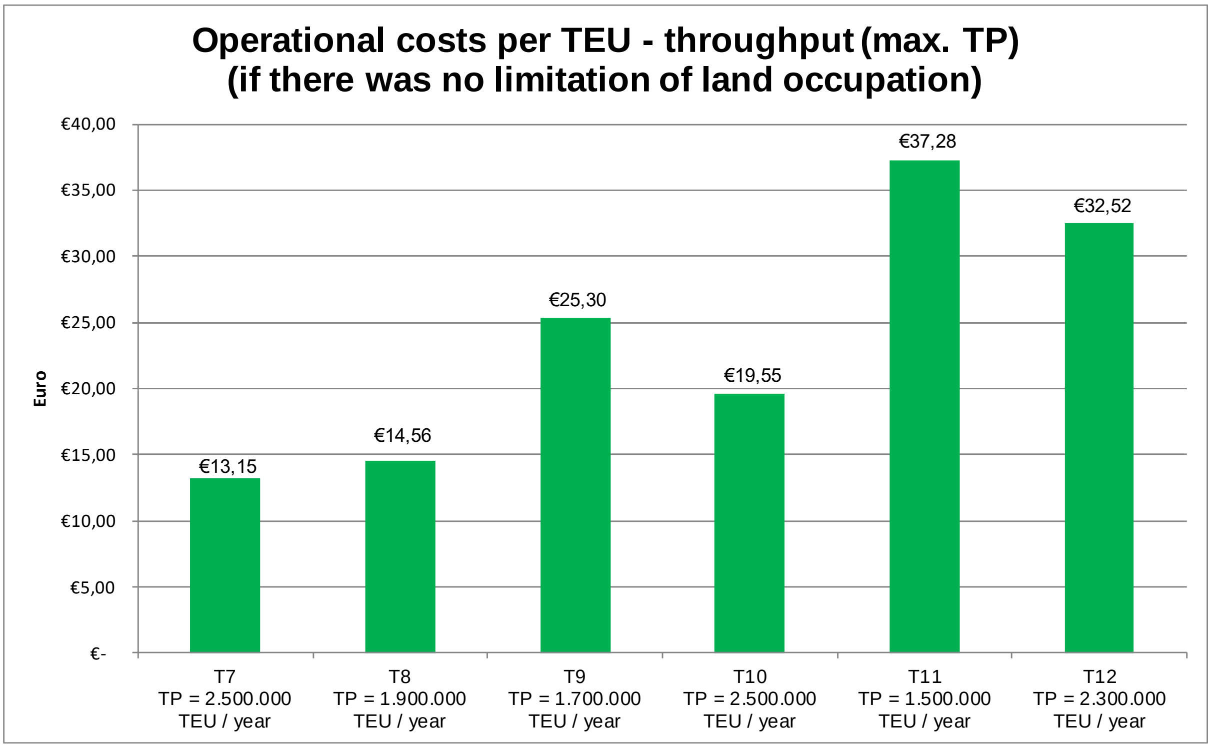


3.2.2.3 Investment costs T7, T8, T9, T10, T11 and T12 per TEU throughput



3.2.3 Comparison operational costs

3.2.3.1 Operational costs T7, T8, T9, T10, T11 and T12 per TEU throughput



3.2.3.2 Saving operational costs T7 versus T10

Comparison OHBC versus ARMG (T7 versus T10)
(if there was no limitation on available land occupation

TP per year TEU	Operational costs per TEU		Saving per year by OHBC
	T10 ARMG 55,2 hectare	T7 OHBC 42,9 hectare	
2.500.000	€ 19,55	€ 13,15	€ 16.000.000,00
2.250.000	€ 21,14	€ 14,40	€ 15.165.000,00
2.000.000	€ 23,12	€ 15,93	€ 14.380.000,00
1.750.000	€ 25,68	€ 17,19	€ 14.857.500,00

3.2.3.3 Saving operational costs T8 versus T9

Comparison OHBC versus ARMG (T8 versus T9)
(if there was no limitation on available land occupation

TP per year TEU	Operational costs per TEU		Saving per year by OHBC
	T9 ARMG 46,8 hectare	T8 OHBC 36,8 hectare	
1.750.000	€ 25,10	€ 16,10	€ 15.750.000,00
1.500.000	€ 27,69	€ 18,08	€ 14.415.000,00
1.250.000	€ 33,20	€ 20,70	€ 15.625.000,00

3.2.3.4 Saving operational costs T7 versus T12

Comparison OHBC versus SC (T7 versus T12)
(if there was no limitation on available land occupation

TP per year TEU	Operational costs per TEU		Saving per year by OHBC
	T12 SC 74,5 hectare	T7 OHBC 42,9 hectare	
2.500.000	€ 32,52	€ 13,15	€ 48.425.000,00
2.250.000	€ 34,10	€ 14,40	€ 44.325.000,00
2.000.000	€ 35,98	€ 15,93	€ 40.100.000,00
1.750.000	€ 38,46	€ 17,19	€ 37.222.500,00

3.2.3.5 Saving operational costs T8 versus T11

Comparison OHBC versus SC (T8 versus T11)
(if there was no limitation on available land occupation

TP per year TEU	Operational costs per TEU		Saving per year by OHBC
	T11 SC 56,0 hectare	T8 OHBC 36,8 hectare	
1.750.000	€ -	€ 16,10	€ -
1.500.000	€ 37,28	€ 18,08	€ 28.800.000,00
1.250.000	€ 40,63	€ 20,70	€ 24.912.500,00

3.2.3.6 Resume operational costs T7 to T12

	T7 OHBC (42,9 hectare)	T8 OHBC (36,8 hectare)	T9 ARMG (46,8 hectare)	T10 ARMG (55,2 hectare)	T11 SC (56,0 hectare)	T12 SC (74,5 hectare)
Total investments costs	€ 207.789.867,00	€ 188.073.005,00	€ 243.831.000,00	€ 255.009.300,00	€ 149.690.000,00	€ 207.625.000,00
Total operational costs per year	€ 32.881.451,00	€ 27.377.481,00	€ 42.457.534,00	€ 48.865.652,00	€ 55.912.522,00	€ 81.287.600,00
Throughput in TEU per year						
2.500.000	***€ 13,15***			***€ 19,55***		***€ 32,52***
2.250.000	€ 14,40			€ 21,14		€ 34,10
2.000.000	€ 15,93	*€ 14,50*		€ 23,12		€ 35,98
1.750.000	€ 17,91	€ 16,10	***€ 25,10***	€ 25,68		€ 38,46
1.500.000		€ 18,08	€ 27,69		€ 37,28	€ 41,76
1.250.000		€ 20,70	€ 33,20		€ 40,63	
1.000.000					€ 45,67	

The figures in red colour are above maximal performance.

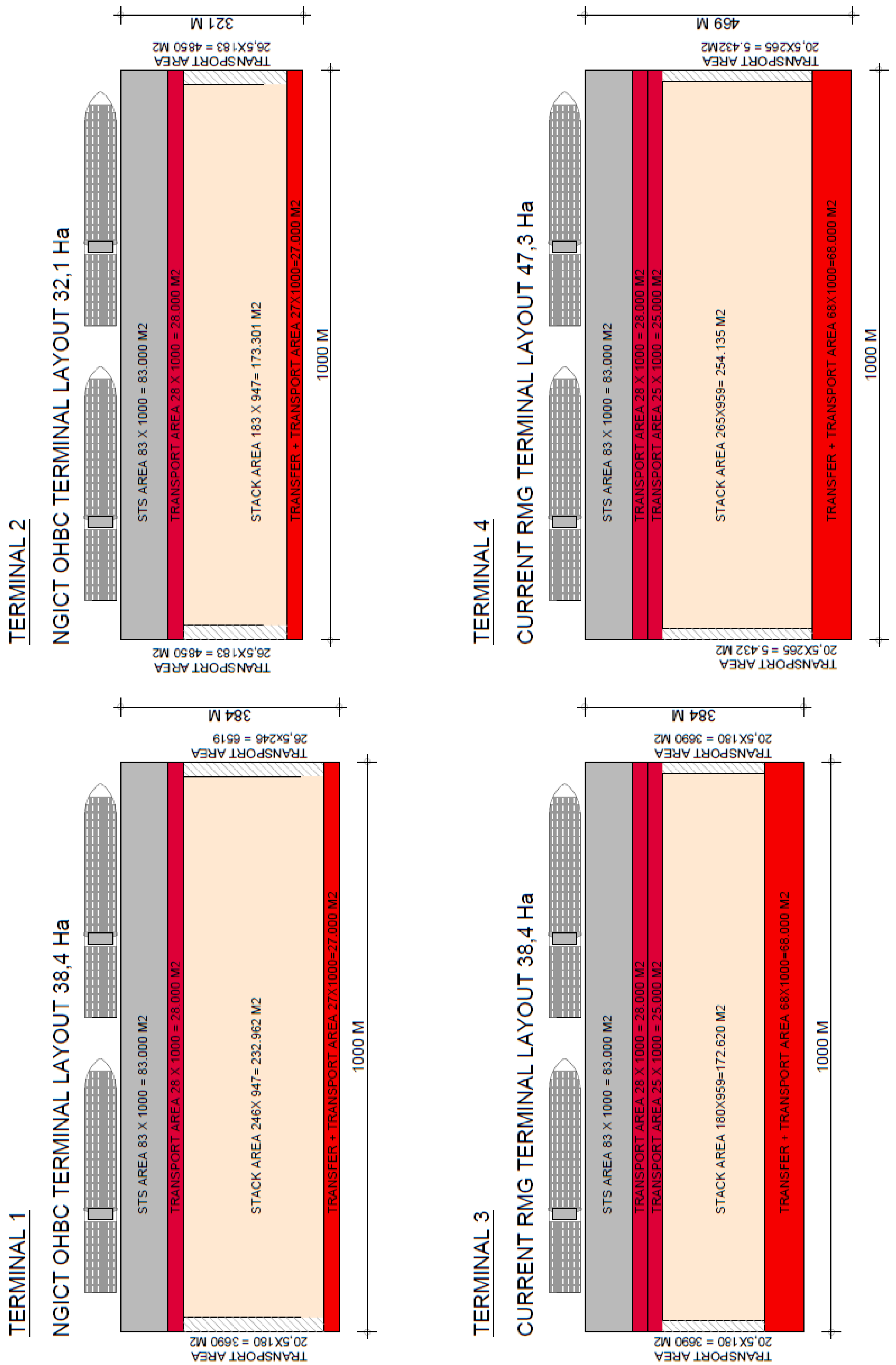
3.2.3.7 Comparison of the normative factors between T7 to T12

Subject	OHBC T7 + T8		ARMG T9 + T10		SC T11 + T12	
	Figures	Average (T7 + T8)	Figures	Average (T9 + T10)	Figures	Average (T11 + T12)
Stack density Stack area + transfer area (TEU per hectare)	T7 = 1.625 T8 = 1.465	1.545 = 100%	T9 = 963 T10 = 1.178	1.070 = 69%	T11 = 645 T12 = 700	672 = 44%
Yearly throughput per hectare land occupation (TEU)	T7 = 57.838 T8 = 51.150	54.494 = 100%	T9 = 35.778 T10 = 44.958	40.368 = 74%	T11 = 27.115 T12 = 30.916	29.015 = 53%
Peak capacity yard handling on water side * (container moves per hour)	T7 = 775 T8 = 775	775 = 100%	T9 = 468 T10 = 468	468 = 60%	T11 = 245 T12 = 350	298 = 38%
Peak capacity yard handling on land side * (container moves per hour)	T7 = 620 T8 = 620	620 = 100%	T9 = 312 T10 = 312	312 = 50%	T11 = 126 T12 = 175	150 = 39%
Total investment costs (Euro) (x 1.000.000)	T7 = 208 T8 = 188	198 = 100%	T9 = 244 T10 = 255	249 = 126%	T11 = 150 T12 = 207	178 = 90%
Investment costs per TEU stack capacity (Euro)	T7 = 3.852 T8 = 4.667	4.260 = 100%	T9 = 6.699 T10 = 4.727	5.713 = 134%	T11 = 4.562 T12 = 4.273	4.418 = 104%
Investment costs per TEU thoughput per year (Euro)	T7 = 83,11 T8 = 98,98	91,04 = 100%	T9 = 143,43 T10 = 102,00	123 = 134%	T11 = 99,79 T12 = 90,27	95,03 = 104%
Operational costs per TEU throughput per year (Euro) (maximal performance)	T7 = 13,15 T8 = 14,40	13,78 = 100%	T9 = 25,10 T10 = 19,29	22,20 = 161%	T11 = 34,84 T12 = 33,67	34,26 = 248%

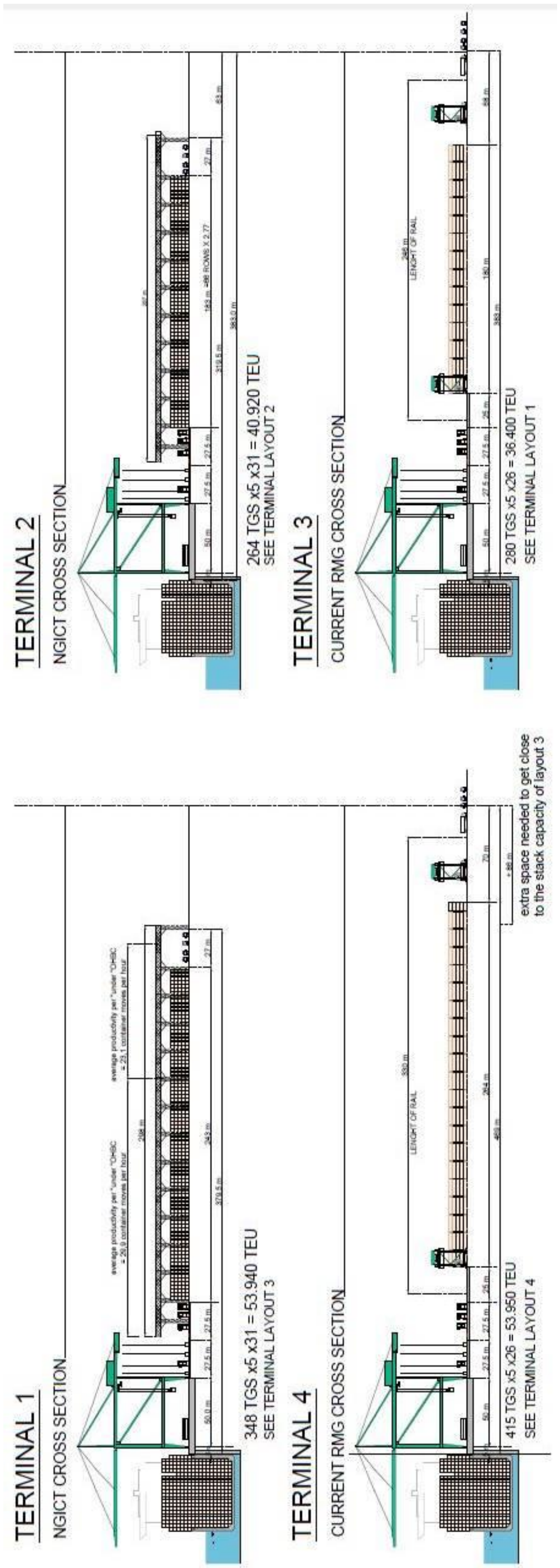
* If 2 containers at the same time inside the OHBC would be transported the handling capacity could be about 900 cmph.

X // X // X

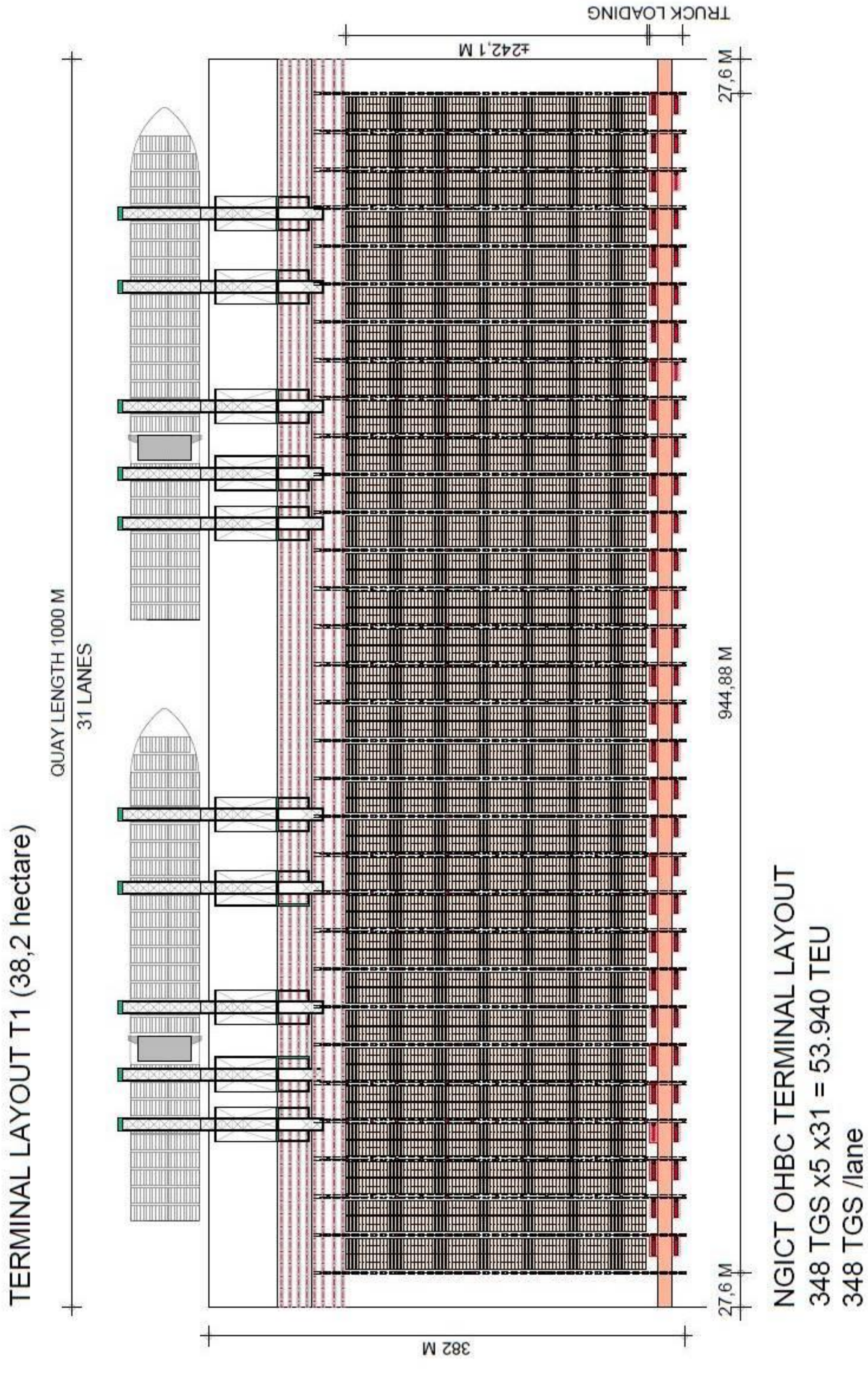
ENCLOSURE 1
Overview terminals T1, T2, T3, T4


TERMINAL 2
NGICT OHBC TERMINAL LAYOUT 32,1 Ha
STS AREA 83 X 1000 = 83.000 M2
TRANSPORT AREA 28 X 1000 = 28.000 M2
STACK AREA 183 X 947= 173.301 M2
TRANSFER + TRANSPORT AREA 27X1000=27.000 M2
1000 M
321 M
TRANSPORT AREA
26,5X183 = 4850 M2
TRANSPORT AREA
26,5X183 = 4850 M2
TERMINAL 1
NGICT OHBC TERMINAL LAYOUT 38,4 Ha
STS AREA 83 X 1000 = 83.000 M2
TRANSPORT AREA 28 X 1000 = 28.000 M2
STACK AREA 246X 947= 232.962 M2
TRANSFER + TRANSPORT AREA 27X1000=27.000 M2
1000 M
384 M
TRANSPORT AREA
26,5x246 = 6519
TRANSPORT AREA
20,5X180 = 3690 M2
TERMINAL 4
CURRENT RMG TERMINAL LAYOUT 47,3 Ha
STS AREA 83 X 1000 = 83.000 M2
TRANSPORT AREA 28 X 1000 = 28.000 M2
TRANSPORT AREA 25 X 1000 = 25.000 M2
STACK AREA 265X959= 254.135 M2
TRANSFER + TRANSPORT AREA 68X1000=68.000 M2
1000 M
469 M
TRANSPORT AREA
20,5X265 = 5.432M2
TRANSPORT AREA
20,5X265 = 5.432 M2
TERMINAL 3
CURRENT RMG TERMINAL LAYOUT 38,4 Ha
STS AREA 83 X 1000 = 83.000 M2
TRANSPORT AREA 28 X 1000 = 28.000 M2
TRANSPORT AREA 25 X 1000 = 25.000 M2
STACK AREA 180X959=172.620 M2
TRANSFER + TRANSPORT AREA 68X1000=68.000 M2
1000 M
384 M
TRANSPORT AREA
20,5X180 = 3690 M2
TRANSPORT AREA
20,5X180 = 3690 M2

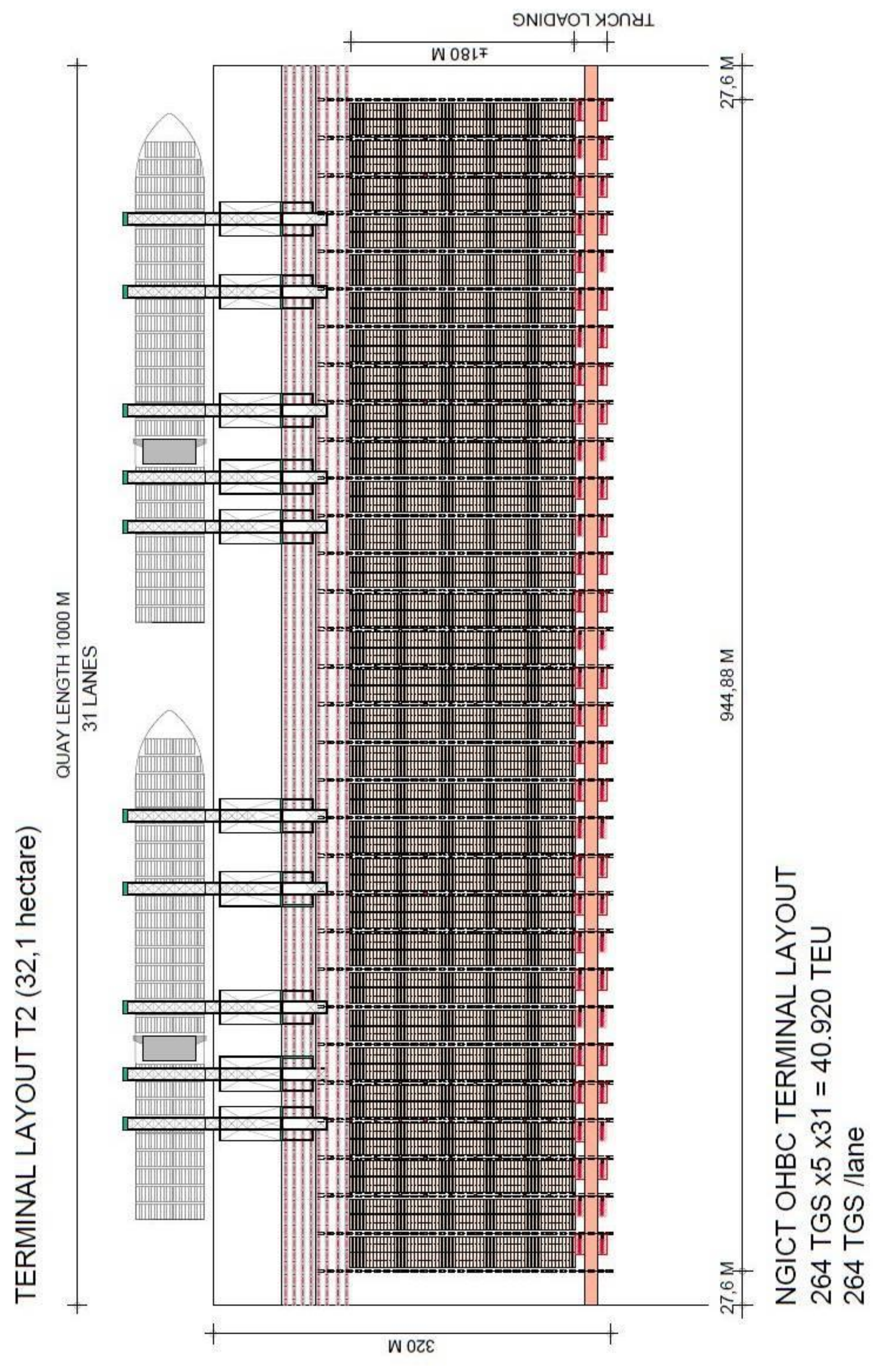
ENCLOSURE 2
Cross sections T1, T2, T3, T4


TERMINAL 2
NGICT CROSS SECTION
264 TGS x5 x31 = 40.920 TEU
SEE TERMINAL LAYOUT 2
TERMINAL 3
CURRENT RMG CROSS SECTION
280 TGS x5 x26 = 36.400 TEU
SEE TERMINAL LAYOUT 1
TERMINAL 1
NGICT CROSS SECTION
348 TGS x5 x31 = 53.940 TEU
SEE TERMINAL LAYOUT 3
TERMINAL 4
CURRENT RMG CROSS SECTION
415 TGS x5 x26 = 53.950 TEU
SEE TERMINAL LAYOUT 4
extra space needed to get close
to the stack capacity of layout 3

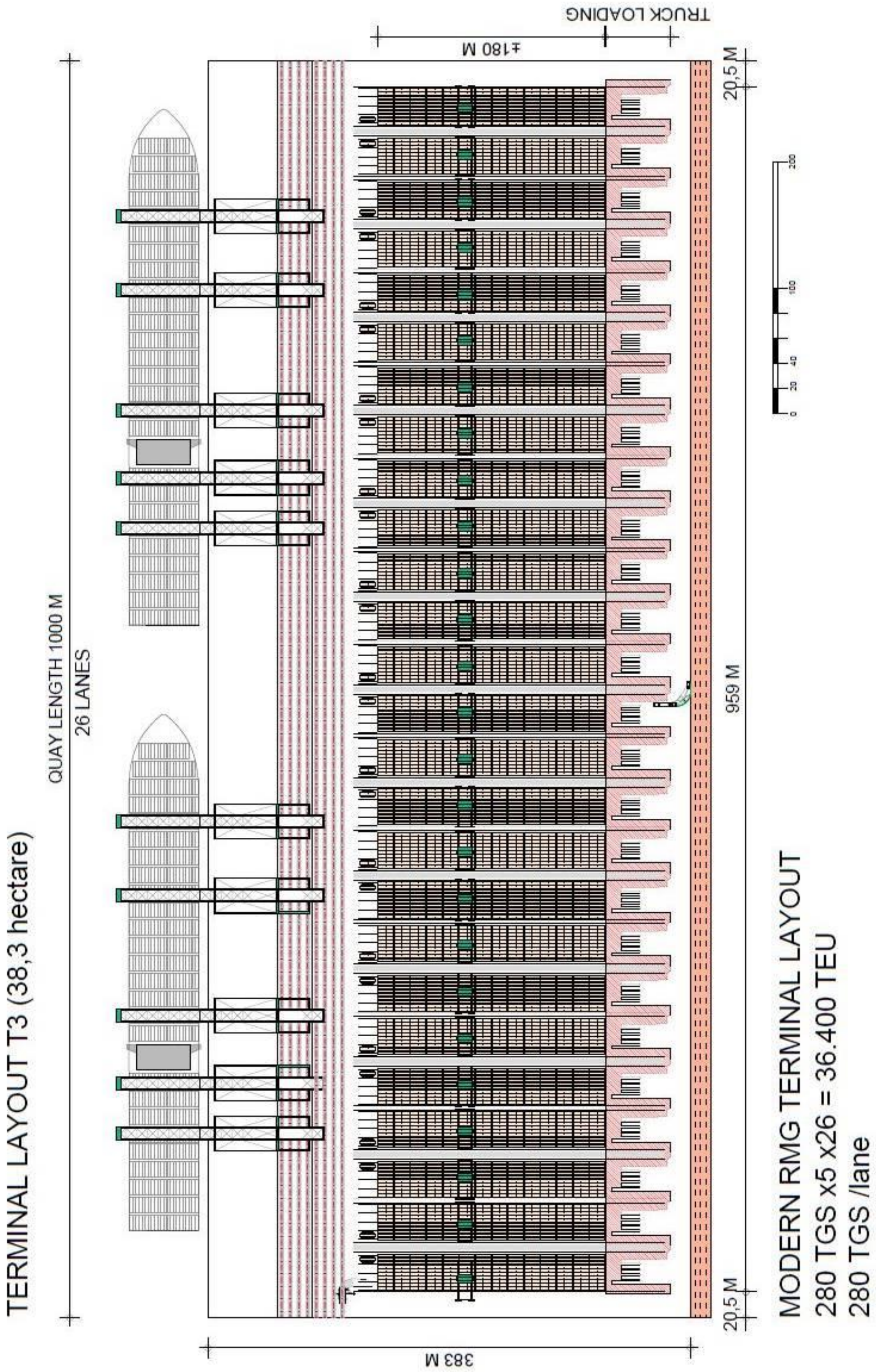
ENCLOSURE 3
Layout T1


TERMINAL LAYOUT T1 (38,2 hectare)
QUAY LENGTH 1000 M
31 LANES
TRUCK LOADING
±242,1 M
27,6 M
944,88 M
27,6 M
382 M
NGICT OHBC TERMINAL LAYOUT
348 TGS x5 x31 = 53.940 TEU
348 TGS /lane

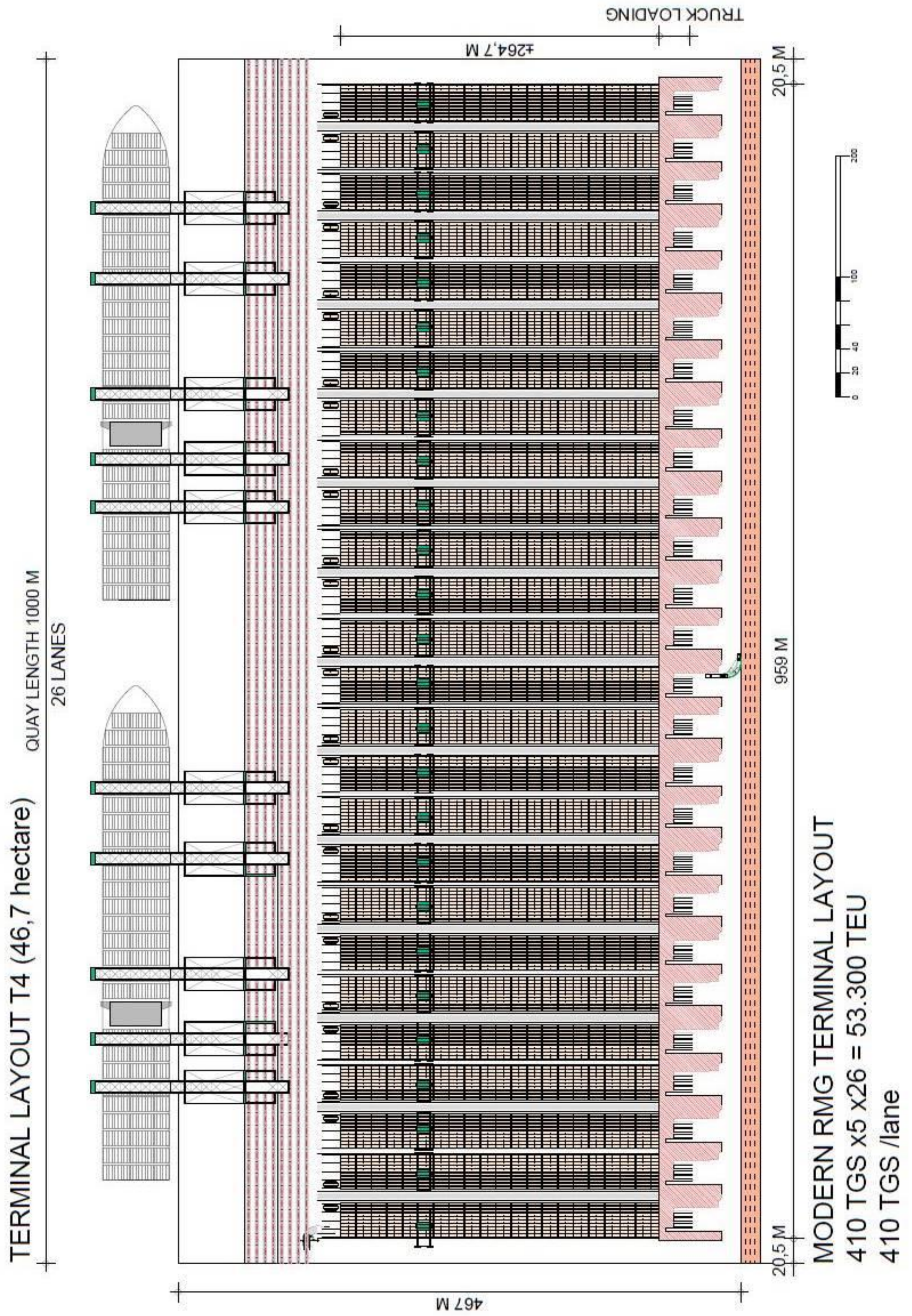
ENCLOSURE 4
Layout T2


TERMINAL LAYOUT T2 (32,1 hectare)
QUAY LENGTH 1000 M
31 LANES
TRUCK LOADING
±180 M
27,6 M
944,88 M
27,6 M
320 M
NGICT OHBC TERMINAL LAYOUT
264 TGS x5 x31 = 40.920 TEU
264 TGS /lane

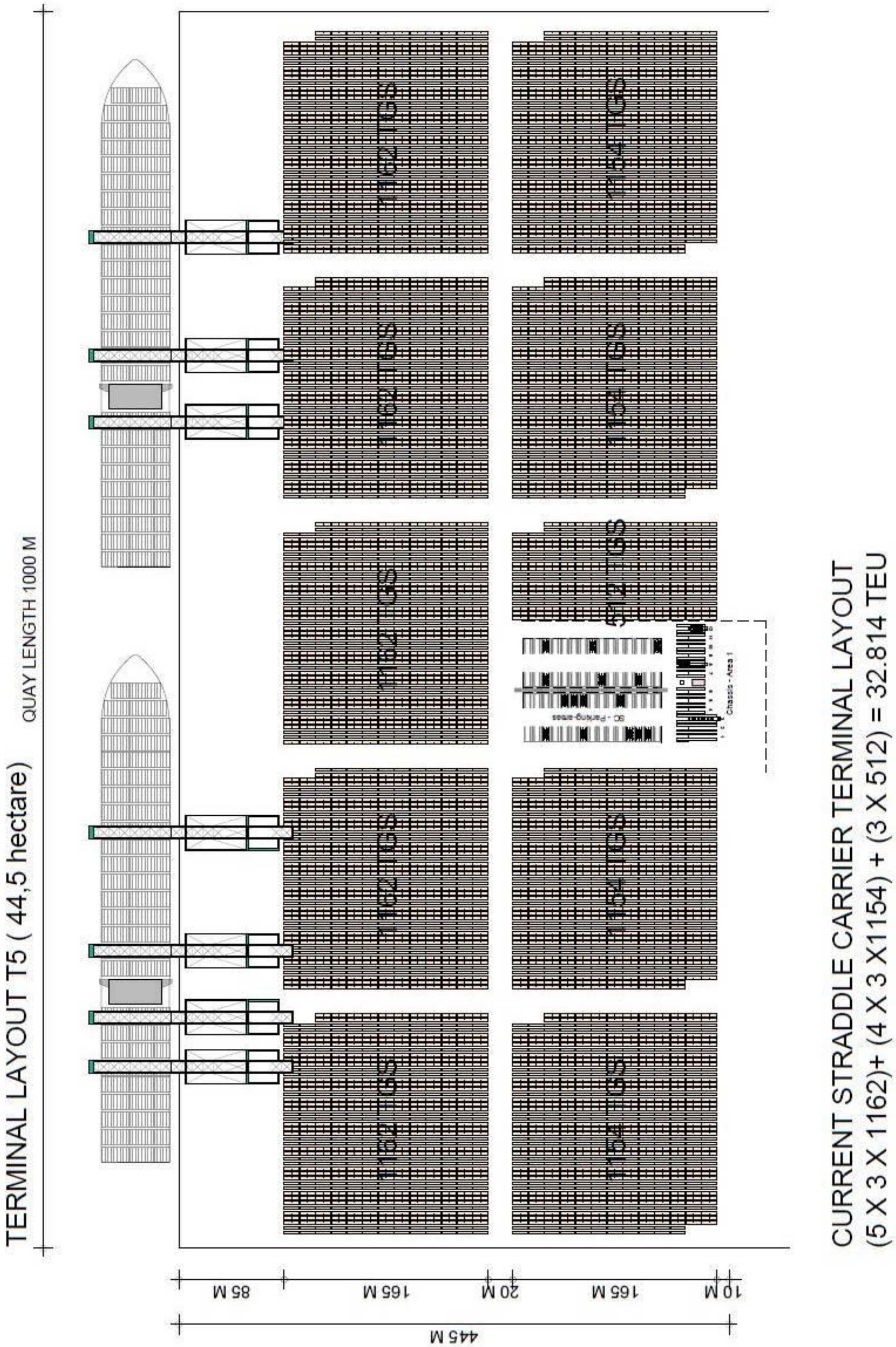
ENCLOSURE 5
Layout T3


TERMINAL LAYOUT T3 (38,3 hectare)
QUAY LENGTH 1000 M
26 LANES
TRUCK LOADING
±180 M
20,5 M
959 M
20,5 M
383 M
MODERN RMG TERMINAL LAYOUT
280 TGS x5 x26 = 36.400 TEU
280 TGS /lane

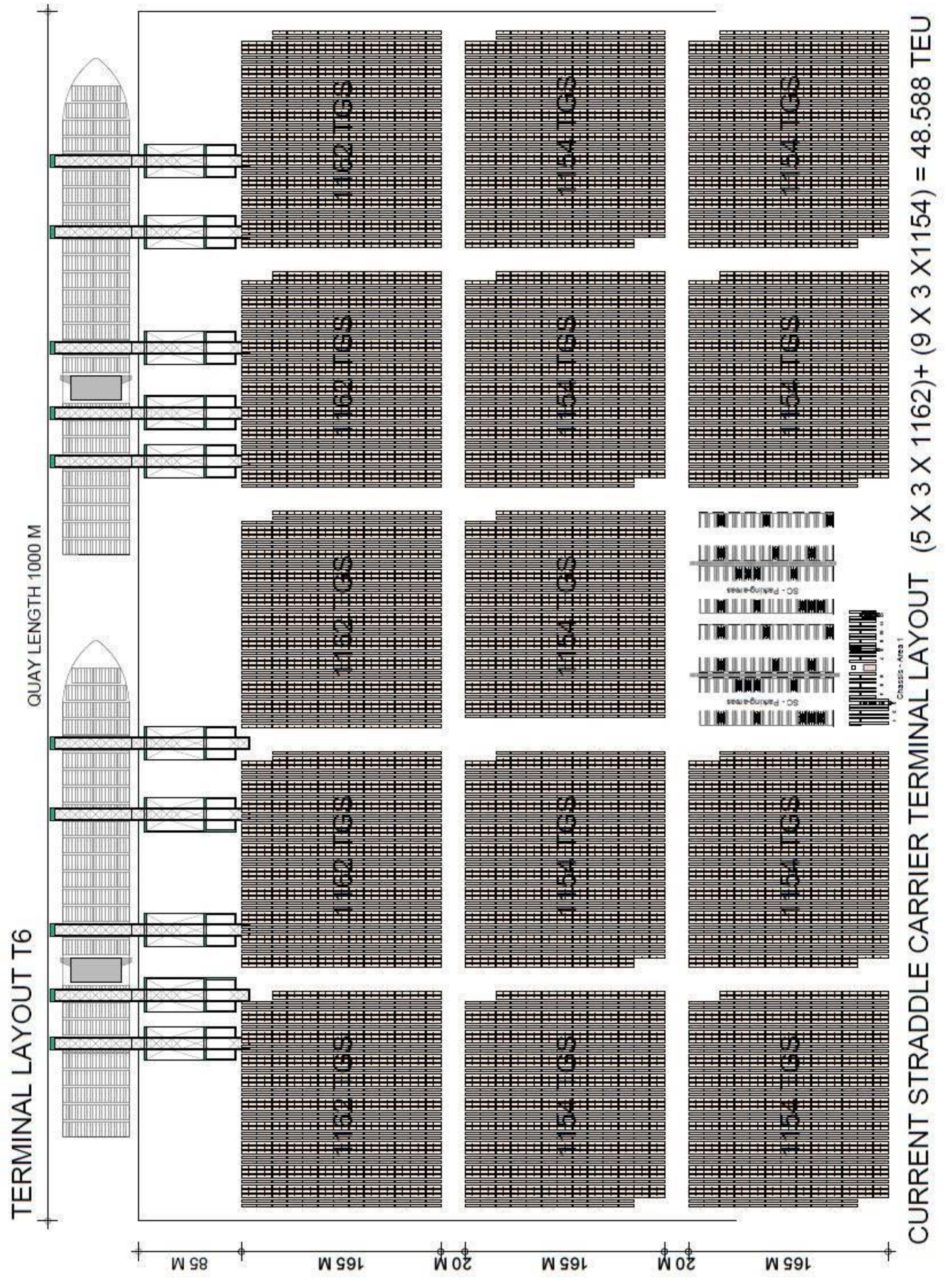
ENCLOSURE 6
Layout T4


TERMINAL LAYOUT T4 (46,7 hectare)
QUAY LENGTH 1000 M
26 LANES
TRUCK LOADING
±264,7 M
20,5 M
959 M
20,5 M
467 M
MODERN RMG TERMINAL LAYOUT
410 TGS x5 x26 = 53.300 TEU
410 TGS /lane

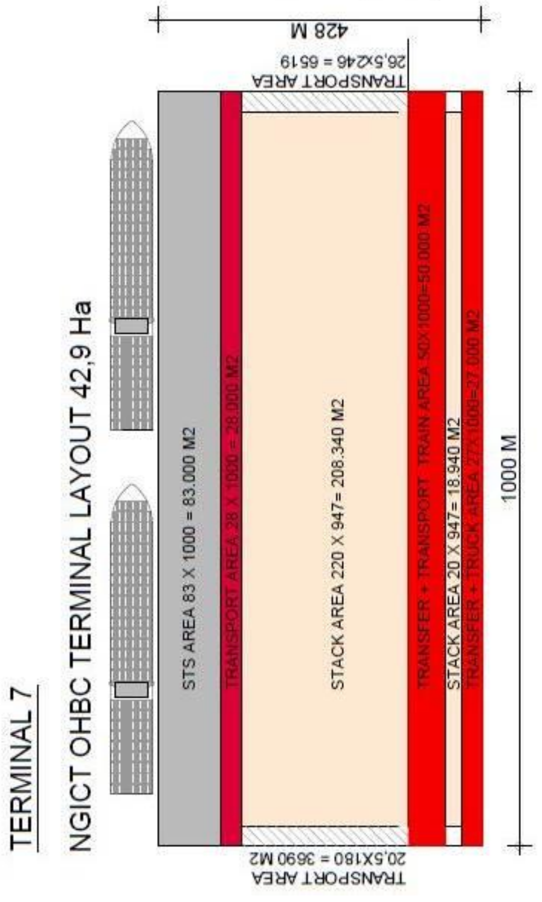
ENCLOSURE 7
Layout T5

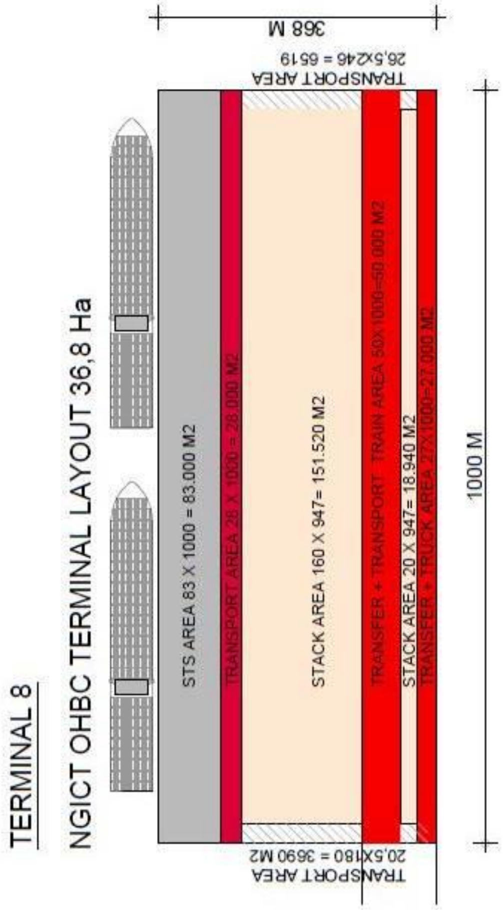

TERMINAL LAYOUT T5 (44,5 hectare)
QUAY LENGTH 1000 M
1162 TGS
1162 TGS
1162 TGS
1162 TGS
1162 TGS
1154 TGS
1154 TGS
512 TGS
1154 TGS
1154 TGS
SC - Parking areas
Chassis - Area 1
85 M
165 M
20 M
165 M
10 M
445 M
CURRENT STRADDLE CARRIER TERMINAL LAYOUT
(5 X 3 X 1162)+ (4 X 3 X1154) + (3 X 512) = 32.814 TEU

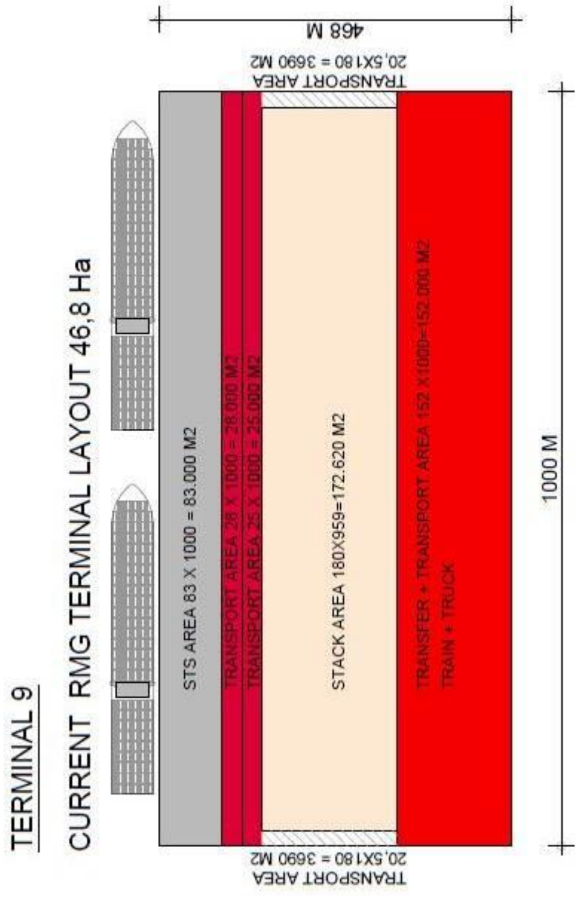
ENCLOSURE 8
Layout T6

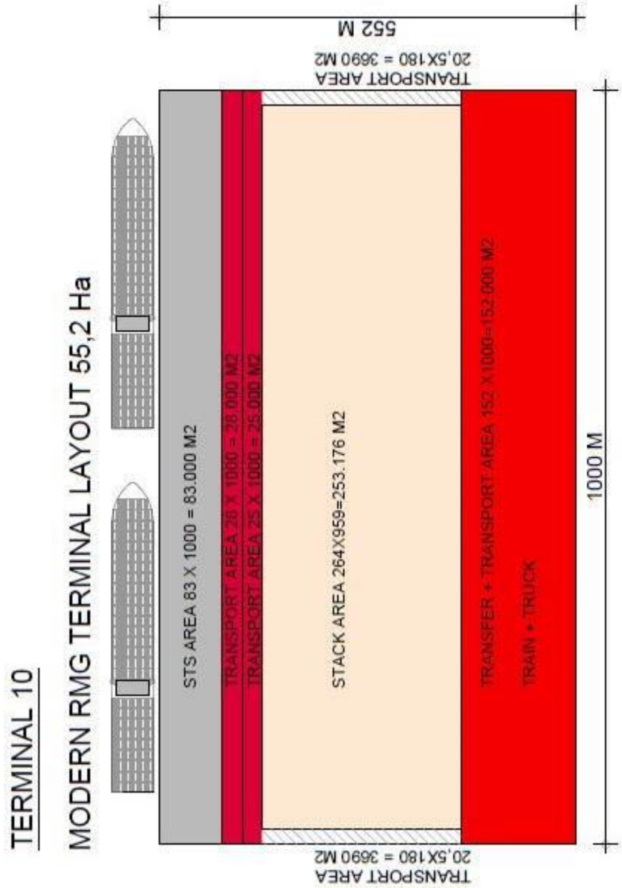

TERMINAL LAYOUT T6
QUAY LENGTH 1000 M
1162 TGS
1162 TGS
1162 TGS
1162 TGS
1162 TGS
1154 TGS
1154 TGS
1154 TGS
1154 TGS
1154 TGS
1154 TGS
1154 TGS
1154 TGS
1154 TGS
1154 TGS
SC - Parking-areas
SC - Parking-areas
Chassis - Area 1
85 M
165 M
20 M
165 M
20 M
165 M
CURRENT STRADDLE CARRIER TERMINAL LAYOUT (5 X 3 X 1162)+ (9 X 3 X1154) = 48.588 TEU

ENCLOSURE 9
Figure 9 Overview terminals T7, T8, T9, T10

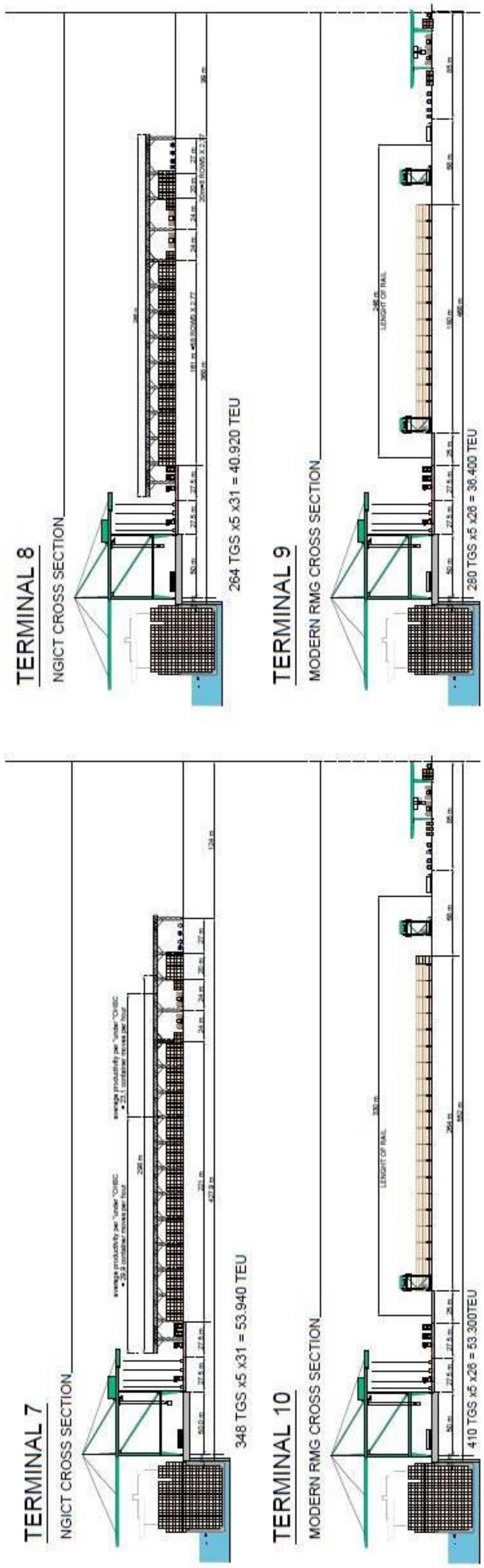

TERMINAL 7
NGICT OHBC TERMINAL LAYOUT 42,9 Ha
STS AREA 83 X 1000 = 83.000 M2
TRANSPORT AREA 28 X 1000 = 28.000 M2
STACK AREA 220 X 947= 208.340 M2
TRANSFER + TRANSPORT TRAIN AREA 50X1000=50.000 M2
STACK AREA 20 X 947= 18.940 M2
TRANSFER + TRUCK AREA 27X1000=27.000 M2
1000 M
428 M
TRANSPORT AREA
26,5X246 = 6519
TRANSPORT AREA
20,5X180 = 3690 M2


TERMINAL 8
NGICT OHBC TERMINAL LAYOUT 36,8 Ha
STS AREA 83 X 1000 = 83.000 M2
TRANSPORT AREA 28 X 1000 = 28.000 M2
STACK AREA 160 X 947= 151.520 M2
TRANSFER + TRANSPORT TRAIN AREA 50X1000=50.000 M2
STACK AREA 20 X 947= 18.940 M2
TRANSFER + TRUCK AREA 27X1000=27.000 M2
1000 M
368 M
TRANSPORT AREA
26,5X246 = 6519
TRANSPORT AREA
20,5X180 = 3690 M2

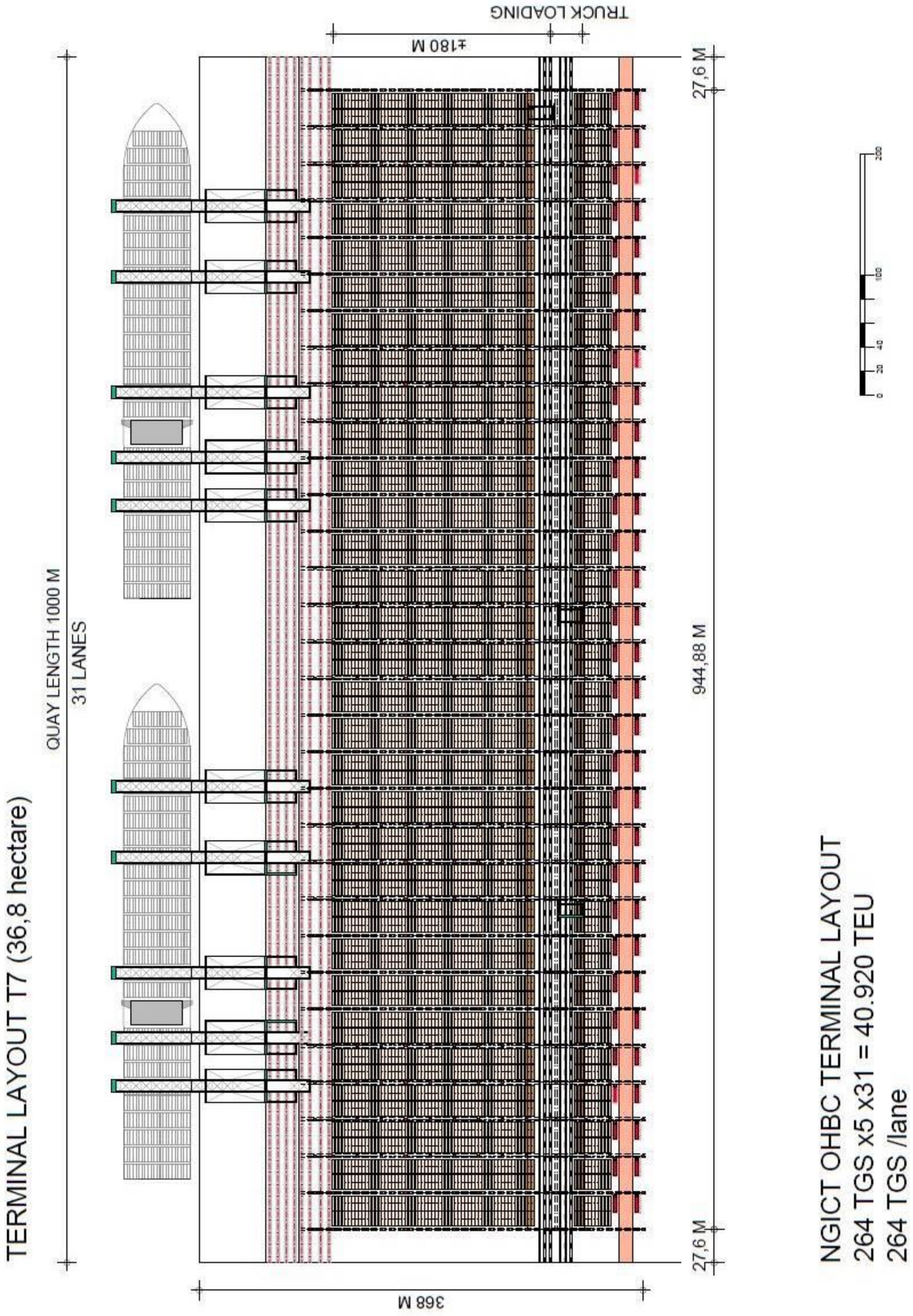

TERMINAL 9
CURRENT RMG TERMINAL LAYOUT 46,8 Ha
STS AREA 83 X 1000 = 83.000 M2
TRANSPORT AREA 28 X 1000 = 28.000 M2
TRANSPORT AREA 25 X 1000 = 25.000 M2
STACK AREA 180X959=172.620 M2
TRANSFER + TRANSPORT AREA 152 X1000=152.000 M2
TRAIN + TRUCK
1000 M
468 M
TRANSPORT AREA
20,5X180 = 3690 M2
TRANSPORT AREA
20,5X180 = 3690 M2


TERMINAL 10
MODERN RMG TERMINAL LAYOUT 55,2 Ha
STS AREA 83 X 1000 = 83.000 M2
TRANSPORT AREA 28 X 1000 = 28.000 M2
TRANSPORT AREA 25 X 1000 = 25.000 M2
STACK AREA 264X959=253.176 M2
TRANSFER + TRANSPORT AREA 152 X1000=152.000 M2
TRAIN + TRUCK
1000 M
552 M
TRANSPORT AREA
20,5X180 = 3690 M2
TRANSPORT AREA
20,5X180 = 3690 M2

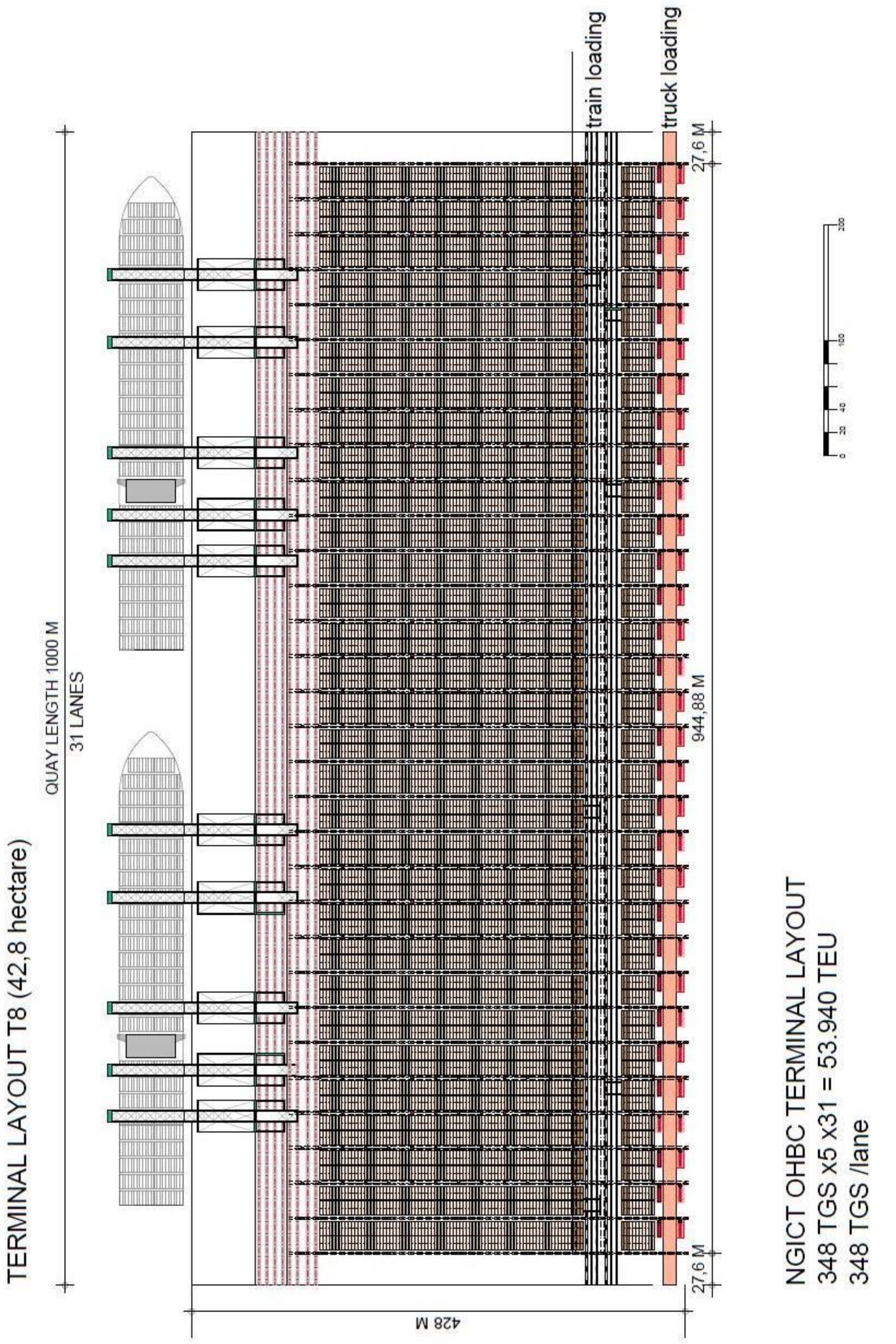
ENCLOSURE 10
Figure 9 Cross sections T7, T8, T9, T10


TERMINAL 8
NGICT CROSS SECTION
264 TGS x5 x31 = 40.920 TEU
TERMINAL 9
MODERN RMG CROSS SECTION
280 TGS x5 x26 = 36.400 TEU
TERMINAL 7
NGICT CROSS SECTION
348 TGS x5 x31 = 53.940 TEU
TERMINAL 10
MODERN RMG CROSS SECTION
410 TGS x5 x26 = 53.300TEU

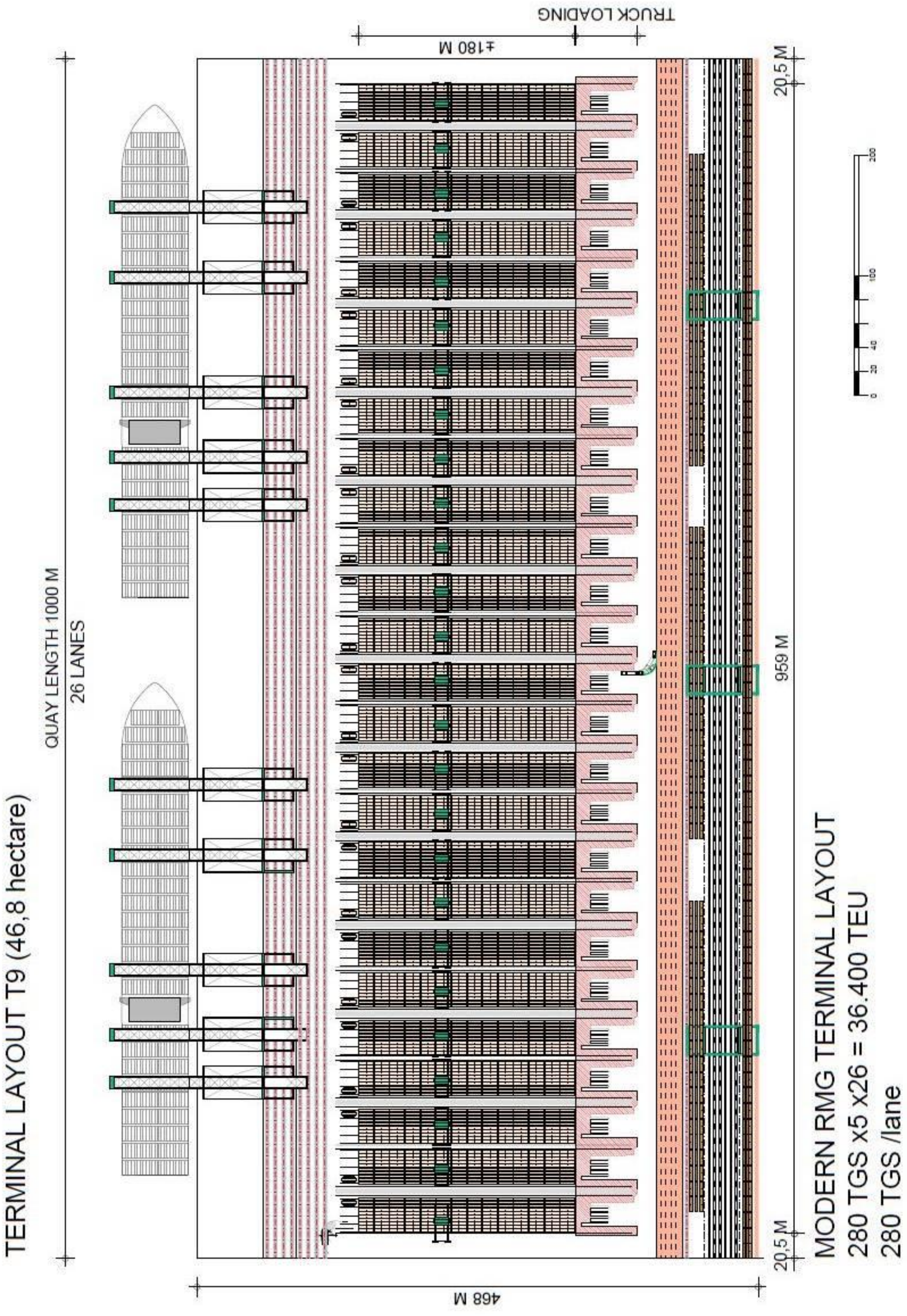
ENCLOSURE 11
Layout T7


TERMINAL LAYOUT T7 (36,8 hectare)
QUAY LENGTH 1000 M
31 LANES
TRUCK LOADING
±180 M
27,6 M
944,88 M
27,6 M
368 M
NGICT OHBC TERMINAL LAYOUT
264 TGS x5 x31 = 40.920 TEU
264 TGS /lane

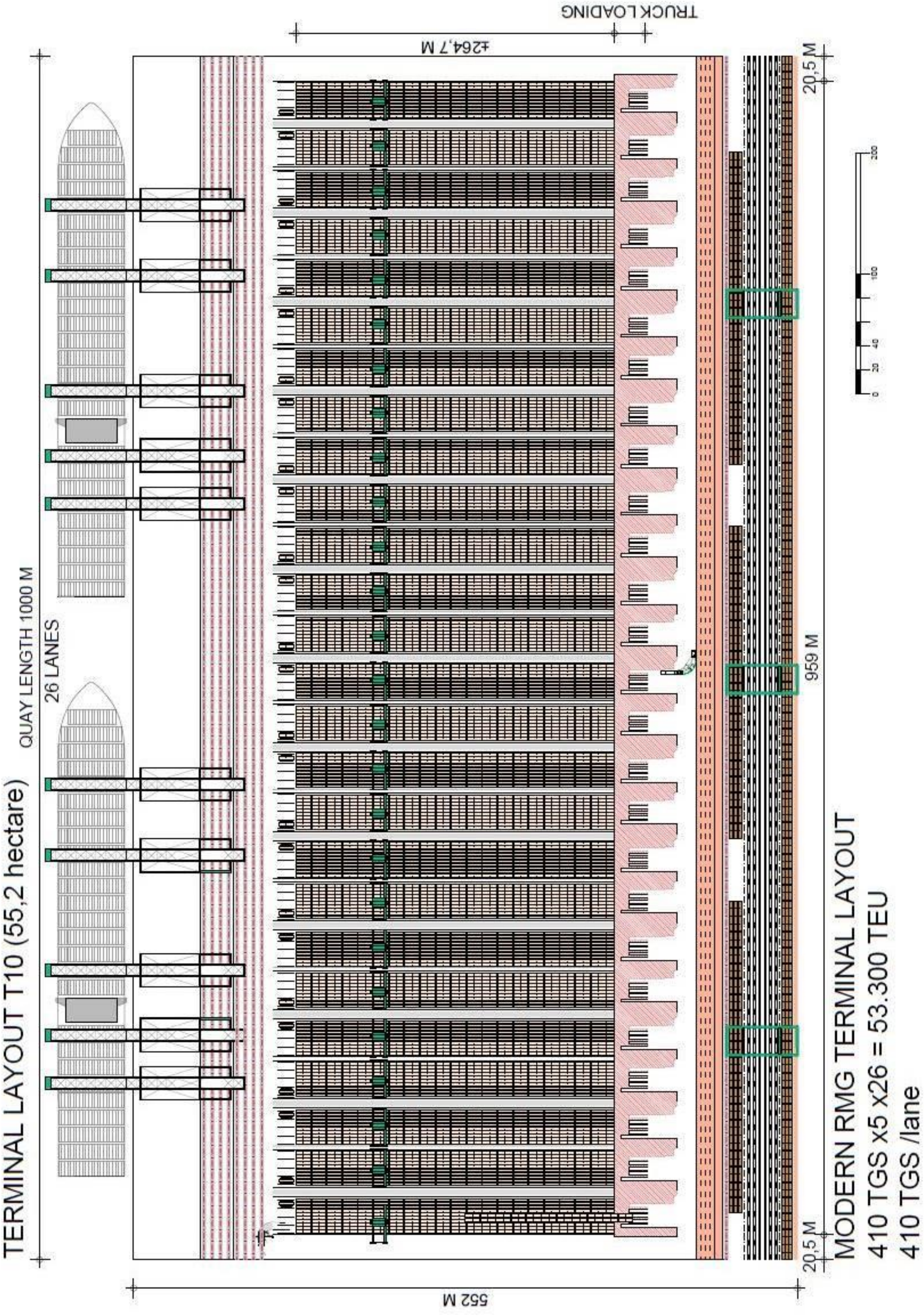
ENCLOSURE 12
Layout T8


TERMINAL LAYOUT T8 (42,8 hectare)
QUAY LENGTH 1000 M
31 LANES
train loading
truck loading
27,6 M
944,88 M
27,6 M
428 M
NGICT OHBC TERMINAL LAYOUT
348 TGS x5 x31 = 53.940 TEU
348 TGS /lane

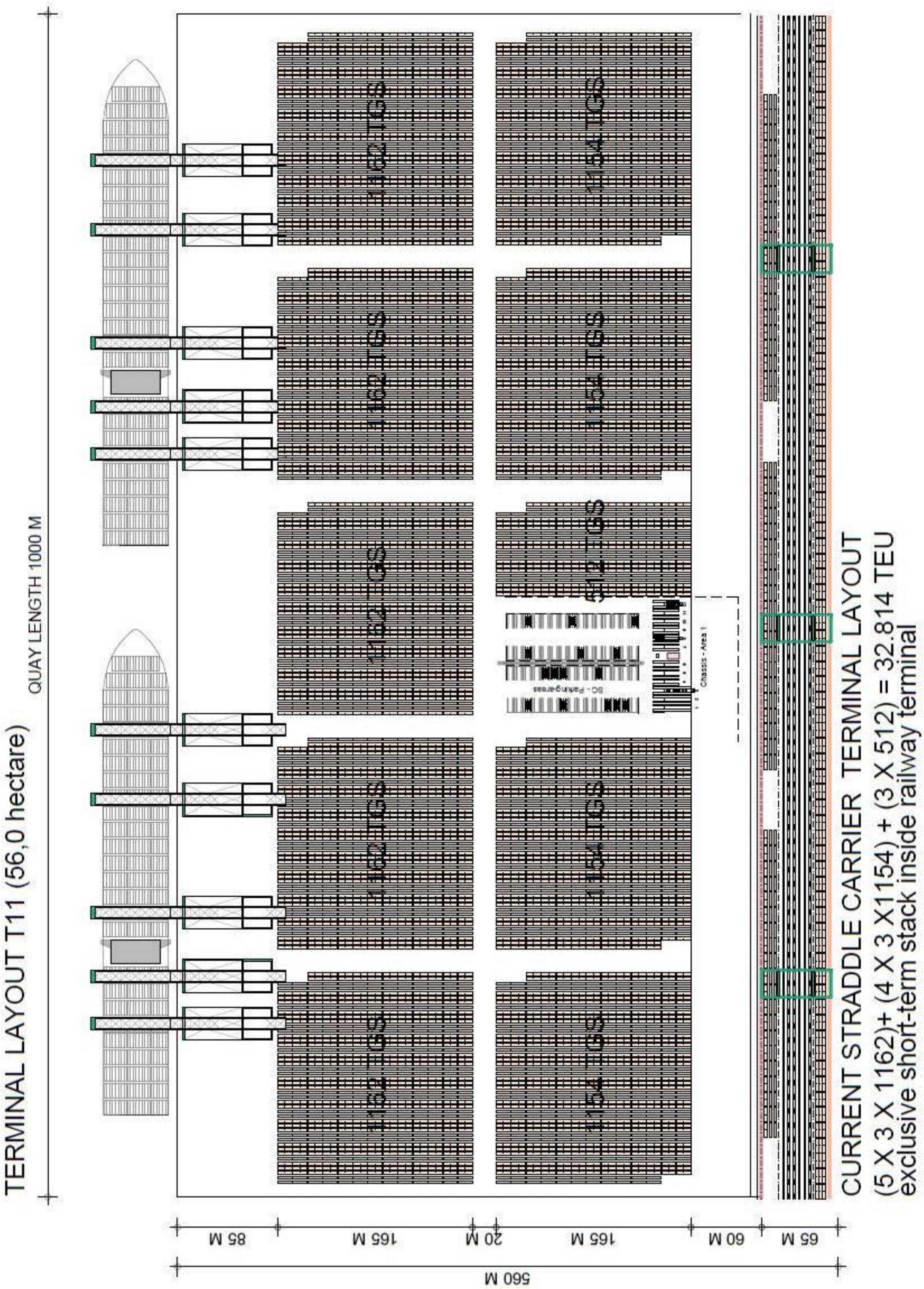
ENCLOSURE 13
Layout T9


TERMINAL LAYOUT T9 (46,8 hectare)
QUAY LENGTH 1000 M
26 LANES
TRUCK LOADING
±180 M
20,5 M
959 M
20,5 M
468 M
MODERN RMG TERMINAL LAYOUT
280 TGS x5 x26 = 36.400 TEU
280 TGS /lane

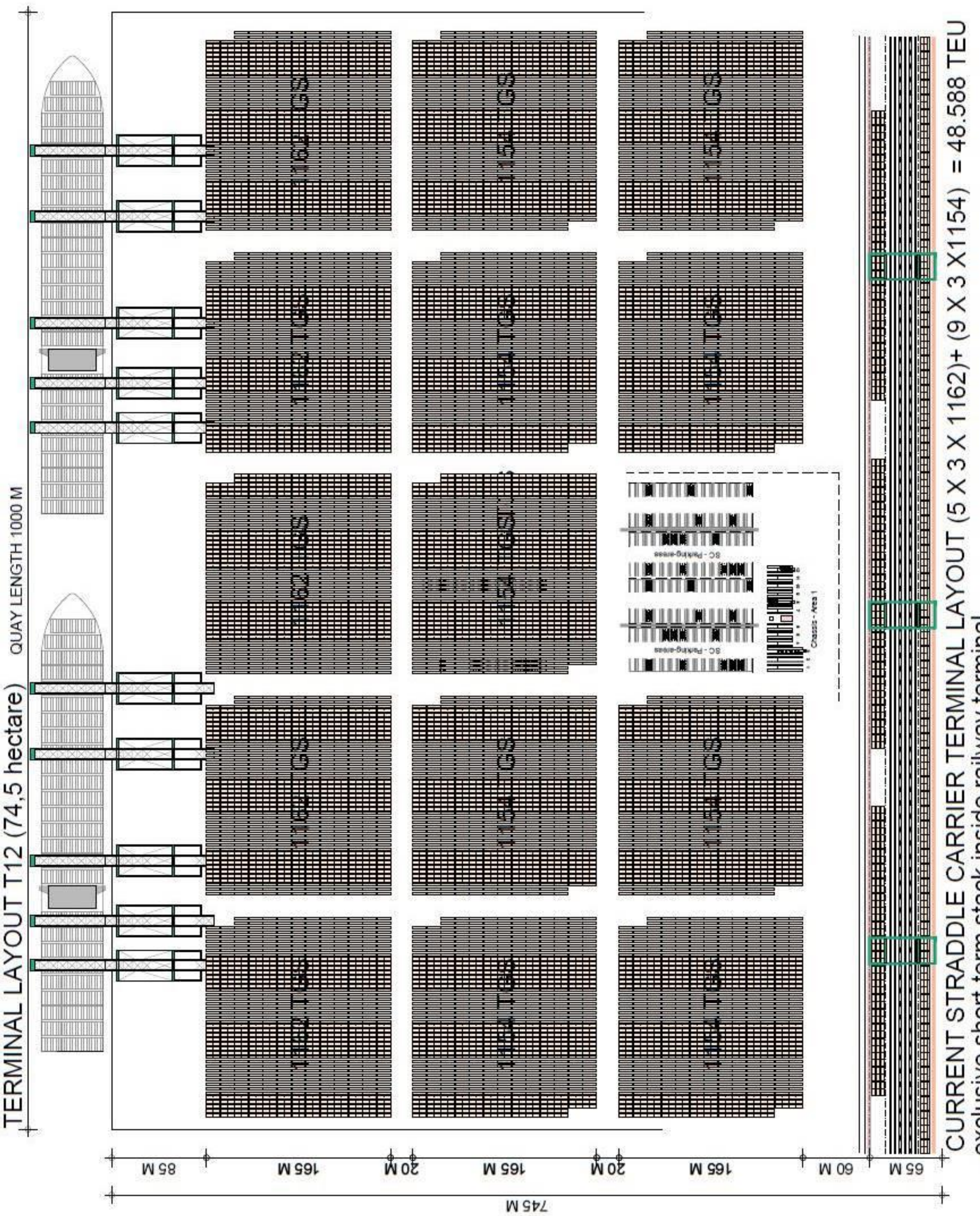
ENCLOSURE 14
Layout T10


TERMINAL LAYOUT T10 (55,2 hectare)
QUAY LENGTH 1000 M
26 LANES
TRUCK LOADING
±264,7 M
20,5 M
959 M
20,5 M
552 M
MODERN RMG TERMINAL LAYOUT
410 TGS x5 x26 = 53.300 TEU
410 TGS /lane

ENCLOSURE 15
Layout T11


TERMINAL LAYOUT T11 (56,0 hectare)
QUAY LENGTH 1000 M
1162 TGS
1162 TGS
1162 TGS
1162 TGS
1162 TGS
1154 TGS
1154 TGS
512 TGS
1154 TGS
1154 TGS
SC - Parking areas
Chassis - Area 1
CURRENT STRADDLE CARRIER TERMINAL LAYOUT
(5 X 3 X 1162)+ (4 X 3 X1154) + (3 X 512) = 32.814 TEU
exclusive short-term stack inside railway terminal
85 M
165 M
20 M
165 M
60 M
65 M
560 M

ENCLOSURE 16
Layout T12


TERMINAL LAYOUT T12 (74,5 hectare)
QUAY LENGTH 1000 M
1162 GS
1154 GS
1162 TGS
1154 TGS
SC - Parking-areas
Chassis - Area 1
CURRENT STRADDLE CARRIER TERMINAL LAYOUT (5 X 3 X 1162)+ (9 X 3 X1154) = 48.588 TEU
exclusive short-term stack inside railway terminal
85 M
165 M
20 M
165 M
20 M
165 M
60 M
65 M
745 M