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Evaluating Straddle Carriers And Rubber TyredGantrys To Determine Which Would Be The Most Suitable Container Handling Infrastructure Between The Quay And Stack Area At The Durban Container Terminal; Pier 2

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Abstract

The Durban Container Terminal (DCT) is currently the largest and busiest container terminal in Africa and handles about 2.7-million TEUs (twenty-foot equivalent unit) a year. Berths 203 to 205 of the Pier 2 Container Terminal have been identified to be widened, deepened and lengthened to be able to accommodate Super Post–Panamax container vessels of 9200 TEU capacity with a draft of 14,5m CD. This expansion will allow larger vessels to safely berth, thus increasing the overall economic production gained from the terminal.

An assessment of container handling infrastructure currently used at the Port of Durban between the quay and stack area was carried out.Furthermore,alternative infrastructure, like the Rubber Tyred Gantry (RTG), that could be used to improve the output results after containers are disembarked from ships were evaluated and is presented in this paper. The results were analyzed and conclusions, as well as recommendations were made.

Keywords: Container Handling Infrastructure, Port Of Durban, Straddle Carriers And Rubber TyredGantrys, Durban Container Terminal

1. Introduction – Background Of The Study

Pier 2, in DCT is divided into North, East and South Quays. The Pier 2 container terminal was constructed around 1970. Originally the pavement was designed to accommodate one over two straddle carriers and two high stacking. After an in-depth evaluation of other methods of construction, the Council for Scientific and Industrial Research (CSIR) decided the most suitable paving system to adapt was in-situ concrete rather than asphalt and concrete block paving. The type of straddle to be used was unknown when the pavement design was carried out, so to be on the safe side the paving was designed for 8 wheeled machinery. This overdesign was a good investment as the pavement is still in a fair condition approximately 35 years after construction with relatively low maintenance. Currently Pier 2 has implemented straddle carriers as the key infrastructure used between the quay and stack areas.The Port of Durban is currently assessing and introducing infrastructure to accommodate the rapid increase in export and import in the container terminal. The problem experienced at the DCT (Pier 2) is that the volume of containers being transhipped is increasing. Seven ZPMC tandem lift Ship to Shore cranes (STS) havebeen added to the fleet and can accommodate the increase in volumes, however the straddle carriers used in the terminal cannot.

1.1 Objectives of the study:

The main purpose of this study was:

1) To identify the current infrastructure used at DCT, Pier 2.
2) To compare the infrastructure used in Pier 1 and Pier 2.
3) To identify if Pier 1 infrastructure between the quay and stack area, would be suitable to be used in Pier 2.
4) To make recommendations,based on the findings, on the best option to efficiently move containers from the quay to stack areas and vise versa.

1.2 Study limitations

This study is based on the infrastructure used between the quay and stack area atDCT, Pier 1 and Pier 2. The following Figure1 and Figure 2shows the locality map and detailed layout of the area covered by this study.

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Fig 1: Layout map for DCT

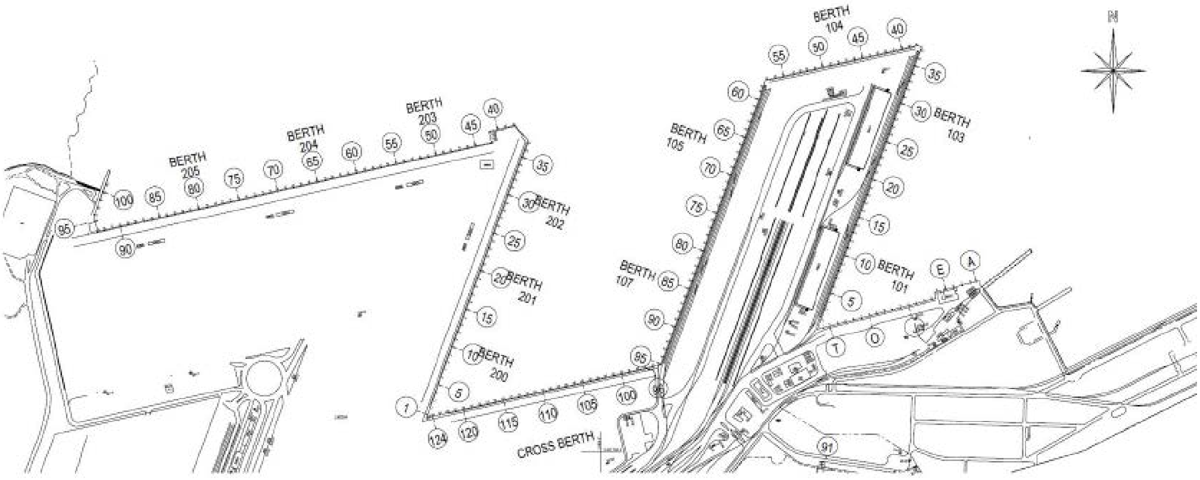

Fig 2: Detailed layout of DCT

2. Evaluation Of Current Container Handling Infrastructure Between The Quay And Stack Area

2.1 Pier 2: Straddle Carriers (SC's)

The SC is a very popular piece of equipment. These carriers can undertake avariety of handling operations such as loading, unloading, stacking and transport of containersbetween the landside and waterside. Its popularity is due to its space efficiency and flexibility. It canmove containers from quay to stack area directly (and visa versa) and covers all kinds of horizontaland vertical movements. SC's can lift a container 1 over 2 and 1 over 3. This equipment stacks containers into rows, separated by a lane wide enough for the wheels ofthe SC(Mohseni 2011: 27). This type of stacking is referred to as block stacking (see figure 3).

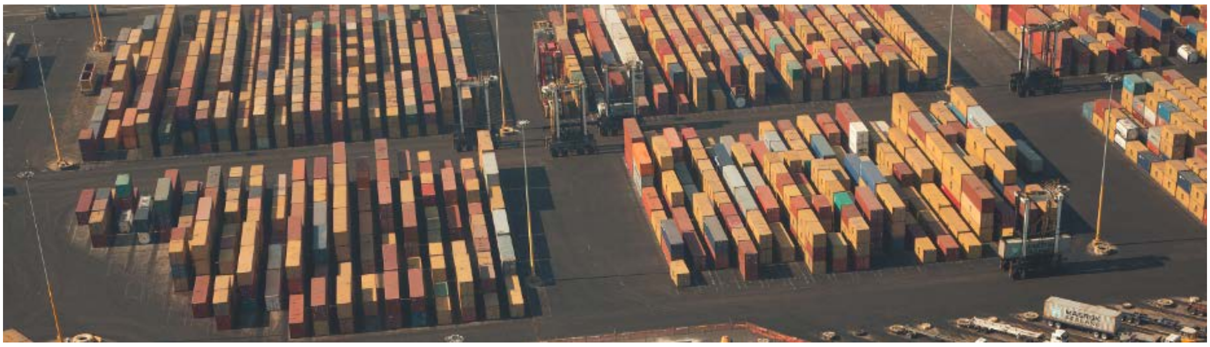

Fig 3: Block Stacking

SC's are highly versatile and combines the function of both the tractor trailerand the reach stacker. The SC is popular at Pier 2 in DCT. There are currently 113 SCs that are in operation at Pier 2. SC systems are often the optimal system for medium and large size terminals when high flexibility in the yard and accessibility of the boxes is required. Within this system, it is easy to alter the layout of the terminal. A Ship to Shore (STS) crane requires an average of between 4-5 straddles. Some of the advantages of a SC are that containers can be dropped at the desired location without waiting. Furthermore the system is flexible to changes based on operational requirements and terminal layouts, can be simply altered as SC's can be easily moved within the terminal since no pre-set routes or tracks are needed. The capacity of Durban Containers with SCoperation is 2.7 M TEU per annum.

<u>During the evaluation of SC's it was noticed that:</u>

- SC's collided with private trucks during loading and offloading of containers,
- They collide with each other (proving they have very poor visibility),
- SC's were a high priority when it came to safety concerns. Incidents vary from damaging of property to SC's overturning,

Fig 4: Fence damaged by a SC

- Breakdowns are very common and the maintenance cost is extremely high. The terminal spends an average of 52 million randon a yearly basis on maintenance only,
- Designated parking areas had to be assigned to SC's which posed an environmental hazard due to oil leaks and grease messing the parking areas,
- High area requirement in comparison to yard cranes as a result of a lower stacking height and a large proportion of traffic (within the yard area),

- When travelling distances are far, SC's are not the first choice as they are considerablyslower compared to Tractor Trailer Units (TTU's) and more costly,
- SC workshops are required to carry out repairs.

Table 1: Specifications of the SC's used at Pier 2

Parameter	Value
Straight maximum speed	5.56 m/s (20 km/h)
Curved maximum speed	3 m/s (11 km/h)
S bend maximum speed	3 m/s (11 km/h)
Acceleration when driving with a container	0.4 m/s^2
Acceleration when driving empty	0.6 m/s^2
Deceleration when driving with a container	0.8 m/s^2
Deceleration when driving empty	1 m/s^2

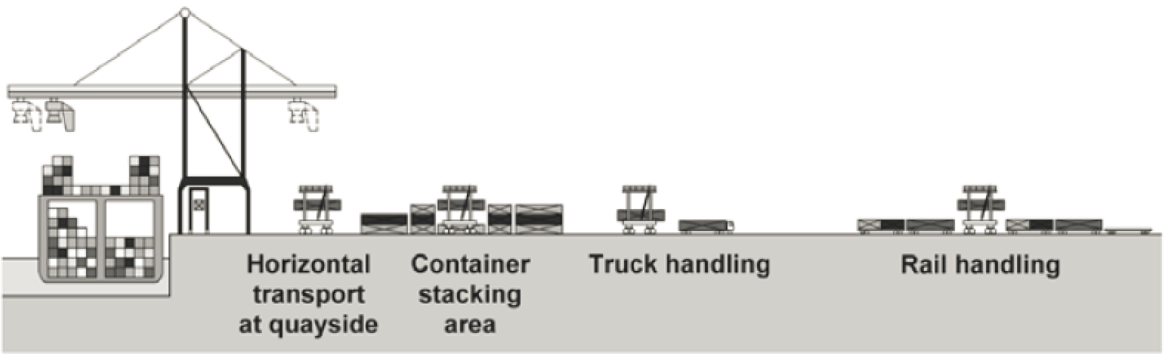

Fig 5: Typical layout of a pure SC system

2.1.1 Production of SC's

SCproduction was monitored on a typical day of operationat Pier 2 and data collected is displayed in the table below. It is noticed that the highest number of boxes moved per hour is approximately 10 boxes/hour (76/7.75).

Table 2: Production for a single shift

SC Name	Total Time Wasted	SC Name	Total Movements/7.75hrs	SC Name	No of Yard Shift / Straddle	First Lift
SC133	00 Hrs:10 min	SC133	30	SC133	6	2014/08/28 16:52
SC102	00 Hrs:52 min	SC102	44	SC102	8	2014/08/28 14:42
SC125	01 Hrs:51 min	SC125	11	SC125	11	2014/08/28 17:10
SC136	00 Hrs:24 min	SC136	35	SC136	7	2014/08/28 16:08
SC137	01 Hrs:21 min	SC137	59	SC137	11	2014/08/28 14:53
SC140	01 Hrs:10 min	SC140	59	SC140	14	2014/08/28 14:47
SC141	01 Hrs:26 min	SC141	48	SC141	9	2014/08/28 14:42

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SC143	**01 Hrs:19 min**	**SC143**	**53**	**SC143**	**5**	2014/08/28 14:59
SC144	**01 Hrs:55 min**	**SC144**	**31**	**SC144**	**3**	2014/08/28 17:24
SC145	**02 Hrs:14 min**	**SC145**	**10**	**SC145**	**3**	2014/08/28 14:48
SC68	**01 Hrs:30 min**	**SC68**	**58**	**SC68**	**9**	2014/08/28 14:50
SC70	**01 Hrs:05 min**	**SC70**	**45**	**SC70**	**7**	2014/08/28 14:43
SC72	**00 Hrs:29 min**	**SC72**	**26**	**SC72**	**4**	2014/08/28 18:07
SC79	**00 Hrs:40 min**	**SC79**	**76**	**SC79**	**11**	2014/08/28 14:47
SC80	**01 Hrs:33 min**	**SC80**	**66**	**SC80**	**8**	2014/08/28 14:33
SC82	**01 Hrs:22 min**	**SC82**	**47**	**SC82**	**10**	2014/08/28 14:41
SC84	**01 Hrs:23 min**	**SC84**	**6**	**SC84**	**6**	2014/08/28 15:14
SC86	**01 Hrs:17 min**	**SC86**	**47**	**SC86**	**9**	2014/08/28 14:39
SC91	**01 Hrs:33 min**	**SC91**	**50**	**SC91**	**9**	2014/08/28 14:52
SC92	**02 Hrs:08 min**	**SC92**	**55**	**SC92**	**10**	2014/08/28 15:21
SC99	**00 Hrs:52 min**	**SC99**	**56**	**SC99**	**16**	2014/08/28 14:41
SC105	**01 Hrs:32 min**	**SC105**	**48**	**SC105**	**3**	2014/08/28 15:14
SC131	**01 Hrs:23 min**	**SC131**	**62**	**SC131**	**11**	2014/08/28 14:35

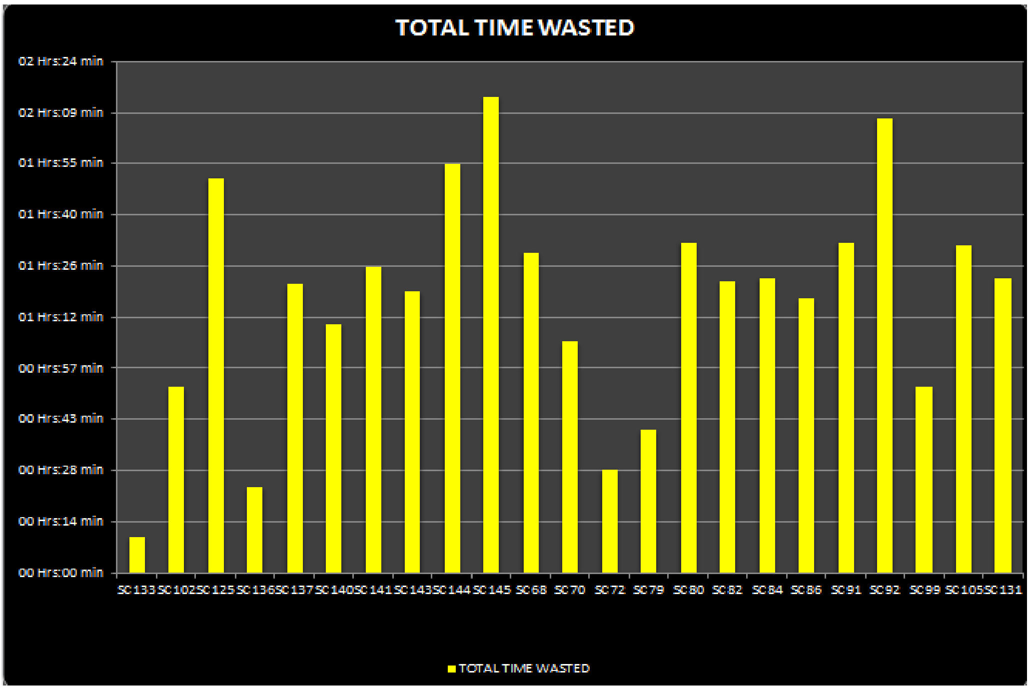

Fig 6: Total time wasted per straddle for that shift

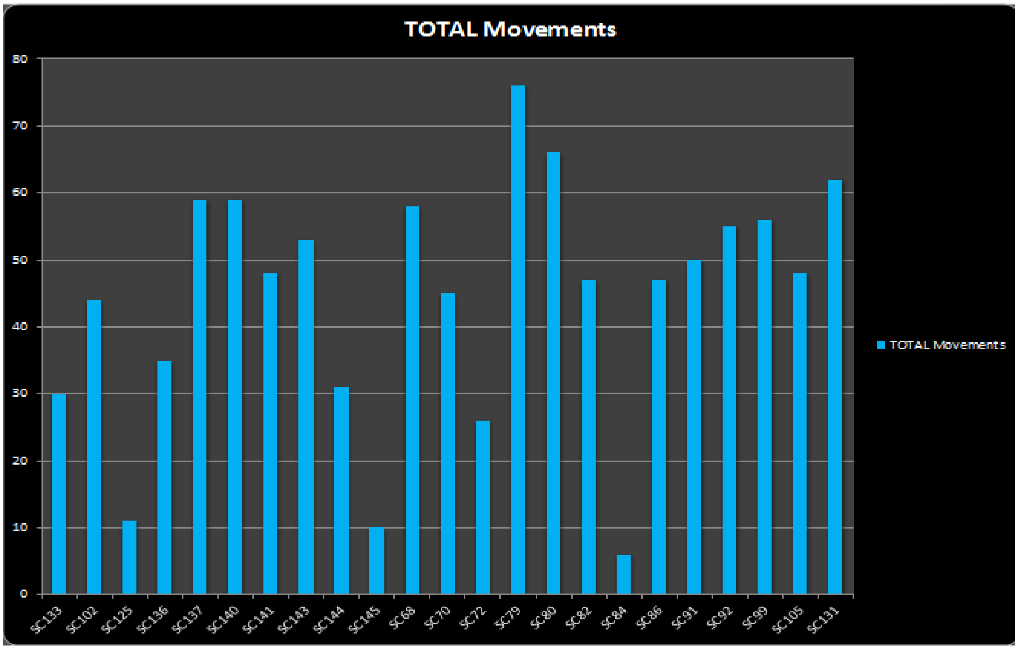

Fig 7: Total moves per straddle for that shift

2.2 Pier 1: Rubber Tyred Gantry (RTG)

Pier 1 operations were based on a pure SC system and have converted to RTG system a few years now. The STS gantry crane places the container on a TTUthat transports the container to the storage area where the RTG crane stacks the containers in long blocks (see Figure 10). A RTG can be used together with TTU'sor road trucks. The size and structure of the RTG crane is determined according to the requirements of the terminal operator. Very heavy concrete paving is required in the wheel tracking areas to support the heavy wheel loads. There are concrete/steel pads necessary for turning purposes of the cranes to travel to adjacent storage areas (or blocks) to perform stacking operations. RTG's are generally smaller and lighter than Rail Mounted Gantrys (RMG's) Therefore, they are sometimes more favorable for terminals built on reclaimed marshland, where reinforced piling would be too costly (Brinkmann 2011: 34). DCT is built on reclaimed land so RTG's would be suitable for this terminal. The current throughput of the terminal is provided as 770,000 TEU. RTG's do not require a workshop like SC's.

Fig 8: RTG operation- DCT Pier 1

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Fig 9: Block Stacking at DCT Pier 1

Table 3: Specifications of the RTGs used at DCT, Pier 1

Parameter	Value
Gantry speed	2.25 m/sec
Gantry acceleration	0.3 m/s²
Gantry deceleration	-0.3 m/s²
Trolley speed	1.16 m/sec
Trolley acceleration	0.3 m/s²
Trolley deceleration	-0.3 m/s²
Spreader max. speed (up until 15 tons of load)	50 m/min
Spreader max. speed (from 40 tons of load onwards)	22 m/min
Bumper to bumper distance	2 m

RTG cranes are often used on large and very large terminals. The system has avery high stacking density because of the high stacking capability and the block stacking. Long travelling distances on the terminal are less problematic as TTUstransport the containers. It can also be effectively used for the handling of containers on roadtrucks or rail cars. According to manufacturers, up to four tracks can be coveredand containers can be stored at the side of the rail tracks. RTG cranes can be allocated from the yard to the landside operation and viceversa, if necessary. Generally 2–3 RTGs and 4–5 TTUs (depending on the distancebetween berth and stacking area) are required per STS crane. RTGs stacks the container in blocks 1-over-4- to -7-high and 5 to 8 containerrows plus 1 lane for container handover lane.

System advantages

- low space requirement in the stacking area because of the high storage capacity in a small area (high stacking density). The containers can be stacked up to 8-high (i.e. 1-over-7-high) without spacing for travelling lanes between the rows. To avoid reshuffling of the containers, an efficient administration of the yard isrequired,
- relatively high flexibility as the RTGs can be transported to other storage blocks,
- medium investment capital costs per piece of equipment.

System disadvantages

- container transport between STS crane and yard area require two handover procedures due to the use of different terminal equipment for transport and stackingtasksdisturbance of TTU operations by trucks being also loaded/unloaded in thestacking area (mixed traffic)(Brinkmann 2011: 34).

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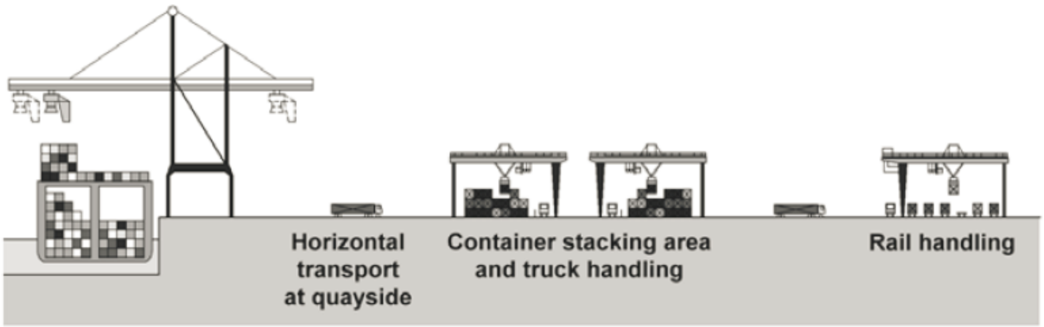

Fig 10: A typical layout of a RTG-TT system

Table 4:EC Statistics Report at 05:51 AM, 2014/08/31

Moves by CHE and Hour of Day (ALL)

che	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	ttl	m/hr	adj m/hr
MH1	-	3	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	2.3	-
MH11	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	2.5	-
MH12	3	3	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	5	3	21	3.0	-
MH14	2	3	3	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	5	21	2.6	-
MH15	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	2	6	1.5	-
MH18	4	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	14	3.5	-
MH19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1.0	-
MH20	1	2	3	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	4	5	3	23	2.3	-
MH21	6	2	6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4	23	3.8	-
MH22	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4	1.3	-
MH26	4	1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4	2	18	2.6	-
MH27	4	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	6	2	19	3.2	-
MH28	4	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	2	17	2.8	-
MH29	6	3	5	3	7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	33	4.1	-
MH30	4	2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	3	20	2.9	-
MH31	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	4	16	2.7	-
MH32	1	3	2	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	6	4	22	2.4	-
MH33	3	2	2	5	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	1	26	3.3	-
MH36	5	2	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	8	1	24	3.0	-
MH4	3	2	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	12	2.4	-
MH5	3	2	1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	14	2.0	-
MH7	2	2	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	9	1.5	-
MH8	3	3	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	13	1.9	-
QC2	10	11	10	10	13	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	17	13	94	10.4	-
QC3	25	16	25	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	20	20	131	18.7	-
QC4	21	10	14	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	27	15	105	15.0	-
QC5	13	14	4	12	20	15	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	5	24	2	110	11.0	-
QC6	3	14	5	10	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	25	21	95	10.6	-
RTG1	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	8	6	18	3.0	-
RTG10	4	6	1	3	8	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	6	52	6.5	-
RTG11	-	-	5	12	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	8	7	43	6.1	-
RTG12	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	10	26	8.7	-
RTG14	2	8	3	2	9	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	4	11	7	49	4.9	-
RTG15	13	-	4	10	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	8	45	6.4	-
RTG17	11	4	6	9	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	9	4	49	5.4	-
RTG18	1	2	-	3	5	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	12	11	48	6.0	-
RTG19	5	9	11	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	35	7.0	-
RTG2	7	4	6	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	11	42	7.0	-
RTG20	15	12	19	12	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	7	87	12.4	-
RTG21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	9	19	9.5	-
RTG22	14	-	7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	7.3	-
RTG4	9	14	5	14	10	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	27	4	97	10.8	-
RTG5	9	14	9	5	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	12	63	7.9	-
RTG8	26	17	25	17	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	16	19	125	13.9	-
RTG9	5	5	2	1	17	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	11	4	61	6.8	-

3. Cost analysis

Table 5: Labour costs

	Manning per equipment hour	Labour costs provided per hour (ZAR)
Quay Crane (STS)	2.28 (2)	116.9 (Pier 2)
SC (1 over 3)	2.36 (2)	103.4 (Pier 2)
RTG (eco)	2.36 (2)	149.8 (Pier 1)

Table 6: Purchase cost

	Purchase costs provided by Transnet		International benchmark	relative difference
	(ZAR)	(euro)	(euro)	(%)
STS – single hoist	75,000,000	6,250,000	6,250,000	0%
STS – tandem hoist	100,000,000	8,300,000	8,300,000	0%
SC (1 over 3)	9,500,000	790,000	750,000	5%
RTG (eco)	17,000,000	1,400,000	1,350,000	4%

Table 7: Maintenance costs

	Maintenance costs provided by Transnet		International benchmark	relative difference	Maintenance costs assumed for Transnet situation	
	(ZAR/hr)	(euro/hr)	(euro/hr)	(%)	(euro)	(ZAR)
Quay crane (STS)	1,280	106.7	95	4%	106.7	1,280
SC (1 over 3)					31.1	373
RTG (eco)	215	17.9	16	7%	17.9	215

4. Conclusions and recommendations

- The capacity of Durban Containers with Straddle Carrier operation is 2.7 M TEU due to storage constraints at Pier 2,
- The financial performance with SC operation is much worse than currently in Transnet's viability model. Not changing from SC operation is the worst choice for Transnet with low financial KPIs, low capacity and operations is struggling to achieve waterside productivity,
- The exercise carried out in the tables 5,6 and 7 above indicate that operating and purchasing costs of RTG's are slightly higher than SC's, however the cost to maintain SC's is exorbitantly higher than RTG's,
- It's very difficult to get an accurate production rate from both piece of equipment since there are a number of factors that needs to be taken into account, however, judging from the statistics that was extracted from a typical shift (Table 2 and 4) it is noticed that the production rate with an RTG-TT system far exceeds that of SC system,
- In conclusion, it is recommended that DCT, Pier 2 adopt the RTG-TT system.

5. References

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