

# CONTAINER TERMINAL SPATIAL PLANNING – A 2041 PARADIGM FOR THE WESTERN CAPE PROVINCE IN SOUTH AFRICA

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## ABSTRACT

This paper investigates the suitable location for an intermodal inland container terminal (IICT) in the city of Cape Town. A container market segmentation approach is used to project growth for container volumes over a 30-year period for all origin and destination pairings on a geographical district level in an identified catchment area. The segmentation guides the decision on what type of facility is necessary to fulfil capacity requirements in the catchment area and will be used to determine the maximum space requirements for a future IICT. Alternative sites are ranked from most suitable to least suitable using multi-criteria analysis, and preferred locations are identified. Currently, South Africa's freight movement is dominated by the road sector. Heavy road congestion is thus prevalent at the Cape Town Container Terminal (CTCT). The paper proposes three possible alternative sites for an IICT that will focus on a hub-and-spoke system of transporting freight.

## INTRODUCTION

Containerised international trade has grown exponentially over the past few years and is the fastest growing cargo segment since 1990 (UNCTAD, 2011). This is fuelled by an increasing proportion of commodities being containerised to promote ease of handling and movement of goods (Garratt, 2006; Rodrigue, 2007; US Department of Transportation, 2011). According to Davies (2007) these increased volumes are placing growing pressure on terminal capacity with ports challenged by the expansion of on-dock capacity due to constraints on land availability, environmental issues, and concerns from local communities regarding traffic congestion and impact on quality of life. He concludes that 'these factors have generated growing interest in the concept of inland container terminals as a means of boosting capacity, through potential reductions in container dwell time at on-dock terminals and the transfer of non-essential terminal activity to inland locations'.

This state of affairs also holds true for the South African situation and for the Port of Cape Town, which has limited expansion capacity within the current Cape Town Container Terminal (CTCT). The port handled a total of 708 526 twenty-foot equivalent units (TEUs) in 2010 with a 50/50 split between imports and exports (Transnet National Ports Authority, 2010). The port container expansion plan provides for 4.4 million TEUs in 2050 (a more than five-fold growth), but this will only be possible if infrastructure expands in a seaward direction. The pressure on port capacity will therefore become more pronounced in future and it is envisaged that an inland intermodal container terminal (IICT) could alleviate some of this pressure. For the purpose of this paper an IICT is seen as a consolidation and de-consolidation point for empty and loaded containers; it thus acts as an inland intermodal trans-shipment and distribution point, but could also offer services such as storage, track-and-trace and maintenance of containers.

## **RESEARCH STRATEGY**

### **Research approach**

The expected growth in container volumes in the Western Cape province in South Africa necessitates the expansion of container terminal capacity. Land restrictions at the port dictate the development of an IICT located in the City of Cape Town that can support the CTCT in meeting future demand capacity and functional handling requirements for containers. Suitable sites for the IICT need to be identified.

To select a suitable site the first step is to characterise the functional scope and size of an intermodal container terminal business in the Cape Town area that aligns with the future development of the container freight industry and captures a substantial market share. The site selection will be informed by forecast regional growth in freight, traffic and economic activity in the context of provincial and municipal spatial and transport planning.

### **Methods of data gathering**

Container volumes for this study are obtained from the South African Freight Demand Model (FDM). It provides a comprehensive measure of freight flows for all modes between 372 geographical districts of South Africa on a 71 commodity level. The FDM also forecasts these flows 30 years into the future with five-year intervals. It utilises a disaggregated social accounting matrix framework based on magisterial district supply and demand. The results are compared with detailed industry research and correlated with known freight flows (GAIN, 2012). The container demand forecast is based on commodity-level export and import-volume forecasts, as well as the propensities of the commodities to be containerised. The methodology for container demand forecasting is therefore driven by information on container content, forecasts of long-term growth in demand for this content, and 'fitting' these to maximum propensities to containerise. This provides more accurate forecasts than purely extrapolating historical trends (Havenga & Van Eeden, 2011).

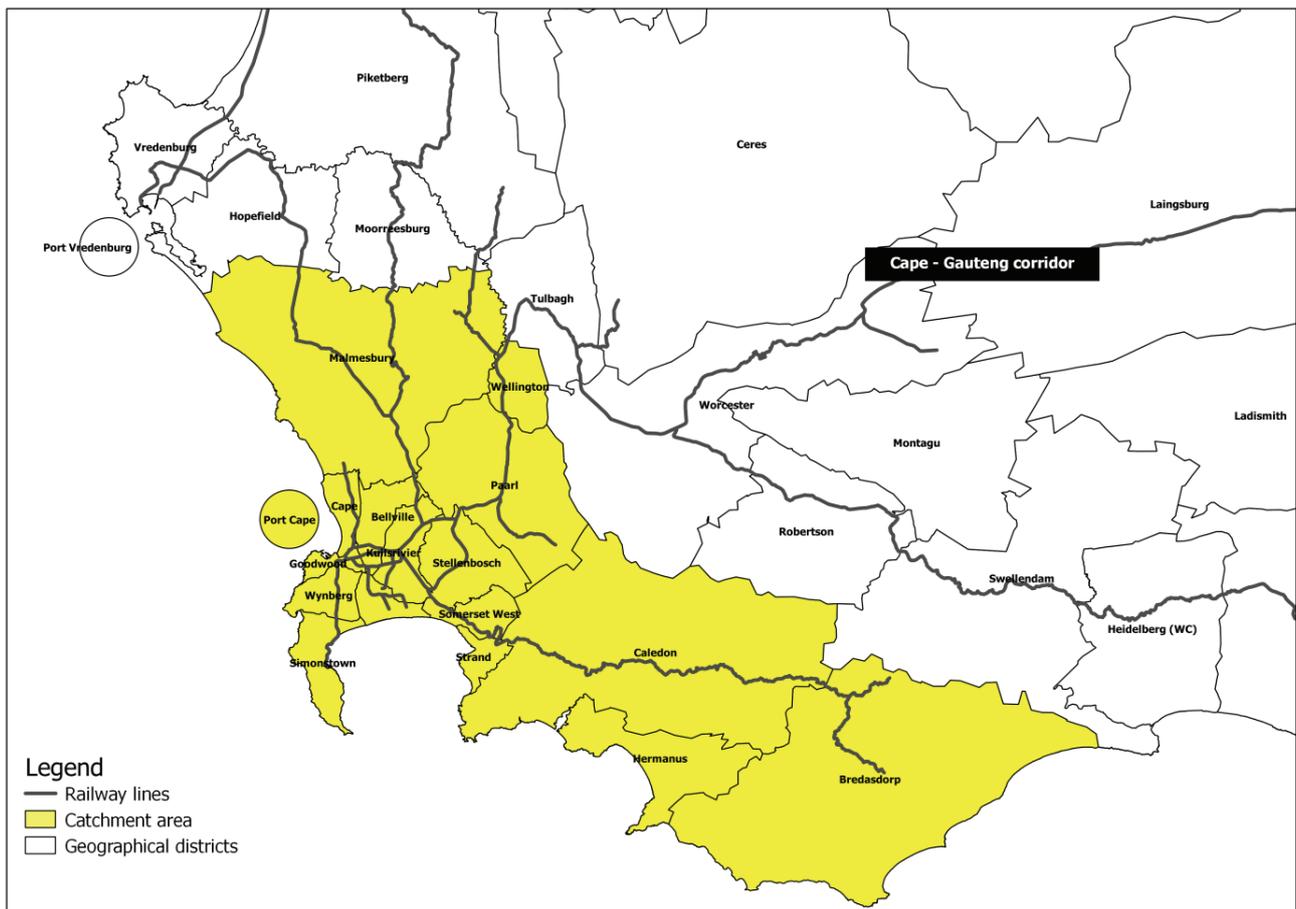
## Procedure

The maximum size and possible location(s) for the IICT are identified through the development of appropriate container market segmentation, based on the movement characteristics of containers through and in a designated catchment area. This also indicates what type of facility should satisfy future demand for container movements on a spatial and functional level.

## DISCUSSION

### Catchment area

The catchment area for the IICT was based on the extent of the railway lines that service the Port of Cape Town and the surrounding geographical districts. The presumption was also made that any future terminal will operate on a hub-and-spoke system with all rail freight originating within or destined for the area passing through the terminal (refer to Figure 1).



**Figure 1: Catchment area for proposed IICT**

Currently, almost all containers are transported by road to and from the CTCT. A future intermodal or bi-modal solution that incorporates rail is envisaged for the IICT.

## Defining the segmented container freight flows

A key point of departure is that any future IICT would most probably not handle all container volumes in a designated area and therefore it is necessary to do a proper market segmentation of container flows. Based on the container handling profile of the current container depot located in the Bellville geographical district, and the type of movements that are best suited to rail transport, it was decided that a future IICT in the Western Cape will accommodate six types of container freight flows. They are listed and briefly discussed in Table 1.

**Table 1: Segmented container freight flows**

Segment number	Name	Description
1	Imported long distance	Imported container-friendly commodities transferred by rail from the CTCT travelling north on the Cape–Gauteng corridor
2	Exported long distance	Container-friendly commodities travelling south on the Cape–Gauteng corridor and exported through the CTCT
3	Exported local customers	High volume local exporters that export deciduous fruit, processed foods, beverages, citrus or motor vehicle parts and accessories (the top five export commodities) through the port
4	Domestic intermodal north	Container-friendly commodities from districts in the catchment area travelling northbound on the Cape–Gauteng corridor
5	Domestic intermodal south	Container-friendly commodities travelling southbound on the Cape–Gauteng corridor destined for catchment area districts
6	Empty containers	Empties are estimated as a percentage of loaded containers: <ul style="list-style-type: none"> <li>• Imported empties are 49% of loaded export TEUs</li> <li>• Exported empties are 43% of loaded import TEUs</li> <li>• Domestic intermodal empties are 36% of loaded TEUs</li> </ul>

The segmented flows are underpinned by a future road–rail intermodal solution for South Africa where a modal shift to rail is aggressively pursued and more rail-friendly commodities are containerised. Furthermore, the segmentation guides the decision on what type of facility is necessary to fulfil capacity requirements in the catchment area and will be used to determine the maximum space requirements for a future IICT.

## Space requirement for the IICT

The maximum spatial requirements for the IICT are estimated by using a land utilisation measure of containers per hectare (ha) per year. This metric evaluates the efficiency of both operations (throughput) and land use. Analysis of a number of studies shows that an acceptable lower and upper bound for this metric would be 2 000 to 13 000 TEUs and an average would be 6 000 TEUs per ha per year (Le-Griffin & Murphy, 2006; Tioga Group, 2010).

## **Alternative site selection**

Stakeholder consultation took place in the policy and regulatory environment, the spatial development and transport environment for the City of Cape Town. An extensive literature study of relevant regulations and policy papers were supplemented with personal interviews with City of Cape Town representatives and Transnet employees. During stakeholder consultation, factors to take into account when identifying potential sites in the catchment area were identified. It was advocated that a suitable site should:

- be located near the centre of production for a catchment area with sufficient demand to ensure the viability of a terminal
- have good mainline access and a direct rail connection
- be directly connected to the major road highway network
- take consideration of environmental and socio-economic impacts on the surrounding area.

There should also be enough available and suitable land for construction and expansion.

Furthermore, a future IICT would essentially need to:

- promote inter- and bi-modality
- render a port service
- provide a solution to empty containers stacking in the port precinct
- alleviate road traffic congestion in the inner-city area
- be ultimately future proof.

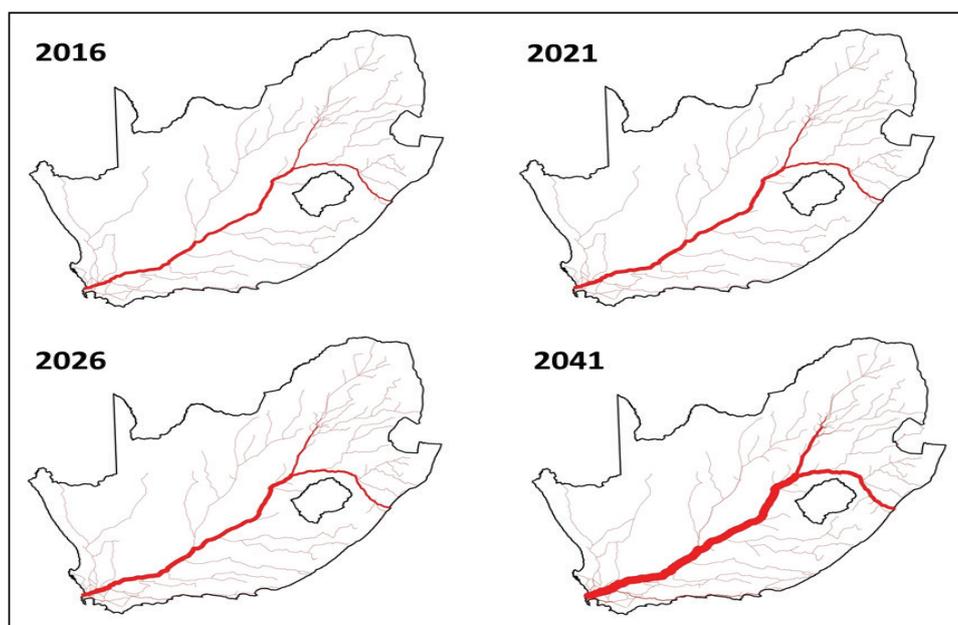
The identified sites were assessed based on three primary criteria, namely, land utilisation (low-key, normal-key or high-key design); rail efficacy (existence of a direct line, railway within 500 m and overhead electrical lines); and road efficacy (proximity to a freeway, distance from port and access to main roads). The sites were chosen on a very high pre-feasibility level and therefore other factors such as environmental, social and financial suitability and sustainability do not form part of this assessment. This site selection process falls into a Front-end loading (FEL) 0 identification phase and has at its main purpose the narrowing down of site choices after which a more elaborate FEL 1, appraisal and selection phase can be conducted. Therefore the three primary criteria as chosen above gave a sound indication of which sites could be further investigated.

## **Analysis and results**

The total loaded container volumes (as extracted out of the FDM) originating in and destined for the catchment area and the compounded annual growth rate (CAGR) for 2010 and for the forecast interval years are shown in Table 2, and graphically depicted in Figure 2. It is forecast that almost 2.2 million loaded TEUs will be handled in the catchment area in 2041.

**Table 2: Total loaded container volumes and CAGR for the catchment area**

Year	TEUs	CAGR
2010	651 240	–
2016	831 132	4.15%
2021	1 007 794	4.05%
2026	1 198 529	3.89%
2041	2 173 114	3.96%



**Figure 2: Forecast inland loaded container flows to and from the catchment area**

The segmented container volumes (which could potentially be captured by an IICT) are shown in Table 3 for the base year (2010) and the forecast intervals up to 2041. The total container volume that could be handled by a future IICT in 2041 is calculated as 723 121 TEUs of which 69% will be loaded containers and 31% empties.

**Table 3: Summary of base year and forecast segmented container volumes (TEUs)**

Segment	Year	2010	2016	2021	2026	2041
1	Imported long-distance	38 244	52 170	66 118	81 235	153 974
2	Exported long-distance	33 593	42 972	50 791	59 038	97 364
3	Exported local customers	92 558	107 906	116 901	124 741	152 862
4	Domestic intermodal northbound	8 396	11 200	14 442	18 513	45 399
5	Domestic intermodal southbound	9 137	12 266	15 867	20 377	50 264
6	Imported empties	61 814	73 930	82 169	90 051	122 611
	Exported empties	16 445	22 433	28 431	34 931	66 209
	Domestic empties	6 312	8 448	10 911	14 000	34 439
<b>Total TEUs</b>		<b>266 499</b>	<b>331 325</b>	<b>385 631</b>	<b>442 886</b>	<b>723 121</b>

The forecast volumes indicate that a strong focus is required on long-distance import and export container movements while accommodating large volumes from local exporters and expanding the domestic intermodal market. This change in focus is in line with the South African government’s policy to shift more freight from road to rail and also with the goals of Transnet Freight Rail (TFR) to target rail-friendly commodities and of moving more palletised commodities into containers.

The results are used to quantify the maximum space requirements for the future IICT.

### Space requirement for the IICT

Table 4 shows the maximum future spatial requirements (in hectares [ha]) for each forecast year based on the limits defined in the research approach.

**Table 4: Maximum future spatial requirements for the IICT**

Land utilisation	TEUs/ha/year	Year	TEUs	ha
Lower limit	2 000	<b>2010</b>	266 499	133
Middle	6 000			44
Upper limit	13 000			20
Lower limit	2 000	<b>2016</b>	331 325	166
Middle	6 000			55
Upper limit	13 000			25
Lower limit	2 000	<b>2021</b>	385 631	193
Middle	6 000			64
Upper limit	13 000			30
Lower limit	2 000	<b>2026</b>	442 886	221
Middle	6 000			74
Upper limit	13 000			34
Lower limit	2 000	<b>2041</b>	723 121	362
Middle	6 000			121
Upper limit	13 000			56

Depending on the level of capacity utilisation (low, medium or high) the maximum space requirement by 2041 for the IICT would be 362 ha, 121 ha and 56 ha, respectively.

### Alternative site selection

Eleven potential sites in the catchment area were identified through stakeholder consultation using the criteria defined in the research approach. Four sites are located within the City of Cape Town urban area (the Atlantis, Kraaifontein [two options] and Kuilsrivier areas); another four are owned by the government or private entities (Acacia Park and Firgrove properties, Wingfield Naval Base and Ysterplaat Air Force base); and three more are owned by Transnet (Salt River property and Bellville and Culemborg precincts).

Table 5 shows the assessment of the 11 locations against the primary criteria.

**Table 5: Location feasibility, road and rail efficacy of selected sites for 2016 and 2041**

Criteria & KPI's Land Area		Locations										
		Acacia Park	Atlantis area	Belville precinct	Culemborg precinct	Firgrove property	Kraaifontein area	Kraaifontein area	Kuilsrivier area	Salt River	Wingfield Naval Base	Ysterplaat Airforce
low-key design	166 ha (2016)	51	2 590	505	23	864	2X146	353	1 353	55	265	253
normal-key design	55 ha (2016)											
high-key design	25 ha (2016)											
low-key design	362 ha (2041)											
normal-key design	121 ha (2041)											
high-key design	56 ha (2041)											
<b>Location Feasibility - Land Area</b>		*	✓	✓	*	✓	✓	✓	✓	*	✓	✓
<b>Rail Efficacy</b>												
Direct Line				Main Cape Town					TRE			
500m		Main (Cape Town)	Blouberg	Marshalling yard	Marshalling yard	Somerset West	Main (CapeCor)	Malmesbury	Stellenbosch		Main (Cape Town)	Side-line to port
Overhead												
<b>Location Feasibility - Rail efficacy</b>			✓	✓		✓	✓	✓	✓		✓	✓
<b>Road Efficacy</b>												
Free-way	1km											
Port (centre)	<20km											
Access	2 main road											
<b>Location Feasibility - Road efficacy</b>			*	✓		*	*	✓	*		*	✓

Three potential sites are accordingly identified as a suitable location for a future IICT. They are the Bellville precinct, Kraaifontein area (second option) and the Ysterplaat Air Force base. Figure 3 shows the capacity utilisation of the three chosen locations over time.

All three sites will have sufficient space if the future terminal is operated at a medium-to-high capacity utilisation level. Ysterplaat and Kraaifontein will run out of space by 2030 and 2040, respectively, on a low capacity utilisation level.

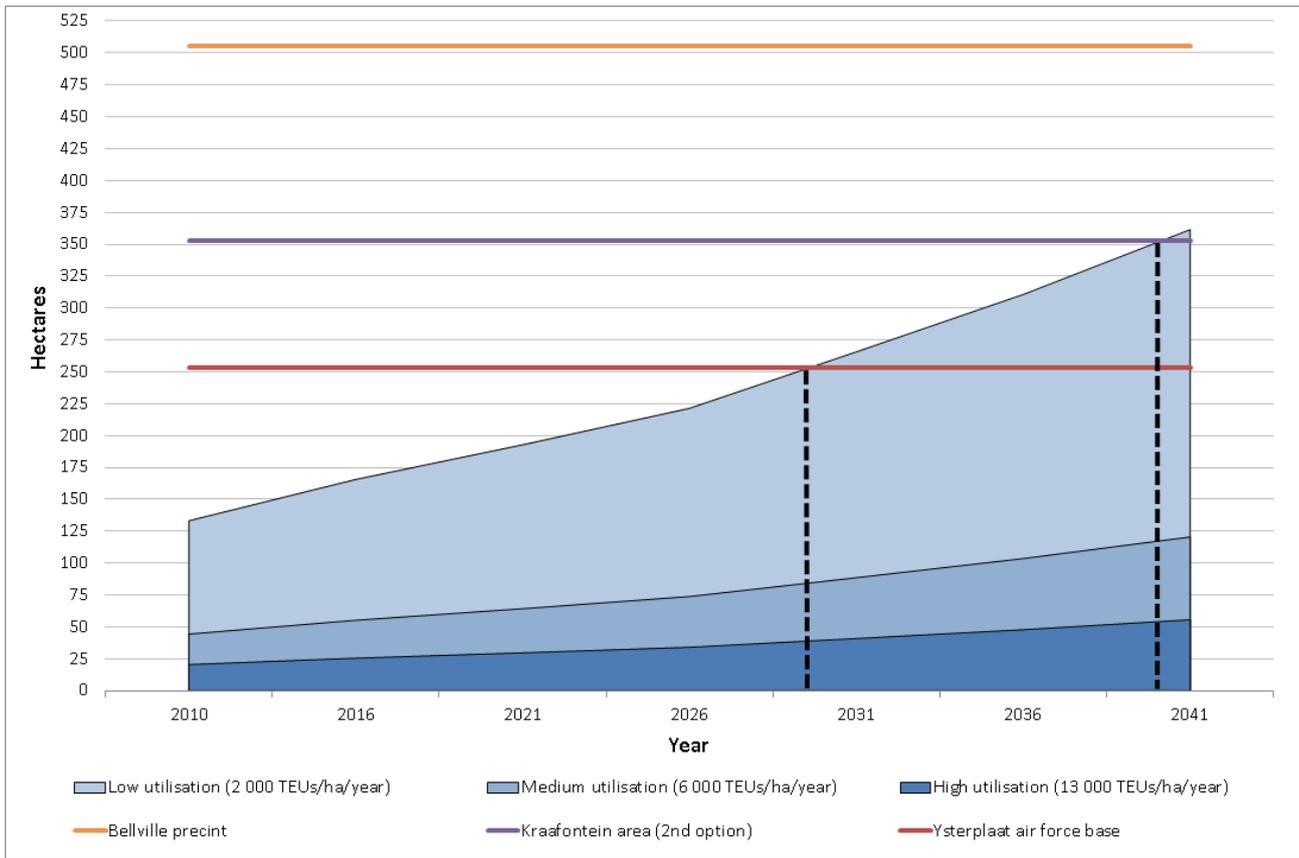


Figure 3: Capacity utilisation of potential locations over time

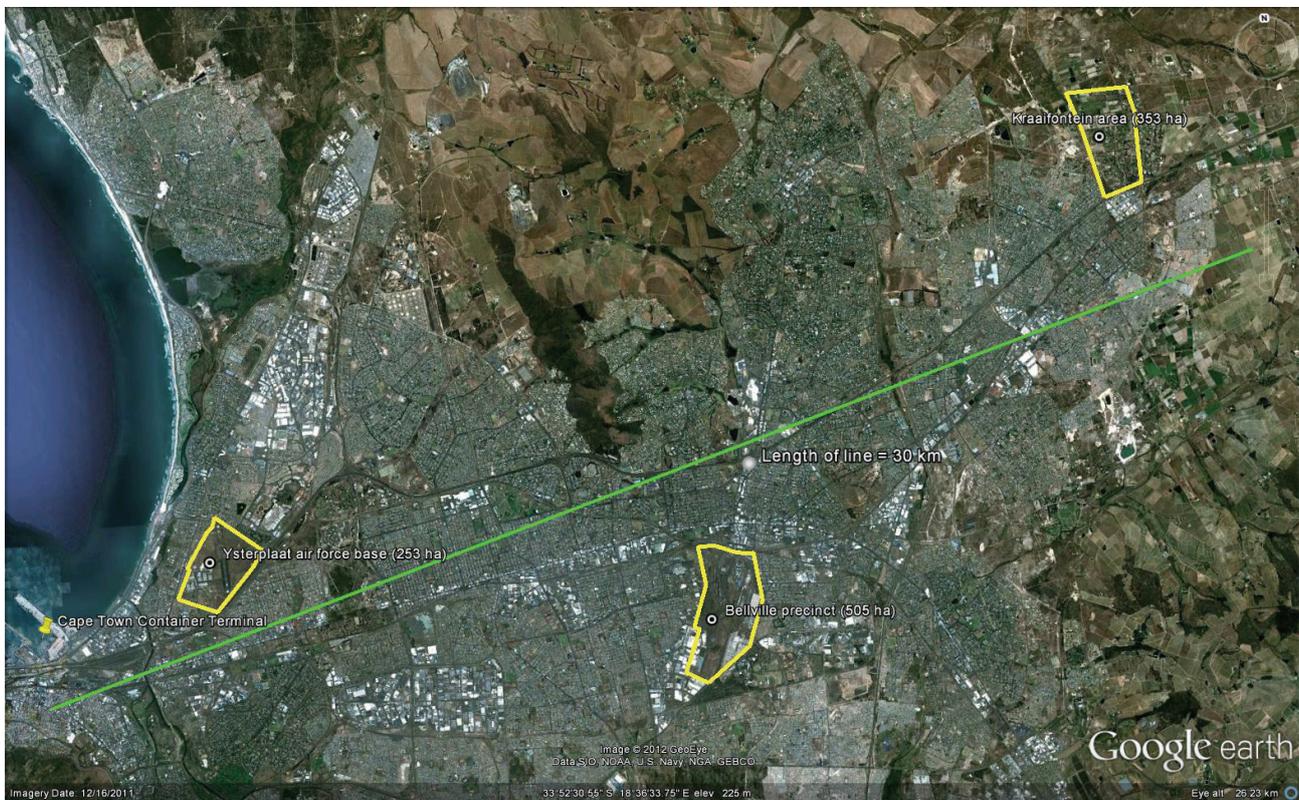


Figure 4: Location of the three potential sites in relation to the Port of Cape Town

Ysterplaat falls within a 5 km radius, Bellville and Kraaifontein within a 15 km and 30 km radius, respectively. All three these sites have major road and rail access within 500 m. Ysterplaat Air Force base is located between the M5 and the N1 and there are off-ramps located at both ends of the site. Rail access can be established from the Cape Town Port feeder line that runs past Lagoon Beach and joins the main line near Acacia Park towards the Bellville railway precinct. The Kraaifontein site consists of a number of privately owned smallholdings with some industrial activity and is located just to the north of the N1, with the Malmesbury railway line running on the western border of the site. The Bellville precinct is owned by Transnet and has established rail access and is located within the N1, N2 and R300 road triangle.

## **CONCLUSION**

Three potential sites were identified for the location of an IICT based on three primary criteria (land utilisation and road and rail efficacy). Space requirements for the IICT were calculated based on container flow segmentations for the catchment area. The availability of forecasts up to 2041 from South Africa's FDM indicate that these sites are future-proof (able to handle future container volumes) – therefore facilitating confidence in the required long-term investment decision.

The three sites were chosen on a high pre-feasibility level and the next step will be to conduct a proper location pre-feasibility study, including the following design and operational considerations:

- A trade-off between the cost of land and the cost of design when choosing which site is most suitable will need to be considered. Transnet (the state-owned rail and port infrastructure owner and operator) owns the Bellville precinct land and could afford a more low-key capacity utilisation design as this is also the biggest land area available. The other two sites will bring the complexity of buying land into the equation and will most probably require a medium-to-high capacity utilisation design. The restriction in size of any container terminal can be mitigated through the design, level of technology and automation employed on site.
- Adding functionality on site will increase the space requirements. Allowing warehousing and distribution functions or including back-of-port activities (such as storage or cold storage, offices, workshops, recreational facilities, commodity processing and restaurants) will add to the footprint of the container terminal.
- Providing dry-port functionality with customs clearance services and administration could alleviate congestion in the port precinct but will place added pressure on an IICT.
- Lastly, environmental, social and financial suitability and sustainability will also need to be analysed.

## REFERENCES

- Davies, P. 2007. *Challenges in Developing Viable Inland Container Terminals*. Conference proceedings of the 2nd Annual National Urban Freight Conference held in Long Beach, CA.
- GAIN (Growth and Intelligence Network). 2012. *Freight Demand Model 2010*, Stellenbosch, South Africa.
- Garratt, M. 2006. *Forecasting for long-term investment in the container shipping industry – a holistic approach*. MDS Transmodal. Available from: [http://www.mdst.co.uk/attachments/downloads/Hamburg\\_Dec06.pdf](http://www.mdst.co.uk/attachments/downloads/Hamburg_Dec06.pdf) (Accessed 18 July 2011).
- Havenga, J.H. & Van Eeden, J. 2011. Forecasting South African containers for international trade: A commodity-based approach. *Journal of Transport and Supply Chain Management* 5(1): 170–85.
- Le-Griffin, H.D. & Murphy, M. 2006. *Container terminal productivity*. USA: University of Southern California.
- Rodrigue, J-P. 2007. *Gateways, corridors and global freight distribution: The Pacific and North American maritime/land interface*. Conference proceedings of the International Conference on Gateways and Corridors held in Pan Pacific Vancouver: Vancouver, 2–4 May 2007.
- Tioga Group. 2010. Improving marine container terminal productivity, *Prepared for the Cargo Handling Cooperative Program, USA*.
- Transnet National Ports Authority. 2010. Port Statistics 2010. *Unpublished figures, South Africa*.
- United Nations Conference on Trade and Development (UNCTAD). 2011. *Review of Maritime Transport 2011*, United Nations Publications, New York, USA.
- US Department of Transportation. 2011. *America's Container Ports: Linking Markets at Home and Abroad*. Washington DC: Bureau of Transportation Statistics, US Department of Transportation.

## Table of acronyms

CAGR	Compounded Annual Growth Rate
CTCT	Cape Town Container Terminal
FDM	Freight Demand Model
FEL	Front-End Loading
IICT	Intermodal Inland Container Terminal
TEU	Twenty-foot Equivalent Unit
TFR	Transnet Freight Rail
UNCTAD	United Nations Conference on Trade and Development