Delft University of Technology

CIE4061-09 Multidisciplinary Project
Durban Dig-Out Port Research

Part 3 Report - Comment on Design Vessel Size

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Preface

In this report the third objective of our Multidisciplinary Project is presented. A comment is made on the port authority’s choice for a design vessel with a 22,000 TEU capacity. Even though this issue has to do less with engineering, the choice for the right design vessel size is important for the final port design. A highly complex system of economics lies behind the choice of the right size, and therefore working on this report gave us a lot of new insights. From the start of our stay in South Africa, WSP and Transnet have made this project a great experience. For this report we would also like to show our special gratitude to the experts who took the time to answer our questions.

Stellenbosch,
January 2015,
## Contents

1 Introduction .................................................. 1

2 Vessel Size Trends ........................................... 3
   2.1 Historical ............................................... 3
   2.2 According to Experts ................................... 4
       2.2.1 The Economical Perspective .................... 4
       2.2.2 The Infrastructural Perspective ............... 5
   2.3 Literature Study ......................................... 6

3 Calling For Durban ........................................... 7
   3.1 Maximum Container Vessels in South Africa ........ 7
   3.2 South African Port Characteristics ................... 8

4 Conclusion and Recommendations ......................... 9
Chapter 1

Introduction

In this report comments are given on the decision of Transnet National Ports Authority (TNPA) to design the Durban Dig-Out Port (DDOP) for a container vessel of 22,000 TEU. The design life for the new port is 50 years. The research moves from the question if the 22,000 TEU vessel will be produced to the question if it is likely for the large vessel to call on the port of Durban, since Durban is not located along the main shipping corridors. The largest container vessel currently in operation worldwide, as of January 2015, has a capacity of 19,100 TEU.

Approach
Several steps are taken to come to a final recommendation for TNPA. The current vessel size trends are investigated. Next to that the expectations of several experts from The Netherlands, Belgium and Germany are summarised. These experts are positioned in universities and in the maritime industry. It is found that two processes are governing in the vessel size trends, which are economic growth and infrastructure capacity growth. Afterwards data from scientific articles is extracted and evaluated. It is also investigated whether it is likely for the large vessel to call at the Port of Durban. This is done based on historical ratios between the world largest vessel and the largest vessels docked in South Africa. Merging the obtained information resulted in the opinion and the recommendation of Project Durban.
In this chapter the research to the expected vessel size trends worldwide is presented. The historical vessel sizes are extrapolated, the opinion of several experts is included and a literature study is performed.

2.1 Historical

Based on the years in which the current largest vessels are built, a possible trend can be determined. Assuming a linear trend, the largest vessel will become more or less 26,000 TEU at the end of the design life of the Durban Dig-Out Port. Historically it can be concluded however that the trend is highly non-linear. The trend line of the historical data is shown in Figure 2.1. The largest vessels are built based on economic expectations, on container demand, and on the capacity of the smallest corridors or the largest cranes. In history the dimensions of vessels are often determined based on the dimensions of the Panama Canal, the Suez Canal (Egypt) and the Malacca Straits (Singapore).
2.2 According to Experts

Since the trends in vessel size depend on several factors, it is decided to include the opinion of experts. The following experts have given their opinion:

- Professor at the faculty of Civil Engineering, TU Delft;
- Professor at the faculty of Mechanical, Maritime and Material engineering, TU Delft;
- Researcher at the faculty of Civil Engineering, TU Delft;
- Professor at the faculty of Transport and Regional Economics, University of Antwerp;
- Port Planner at Port of Rotterdam;
- Senior at DNV GL Maritime;
- Advisor at Deltares.

The key words most used by the experts in the elaboration of their expectation were economic growth and infrastructure capacity. Hereafter these two criteria are used to explain their views.

2.2.1 The Economical Perspective

Most of the experts’ opinion is that the economy is the governing process in the container vessel size trend. As long as it is economically attractive the vessels will grow. It is important to include the whole transport chain in the decision of the design vessel. An example is the new Airbus A380. This Airbus A380 is designed too large for the economical demands and Airbus might be forced to stop its production. It is not excluded that this can happen with container vessels in the future.

One expert focuses on the infrastructure and states that especially an increase in vessel width leads to reinvestments for the ports, since larger cranes are necessary to unload the containers. It is possible to load vessels from two sides (as currently done with the Maersk Triple E Series), this has however logistical consequences. The expert expects the 22,000 TEU vessel to be produced, but in low numbers and with the same width as the current largest vessels (around 50 m).

The Malacca Strait allows vessels with a maximum draft of 21 m and the Suez Canal has a maximum draft of 20 m. But it seems that at the moment the draft of these canals is not a limiting factor. The draft at the ports is normative, and thus to keep an economically viable situation the vessels are designed with a minimal draft. By creative engineering, designers have been able to increase vessel size without increasing the draft as much.

Saving fuel per TEU seems to be the largest driving force behind increasing vessel size for the vessel operators. According to the ‘economy of scale’ principle, more TEUs on one ship leads to an increase of the profit margin. Although by increasing the vessel size the amount of ports the vessel is capable of mooring will be limited. This arises a new problem, the economic flexibility of a (very) large container vessel.

One of the experts expects an upper limit for the capacity of container vessels based on this limited economic flexibility. At this moment the current largest 19,100 TEU vessel is already unable to enter ports in North America [H. Ligteringen and H. Velsink, 2012]. A similar trend is observed in the history of crude carriers. At a certain moment the carriers became less flexible as they could...
not enter the majority of the ports. It has to be remarked that the safety with regard to oil spills also played a role in this process.

Likely the number of terminals where these ships are able to moor will be very small and they will possibly have done major investments in accommodating the vessels. One of the experts states that in this case a monopoly pricing situation can arise in which the market has low influence on the fees the terminal charges for the mooring vessel. Very high prices for mooring can nullify the effect of the economy of scale for vessel operators.

One thing that is very clear is that the economics of the shipping industry are very dynamic and complex. Both the terminal operators and the vessel operators have to do large investments with a lot of uncertainty. The optimisation of profitability on both sides makes it a hard balancing act.

### 2.2.2 The Infrastructural Perspective

With increasing vessel size the experts expect two major problems to arise on the port infrastructure side. The first one to mention is the depth at the quay and subsequently the foundation of the quay walls. The other one is the limited reach of the harbour cranes.

One of the opinions is that the depth of the ports at this moment is the governing factor. Although the container capacity of vessels can increase without increasing the draft of the vessel significantly, at some point the depth of the quay of ports will be insufficient to handle the largest vessels. It is likely that the quay walls are not deep enough to allow deepening of the basin. In this case the quay walls will have to be replaced, which is a major investment and undertaking for a terminal.

The other limiting factor of the port infrastructure is the crane fleet. As the width of the vessels increases, the amount of rows of containers on the vessel increases. The newer ships will surpass the reach of most of the largest cranes currently in use. As mentioned before the Maersk Triple E Series has to be loaded from two sides in some of the ports where it docks. One of the experts gives a width dimension of 58.5 m for the 22,000 TEU vessel. The total amount of TEUs side by side is 23 on this type of vessels. Upgrading the cranes will again mean a large and risky investment and possible long downtime for a terminal.

Though one of the experts mentions that the latest crane available on the market can reach to 25 containers side by side. This would indicate that the width of the vessels can increase further to 63-65 m. His opinion is that a 30,000 TEU vessel will be operational the coming decades.
2.3 Literature Study

In this section the literature study to the vessel sizes is presented. The report ‘An Empirical Study of Fleet Expansion and Growth of Ship Size in Container Liner Shipping’ is used [N.K. Tran and H.D. Haasis, 2014].

From 1982 until 2014 the container carrier fleet increased with an average of 8.2% per year. In harmony with the fleet scale’s expansion, there has been an upturn in vessel size. In 2014, the Post-Panamax armada represents 55% of the total fleet capacity. Until 2016, 113 new titan vessels with a combined capacity of 1.6 million TEUs will be delivered, which is 47% of the global new-built capacity. This is an average of approximately 14,100 TEUs per vessel. Table 2.1 shows the development of very large container carriers from 2007 until 2013.

Several conclusions can be drawn from Table 2.1. The very large container carrier is getting more common in the total fleet of container carriers. The average capacity of all titan vessels constructed however does not increase significantly. The largest vessels to be constructed are getting close to the 22,000 TEU, but the average certainly is not. Therefore it will take a long time before the 22,000 TEU vessel is a common vessel on the ocean trading routes.

Table 2.1: Overview very large container carriers

<table>
<thead>
<tr>
<th>Number of Titan Vessels</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of Total Fleet Capacity [%]</td>
<td>0.67</td>
<td>1.3</td>
<td>2.5</td>
<td>3.6</td>
<td>8.0</td>
<td>11.9</td>
<td>13.9</td>
</tr>
<tr>
<td>Average Capacity per Vessel [TEU]</td>
<td>14,000</td>
<td>12,500</td>
<td>11,800</td>
<td>12,300</td>
<td>12,600</td>
<td>12,600</td>
<td>12,800</td>
</tr>
<tr>
<td>Average Capacity of New Built Vessel [TEU]</td>
<td>n/a</td>
<td>11,500</td>
<td>11,300</td>
<td>11,300</td>
<td>12,800</td>
<td>12,700</td>
<td>13,300</td>
</tr>
<tr>
<td>Growth Rate Average Capacity of New Built Vessel [-]</td>
<td>n/a</td>
<td>n/a</td>
<td>1.018</td>
<td>1.0</td>
<td>1.133</td>
<td>0.992</td>
<td>1.047</td>
</tr>
<tr>
<td>Capacity of Largest Vessel [TEU]</td>
<td>15,500</td>
<td>15,500</td>
<td>14,000</td>
<td>14,100</td>
<td>14,100</td>
<td>16,000</td>
<td>18,300</td>
</tr>
</tbody>
</table>

Also the report ‘Shipping 2020’ [DNV, 2012] is reviewed and it states that container demand is strongly driven by development of the GDP (Gross Domestic Product) in countries and regions and as well as demographic developments. South Africa is still in development and the trade route past Africa is stated as an increasingly growing trade route. Whereas the current main trade routes are seeing a slowdown in their growth. The report draws the conclusion that the rapid growth past 18,000 TEU vessels will continue, but that a practical maximum ship size of somewhere over 20,000 TEU will be established in the next decade.
Chapter 3

Calling For Durban

In this chapter the research for the port of Durban with respect to the main shipping lines is presented. An investigation is done to gain knowledge about which vessel sizes can be expected in Durban.

3.1 Maximum Container Vessels in South Africa

In this section the ratio is determined between the maximum TEU vessel that has docked in South Africa and the maximum TEU vessel that is in operation. This is done for several years. First, the largest container vessels docked in South Africa are determined. To do this, information of [Drewry Maritime Advisors, 2014] is used, see Table 3.1. For these years, the largest container vessel (with respect to TEUs) are assorted.

<table>
<thead>
<tr>
<th>Year</th>
<th>Max. Vessel SA</th>
<th>TEUs</th>
<th>Max. Vessel Worldwide</th>
<th>TEUs</th>
<th>Ratio</th>
<th>Draft Vessel</th>
<th>Largest Vessel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>ML New Oasis</td>
<td>1,902</td>
<td>Susan Maersk</td>
<td>6,600</td>
<td>0.29</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>Maersk Tacoma</td>
<td>3,584</td>
<td>OOCL Shenzhen</td>
<td>8,000</td>
<td>0.45</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>MOL Wish</td>
<td>3,660</td>
<td>Emma Maersk</td>
<td>14,000</td>
<td>0.26</td>
<td>15.5</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>MSC Ships</td>
<td>6,732</td>
<td>MSC Danit</td>
<td>15,200</td>
<td>0.44</td>
<td>16.0</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>MSC Sola</td>
<td>11,660</td>
<td>CMA CGM Marco Polo</td>
<td>16,020</td>
<td>0.73</td>
<td>16.0</td>
<td></td>
</tr>
</tbody>
</table>

This ratio gives historical insight in the size of the largest docked vessel was compared to the largest operational vessel in the world. If this ratio is close to 1, it means that the docked vessels in South Africa are close to the capacity of the largest operational vessel worldwide in that year. If the ratio is close to 0, it implies that the vessel docked in the ports of South Africa is much smaller than the largest operational vessel. This relation is linear, e.g. if the ratio is 0.6 it indicates that the vessel docked in South Africa has a capacity of 60% of the largest operational vessel.
Table 3.1 shows the ratios for the different years considered. The ratios for the years 1997 and 2006 are significantly lower than the other years. The global import and export started to grow from 1997. In 2006 Maersk took the Emma Maersk into operation, which was extremely large for that time. The Emma Maersk is still one of the bigger vessels in operation now. The ratio for the year 2006 is therefore biased. Due to the smaller container import and export in South Africa compared to other parts of the world, the capacity of the incoming container vessels is also lower, but a growth in handled large ships is clearly visible.

From the year 2006 to 2012 the maximum capacity vessels docked in South Africa increases significantly. From 2006 to 2009 by 83% and from 2009 to 2012 by 73%. The growth of the largest operational vessel in the world is much lower, 8.6% from 2006 to 2009 and 5.4% from 2009 to 2012.

### 3.2 South African Port Characteristics

In Table 3.2 an overview of South African ports is given with respect to depth, quay length and crane reach. The information is extracted from [Drewry Maritime Advisors, 2014].

<table>
<thead>
<tr>
<th>Port</th>
<th>Depth [m]</th>
<th>Quay Length [m]</th>
<th>Cranes &gt;22 rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ngqura</td>
<td>16.5</td>
<td>300</td>
<td>6</td>
</tr>
<tr>
<td>Port Elizabeth</td>
<td>12.0</td>
<td>635</td>
<td>0</td>
</tr>
<tr>
<td>Durban</td>
<td>14.0</td>
<td>1372</td>
<td>7</td>
</tr>
<tr>
<td>Cape Town</td>
<td>14.0</td>
<td>1372</td>
<td>0</td>
</tr>
<tr>
<td>Richards Bay</td>
<td>13.5</td>
<td>1244</td>
<td>0</td>
</tr>
<tr>
<td>East London</td>
<td>12.0</td>
<td>2410</td>
<td>0</td>
</tr>
<tr>
<td>Durban Dig-Out Port</td>
<td>18.4</td>
<td>5196</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Project Durban’s expectation of the 22,000 TEU vessel size is that its draft will be 16.3 m [Project Durban, 2014]. With this draft of 16.3 m, the required depth at the quay in the DDOP than becomes 18.4 m. Compared to the other large ports in South Africa this is very deep. There might be room for increasing the depth in the current ports but it is likely that in the future they will not be able to moor the largest vessels. Constructing the DDOP with a draft of 18.4 m is, again, not so much a technical problem, but an economical one. The danger is that the investment in making the port deeper does not pay back, because it may not be economical for the largest vessels to visit South Africa if the DDOP is the only place they can dock.

As vessels increase in size, the amount of containers side-by-side grows. The new generation of container vessels have a row of 23 or more containers. Apparently, cranes with a capacity up to 22 rows are common to use. The turning point is then the 22+ row crane, with which the DDOP will have to be equipped. The same problem as with the draft arises, if the DDOP is one of the two South African ports equipped with 22+ row cranes it may not be profitable for ships to go to South Africa.
Chapter 4

Conclusion and Recommendations

The first question that needs answering is whether it is likely for the 22,000 TEU vessels to be constructed. For this the economic growth and infrastructural capacity have to be considered. From the expertise of the port experts it can be concluded that it is technologically feasible to construct this vessel. With regard to the rapid increase of vessel size over the last decades, Project Durban expects that also the economic growth suits the size of the design vessel on the longer term. As is observed for crude carriers there is a limit expected to be reached one day, but based on the numbers it is expected that this limit is not reached yet. From the literature study it can be concluded that the growth of the average capacity of the large container carriers is not growing significantly yet, thus in the near future the 22,000 TEU vessel will only sail in small numbers.

The second question is whether it is likely for the 22,000 TEU vessels to call for the Port of Durban. The answer to this question is twofold. Chapter 3 elaborates the ratio of the largest vessels docking in South Africa to the largest vessels produced. Table 3.1 makes clear that the docking vessel size in South Africa is growing faster than the worldwide size is growing. If this trend continues South Africa will receive more and more ships close to the maximum vessel size.

However, Table 3.2 makes clear that the different ports in South Africa are not ready to receive vessels of that size. The design vessel will have a draft over 16 m and will require cranes with a capacity of over 22 rows. Because profitability is the largest consideration in letting a vessel sail on a certain route, the future economic growth and container demand of South Africa will show whether it is economically feasible to establish a trading route with very large container carriers. Project Durban’s expectation is that if the infrastructure of more ports in (South) Africa will be able to accommodate the design vessel, the possibility of establishing this trade route will be significantly higher.

Nevertheless Project Durban recommends designing the new port for the design vessel dimensions and with the new cranes. Since dredging the port to depth is a costly investment, a more economically flexible solution can be proposed. If the quay walls are constructed for the design vessel the port can be ready for future vessels, but the investment in the dredging can be postponed. Thus the port could be operational at a shallower depth until it is profitable to dredge it and make the port ready to accommodate the 22,000 TEU vessel.
One point of attention Project Durban would like to highlight is the danger of a monopoly. If the Durban Dig-Out Port will be one of the few ports that can handle the largest vessel and has made the necessary investments, probably the charge for ships to dock in Durban will be high which will put large pressure on the profitability of the vessel operator. As a consequence, less vessels might make use of the port of Durban, which results in a financial downturn for the port.
Bibliography


