JOURNAL OF MARITIME RESEARCH

Vol XIII. No. I (2016) pp 41–46

ISSN: 1697-4040, www.jmr.unican.es

Vessel dimensions: A key factor to the design and location of dry bulk terminals

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ARTICLE INFO

Article history:
Received 09 Dicember 2015;
in revised form 19 Dicember 2015;
accepted 20 March 2016.

Keywords:
Bulk Carriers, Freight, Bulk, Cargo Handling, Ports, Bulk Terminals.

ABSTRACT

Bulk solids represent approximately one third of traded goods. The dry bulk shipping sector has been steadily growing in recent years. It is a sector with special characteristics in transport operations, freightage and with a dedicated fleet of ships that have been growing in size up to the current large bulk carriers capable of transporting 400,000 tons of bulk. It is in this context that this study seeks to identify and deepen on the characteristics of vessels in relation to their groups and categories, especially in core factors such as draught and beam, in order to know the requirements of installation where they can operate. As a result we obtain a model in which we can identify those characteristics as a function of the segment they belong to.

1. Introduction

World maritime trade, which according to UNCTAD[2] represents 80% of all goods trade, is still dominated by the transport of raw materials; oil tanker traffic accounted, in the year 2013, one third of global traffic. On the other hand the 5 major bulks (iron, grains, coal, bauxite/alumina and phosphates) accounted for approximately 28% of total goods moved by sea.

Sea transportation represented in 2013 a total of 9,548 million tons, of which more than 60% were bulk petroleum products and major dry bulk (iron ore, grains, coal, bauxite / alumina and phosphates) as shown in Table 1.

This gives us an idea of the importance of supply chains of solid and liquids bulk, also called commodities.

An important factor in the chain are specialized terminals or intermodal nodes in ports, complex and dynamic systems, through which all material flows should circulate efficiently. These systems are influenced by a number of factors including the size of vessels, which will be part of the study. Other factors, such as freight rates and supply and demand markets, will approach or move away markets.

Table 1: Evolution of international maritime traffic.

Year	Oil and Gas	Major Bulks	Containers and other dry cargo	TOTAL
1970	1,442	448	676	2,566
1980	1,871	796	1,037	3,704
1990	1,755	968	1,285	4,008
2000	2,163	1,288	2,533	5,984
2006	2,698	1,836	,3,166	7,700
2007	2,747	1,957	3,330	8,034
2008	2,742	2,059	3,428	8,229
2009	2,642	2,094	3,122	7,585
2010	2,752	2,333	3,323	8,408
2011	2,794	2,486	3,505	8,785
2012	2,841	2,742	3,614	9,197
2013	2,844	2,920	3,784	9,548

Source: Authors, self made with data from UNCTAD 2014 and based on data from Clarkson Research Services

The major causes of problems in managing the flow of bulk are often the problem of bulk solids handling (storage, transport and processing). A poor design in the nodal exchange node can affect the flow generating bottle-necks, delays and unnecessary

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[2]UNCTAD: United Nations Conference on Trade And Development

costs, so seeking the maximum efficiency and productivity of the installation is key in the flow chain of bulk operations. Also we should not forget those environmental problems caused by the activity. Therefore, a correct characterization of the vessel to operate and its size is a critical factor.

As defined in Chapter VI of SOLAS[3], we understand by "Bulk-carrier": a ship, generally built with a single deck, with high and low side ballast tanks in cargo spaces and used primarily to transport dry bulk. This definition includes other types of vessels such as minerals tankers and combined ships (hydrocarbons and solid bulk loads).

Given its dimensions we can find different classifications, such as we find in Table 2.

Table 2: Title to refer to bulk vessels by UNCTAD is reflected in the table

Classification	Size (DWT)	Length (*meters*)
Small Ships	<10,000	
Handysize	10,000 - 39,999	<160
Handymax	40,000 - 59,000	<190
Panamax	60,000 - 99,999	<240
Capesize	100,000 - 200,000	<310
VLOC & ULOC	>200,000	>310

Source: Authors, self made with data from UNCTAD and Barry Roglyano annual review

Small ships or 'conters' are those of up to 10,000 DWT involved in proximity transportation

Handysize ships are those with a capacity up to 35,000 DWT. These ships are normally intended for minor bulk trafficking and/or intended for small ports with strong dimensions restrictions for the operation of bulk carriers.

Handymax are ships with less than 60,000 DWT. A Handymax is typically a ship with a length of 150-200 *meters* (492-656 *feet*), even though certain restrictions applied by a few bulk terminals, such as the ones in Japan, have caused many Handymax to have been built with a length of some 190 *meters*. The designs of modern Handymax ships range between 52,000 and 58,000 DWT, they have five cargo holds and four cranes of approximately 30 *tons*.

We can also find the ***Supramax***, in naval architecture terminology, to designate the largest bulk carriers in the Handysize class. In some specialized sectors Handysize class is divided into Supramax (50,000 to 60,000 DWT) and Handymax (40,000 to 50,000 DWT), and Handy (¡40,000 DWT). But in a constantly evolving sector we find over recent years new designs of naval architecture, enhancing the operational characteristics of handymax vessels, increased in size from the 45,000 DWT Handymax of the 1990s, to the 64,000 DWT of Ultramax today along with the Supramax.

During the golden years of sea shipping, 2004-2008, the largest naval architects developed designs to improve the capacity of vessels, emphasizing the Handymax and Capesizes series, with the main objective of increasing operating results.

The Ultramax is basically a Supramax with a ship-length 10 meters longer. The Ultramax is the latest culmination of these efforts of ship design. The Ultramax offers a better all around investment for charterers and shipowners due to its higher cargo carrying capacity and better fuel efficiency (partially gained from derated engine with less HP) as compared to the Supramax, and due to the upgrade in the Panama Canal that will allowing transits to Capesizes at 15.2 meters of draught. It is still not sure how it will impact in Panamax cargo volumes, but it is expected to reduce Panamax loads available as competition with Capesize vessels starts in various traffics.

Hellenic News magazine presented the analysis *The 'Ultramax' Pushing it to the Max: A comparison with the Supramax and Panamax*. The Ultramax is the way to go as Handymax cargo sizes slowly become larger and shippers/receivers continually look for cheaper freight alternatives. This will see the Supramax becoming less desirable and the Ultramax competes directly for Supramax cargoes as well as Panamax cargoes.

Panamax are vessels with a capacity between 60,000 and 100,000 DWT and they represent those vessels with the largest acceptable size to transit, even in ballast[4], through the Panama Canal. The maximum dimensions allowed in the Canal are determined by the size of the locks available, each of which is 33.5 *meters* wide by 320 *meters* (1,050 *feet*) long and 25.9 *meters* deep. The depth of the water available in the locks varies, but the minimum depth is still on the ledge of Pedro Miguel's Locks, and it is of 12.55 *meters*.

With the increase on the beam (49 *meters*) and drought (15.2 *meters*) on the Panama Canal[5], Panamax will lose their status as "maximum Panama" and begin to compete with other types of ships from 2016 onward. The Panamax vessel will still be the common ship for coal and grain for years to come, but it is difficult to analyze the impact of a deeper Panama Canal on the market of cargo and freights, in a stage where boats ultimately determine the size of shipments.

Capesize refers to vessels with a cargo capacity of over 100,000 DWT in a quite ill-defined standard, which is the common characteristic of being unable to use the channels of Panama and Suez, not necessarily for their tonnage, but because of their size. This vessels serve very deep water terminals operating mainly iron ore and coal. As a result, they must sail arround Cape Horn (South America) or the Cape of Good Hope (South Africa). Its size ranges from 10,000 to 250,000 DWT and there is only a relatively small number of ports around the world with the infrastructure to accommodate such vessel sizes.

In recent years a new series of vessels have been developed called VLOC/ULOC: Very Large Ore Carrier / Ultra Large Ore Carrier, a new kind of bulk-carrier above 200,000 DWT for the transport of iron ore. The largest boats of the ULOC class, above 350,000 DWT, carry iron ore between Brazil and Asia. Because of its huge size there is only a relatively small number of ports around the world with the infrastructure to accommodate such vessel size

The maximum representative of these vessels is found in

[3]IMO's International Convention for the Safety of Life at Sea

[4]Ballast refers to a vessel sailing without cargo

[5]The Panama Canal expansion, which will be effective from 2016, represents a quantum leap in commercial terms because, once completed in 2015, it will allow the navigation of ships 400 *m* long, 52 *m* wide and 52 *m* of drought

those built by the Brazilian company VALE, the Valemax or Chinamax (Image 1 and 2). They are named after the Brazilian mining giant VALE, which today it manages a fleet of more than 30 units carrying iron ore from Brazil to major ports in Europe and Asia. It made it's first major order in 2008, twelve 400,000 DWT VLOC/ULOC to the Chinese shipyard Jingsu Rongsheng Heavy Industries and After the order of 2008, it executed another order for seven vessels in 2009, to the shipyard DSME in South Korea, and then another sixteen more to STX Offshore & Shipbuilding along Korea and China, which conformed a fleet of 35 operating ships in 2014.

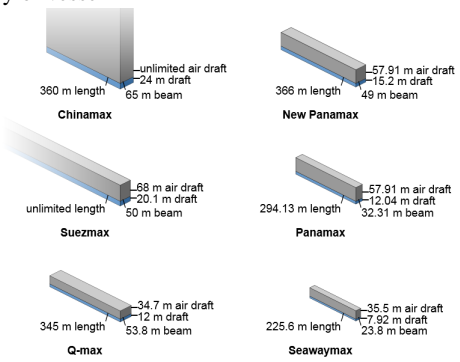
The lengths of these vessels range from 360 to 362 *meters*, making them the largest ULOC in the world, if not the largest ships in service today. Their drroughts are also very important, around 23 *meters* fully loaded (around 12 *meters* in ballast mode), so they can only be operated in a very small number of terminals worldwide. In Europe they operate in the port of Rotterdam. The beam is 65 *meters*, limited to the capacity of the arms of terminals to operate (beam for vessels called Chinamax). The seven cargo holds accomodate about 220,000 cubic meters and each can hold the same cargo as a small Panamax. Valemax are powered by engines of around 29,000 kWvat 78 rpm with an estimated consumption of 100 *tons* of fuel per day.

Figure 1: The VALE BEIJING maneuvering in port

Source: http://www.atmosferis.com/wp-content/uploads/2013/07/vale-beijing.jpg

VALE capacity, together with the availability of the fleet to control the global steel economy forced the Chinese government, whose revenues from iron ore business are an important link in its heavy industry, to regulate laws that prevented the VALE fleet to unload in Chinese ports. VALE planned to operate their own vessels, assuming the risk involved in this decision, because in this way it could have some control over the world price of freightage by setting the prices themselves. The Beijing government introduced a regulation that such vessels could not operate in Chinese ports if they had more than 300,000 DWT. This legislation was based on environmental grounds, because of the more than 10,000 *tons* of fuel capacity, which would be difficult to control in case of an incident.At the end, the tensions between VALE and the Beijing government, which began with the threat of stopping the payment of ships that were still being built in Chinese shipyards, ended up with a very lax regulation and VALE was able to complete its first unload. However, a continuous confrontation, increased by structural faults that occurred in December 2011 while VALE BEIJING was being loaded at the port of Ponta da Madeira, and has forced VALE to negotiate the sale of part of its fleet to the Chinese operator COSCO.

Figure 2: Comparison of a "Chinamax" Volume with different volumes by category of vessel



Source: https://en.wikipedia.org/wiki/Chinamax

But we can also find other acronyms like:

- The ***'Kamsarmax'***: Are Panamax vessels of about 82,000 DWT and with increased length up to 229 *meters*. Its name comes from the name of Port Kamsar in Equatorial Guinea and its dimensions are given by the constraints of its bauxite terminal.
- The ***'Newcastlemax'***: Maximum beam of 50 *meters* and a length of 300 *meters*. Its name is based on the largest ship that can operate in the terminal of the Port of Newcastle in Australia; they are ships of about 185,000 DWT.
- The ***'Setouchmax'***: Vessels of about 203,000 DWT, they are the largest ships that can navigate the sea of Setouch in Japan.
- The ***'Seawaymax'***: With a maximum length of 226 *meters* and a maximum drought of 7.92 *meters* is the largest ship that can pass through the St. Lawrence Seaway Canal (Great Lakes, Canada).
- ***The 'Malaccamax'***: With a maximum length of 330 *meters*, a maximum drought of 20 *meters* and approximately 300,000 DWT refers to the maximum dimensions of the vessel able to cross the Strait of Malacca in Indonesia.
- ***The 'Dunkirkmax'***: With a maximum length of 289 *meters*, a maximum beam of 45 *meters* and approximately 175,000 DWT refers to the maximum dimensions of the vessel able to operate in the eastern dock of the Port of Dunkirk.

Or more specialized bulk carriers:

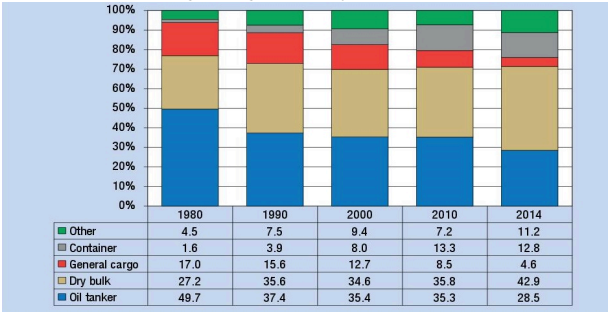
- The ***'Self-dischargers'*** are ships equipped with a system of chains and belts that allow automatic unload in the docks through its unloading arm, which is equipped with a conveyor belt.

- The ***'BIBO'*** or ***'Bulk In, Bags Out'*** are bulk carriers equipped to produce bags with bulk that they have in their cargo holds. Bulk is loaded and sacks unloaded.
- The ***'OBO'*** (ore-bulk-oil) are bulk-carriers able to transport dry bulk cargo along with oil by-products.

In the case of ships destined to transport oil and oil by-products:

- The ***'Aftermax'*** bulk carriers which are used to transport oil and oil products with a capacity of 80,000 to 120,000 DWT.
- The ***'Suezmax'*** bulk carriers for the transport of oil and oil with a capacity of 120,000 to 200,000 DWT.
- The ***'VLCC'***: The so-called 'Very Large Crude Carrier'. They are vessels exclusively destined to transport oil and its derivatives with a capacity of 150,000 to 320,000 DWT. They offer good flexibility for the use of terminals, and are used in ports that have depth limitations, especially in the Mediterranean, West Africa and the North Sea. They can circulate through the Suez Canal when sailing in ballast.
- ***'ULCC'***: Ultra Large Crude Carriers are ships to transport oil and derivatives, and have sizes of 320,000 to 550,000 DWT. They are used to carry crude oil in long transport routes from the Persian Gulf to Europe, America and Asia via the Cape of Good Hope or the Strait of Malacca. Their huge dimensions require very specialized terminals.

Figure 3: Evolution of global fleet 1980-2013 by types of ship and in million DWT at the beginning of each year



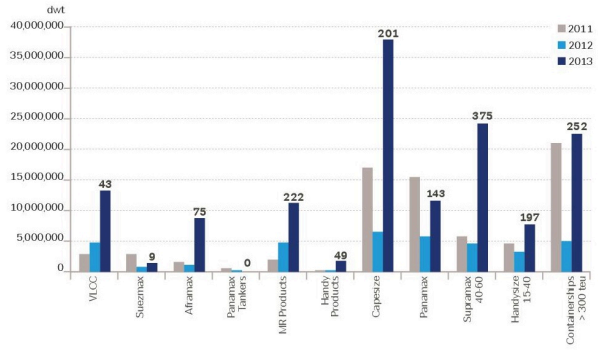
	1980	1990	2000	2010	2014
Other	4.5	7.5	9.4	7.2	11.2
Container	1.6	3.9	8.0	13.3	12.8
General cargo	17.0	15.6	12.7	8.5	4.6
Dry bulk	27.2	35.6	34.6	35.8	42.9
Oil tanker	49.7	37.4	35.4	35.3	28.5

Source: UNCTAD Maritime Transport 2013

Considering the growth of bulk carriers during the past 35 years (Figure 3) and taking into account the growing size of bulk carriers (Figure 4), we can conclude a growing sizing of ships for the transport of bulk

One reason is found from the standpoint of international trade, if one takes into consideration China and India as major unloading areas, as they are the engine of growth for imports for Ultramax vessels, and because these boats really are designed for intra-Asian trade, where the dimensions of the vessels play an important role, and where drought constraints are lower.

Figure 4: Size of fleet by types of bulk carriers in DWT.



Source: Rogliano Salles: 2014 Annual Review

The Ultramax offers a better all around investment for charterers and shipowners due to its higher cargo carrying capacity and better fuel efficiency (partially gained from derated engine with less HP) as compared to the Supramax, and due to the upgrade in the Panama Canal that will allowing transits to Capesizes at 15.2 *meters* of draught. It is still not sure how it will impact in Panamax cargo volumes, but it is expected to reduce Panamax loads available as competition with Capesize vessels starts in several destinations. A new routing with loads of coal of Capesize vessels from the East coast of the US to Asia, or loads of grain from Atlantic origin through the expanded Panama Canal, they can change some patterns of maritime transport.

Also worth mentioning at this point is another ongoing project, supposed to be operational in 2020, such as the Nicaragua Canal. This future 278 kilometers channel, currently in the startup stage and the result of a 50-year concession to the Hong Kong based company HKND, may change some patterns of maritime traffic, as the project forsees a drought of 26 to 30 *meters* that would allow passage to large vessels.

Ultramax vessels are ideal for Asian trade. With a length of 199 *meters*, the Ultramax is still smaller than a Panamax and a little larger than a Supramax, and offers its own cranes. All ports that can handle Panamax vessels can easily handle a Ultramax. Similarly, most of the ports that can handle a Supramax can also handle a Ultramax. Even in countries like Bangladesh, India, Indonesia, the Philippines, Singapore and Vietnam, where the loads are performed offshore and where there are rarely any restrictions. The Ultramax has over 6,500 *tons* of cargo capacityabove the Supramax (Shipping News 2013) in a comparison among Supramax, Panamax and Ultramax.

2. Methods

The dimensions of vessels have been processed based on the creation of a database of 740 ships, built and operational since 1997, and depending on their classification. We used the fleets operated by four large operators: Oldendorf , Swismarine, Lautitzen and Wester bulk.

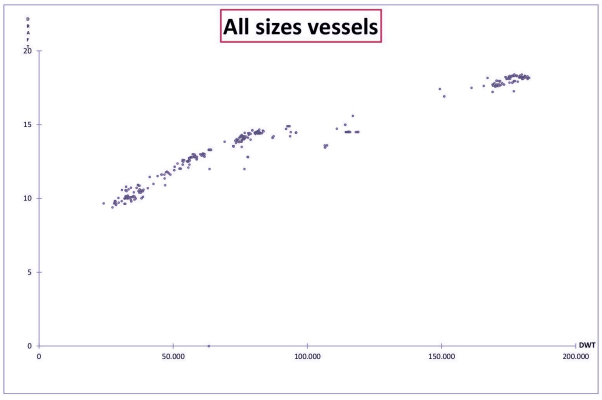
Universe	4 big ships Operators
Geoggraphical Scope	World
Sample Size	740 ships
Field Work	1st. semester 2015

The dimensions analyzed, which will be presented in graphics below, were the drought and beam of the ship. Also the vessel's drought is related to the DWT. Each point is extracted from the generated database and corresponds to a different vessel.

3. Development

In the subsequent graphic (Figure 5) we can see the relationship between drought and DWT for all ships investigated and a ranking chart in terms of operated traffic.

Figure 5: Drought / DWT for different types of vessels and total sample.



Source: Authors

For beams, a similar table has been developed which is reflected in subsequent models. Also we have identified traffic (local, continental, intercontinental) that are related to the type of ship according to the table below (Table 3).

Table 3: Characterization of ships according to traffic

	Local/Regional	Continental	Intercontinental
Type of Vessels	Coaster, Handymax	Coasters, Handymax, Panamax	Handymax, Panamax, Ultramax, Capesize, VLOC, ULOC
Berthing (min)	180 *m*	200 - 250 *m*	200 - 350 *m*
Drought (min)	9 *m*	12 - 15 *m*	12 - 20 *m*
Air Draft (min)	>12 *m*	>14 *m*	>18 *m*
Beam	<32 *m*	<35 *m*	>35 *m*

4. Conclusions

The expected increase in global trade, especially the global traffic of bulk, will generate new flows of sea traffic especially of coal and iron ore. Many of the existing terminals will have to increase their availability for receiving larger vessels, while extending and / or modifying its operations, or consider moving to facilities capable of hosting ships of higher dimensions and with higher operational requirements.

It is also important to consider the evolution of freightage, in a bear market like the one we have nowadays, markets are getting closer and sources of supply can be found in the other side of the globe where demand occurs. A clear example is the modification of the type of traffic and ships berthing in Tarragona, from the old Handymax vessels with grain originating in Brazil and Southern USA, to new smaller Handy type vessels with grains of Eastern European origin.

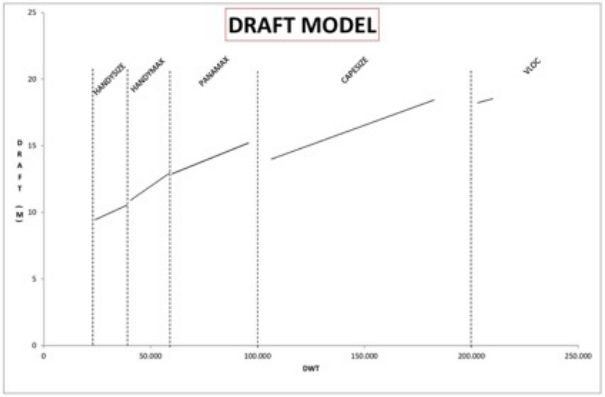
Dry-bulk terminals can be clustered into four main groups according to the annual volume they handle. The first group are terminals with less than 1,000,000 *tons* of traffic and they often operate in unlicensed piers. The second group are terminals moving between one million and five million tons per year with a lot of concessions with special facilities in Spain. The third group are those terminals capable of receiving large ships such as 'Capesize' and generate excess of 5,000,000 *tons* of annual traffic. Finally we would find those terminals that generate traffic over 50,000,000 tons a year and capable for receiving the greatest 'Valemax' or 'Chinamax' series vessels, with high performance in cargo ships operating volumes, often with loading rates higher than 200,000 *tons* per day and closely linked to traffic for coal and iron.

There is a strong connection between the design of the terminal and vessel operations and its annual turnover, which could establish the design parameters based on the maximum operating vessels as well as their frequency. A model to determine the necessary dock characteristics depending on operating vessels (drought in dock) is provided.

We also have a direct relationship between the size of the ship and traffic operations, choosing the largest ship by scaled economies provided the characteristics of the source and destination terminals allow the dimensions of the ship with the minimum requirements of the terminal to accommodate these vessels (Table 3 and 4).

At the same time we present in Figure 6 and 7 models to obtain drought and beam as a function of DWT and type of vessels.

Figure 6: Drought of the ship depending on the type and DWT

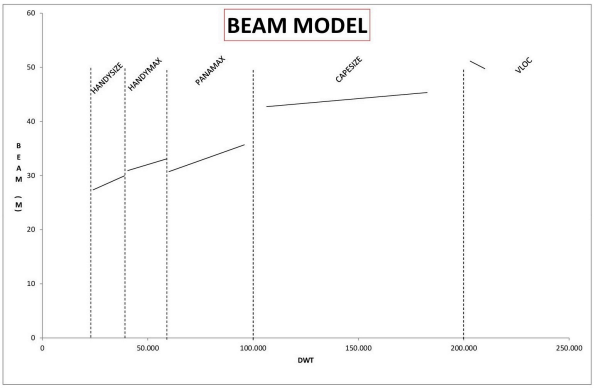


Source: Authors

Table 4: Dimensions of bulk carriers by type.

Classification	Size (DWT)	Length (*meters*)	Drought (*meters*)	
Small	<10,000			
Handysize	10,000 - 39,0000	<160	8 - 10.5	Handymax 40,000 - 50,000 DWT Supramax 50,000 - 60,000 DWT Ultramax length 10 *m* more Supramax
Handymax	40,000 - 59,000	<190	10.5 - 12	
Panamax	60,000 - 99,9999	<240	12 - 14.5	
Capesize	10,000 - 200,000	<310	13 - 18	
VLOC & ULOC	>200,000	>310	>18	Valemax & Chinamax 360 *m* length and 23 *m* drought

Figure 7: Beam, in terms of type and DWT



Source: Authors

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