Rapid Literature Review: Unpacking Containerisation

The Hindsight Perspectives Project led by the Lloyd's Register Foundation is grounded in the understanding that no idea, invention or occurrence is entirely new. Instead, every 'innovation' is fundamentally built up of components of history that, when put together, construct our future. With this in mind, our past can be seen as a beacon of light that empowers us with the opportunity to take lessons, whether they be from success or failure, and apply them to brighten the future and create a safer, more sustainable world.

One challenge that the maritime sector is facing today which global maritime history can shed light on is the increasing trend of transporting containers on the decks of bulk carrier vessels. This is primarily due to the current shortage of containerships (in part as a result of COVID-19) alongside the potential short-term economic gain that such trading methods offer. The literature review that follows is a summary of potential historic sources that may contain useful guidance for the maritime industry in navigating this foreign ground; recognising patterns in the past of containerisation and beyond could unlock an understanding that enables us to predict the long-term consequences and necessary actions for today.

The resources listed below have been collated from a variety of locations, including the Heritage & Education Centre (HEC) archives, Lloyd's Register publication articles and other resources accessible online. A brief summary is given as an explanation for why each resource may prove useful for this case study. The methodology taken for the accumulation of these resources was to begin with more general sources that offered an understanding of the history of containerisation and a discussion of the current climate in container transport. This information was particularly taken from online sources, annual reports and "Container Shipping Milestones" by Tozer, as the summaries contained were extremely beneficial for highlighting the most relevant occurrences in container shipping history. After this, more detailed and specific resources were pulled together, each building on different hypotheses developed to understand the ultimate cause, and thus solution, to the transportation of containers on bulk carriers. These resources were mainly those taken from the HEC and LR archives. Additionally, the brainstorm meetings held as part of the placement were an extremely useful resource for bouncing ideas off other interns and members of the Lloyd's Register Foundation, who shared invaluable experiences that guided the direction of my research greatly.

The findings documented here are just the tip of the iceberg, and this review records possible avenues for further research into the field of containerisation and on-deck container storage, as well as resources that could complement this study.

HEC (Heritage & Education Centre) Archives

The Heritage & Education Centre provides some phenomenal resources that unlock a deep understanding into the maritime industry from its beginning through to modern times. Below are a few resources that could be further explored to gain further insight to the history of containerisation and beyond.

Watson, N., 2017. *Marine Science and Technology: Changing our World*. UK: Lloyd's Register Foundation and the Heritage & Education Centre.

This book is a summary of the history of technology development in the maritime industry, including a section on 'the container revolution' from 1945-2015. This section is a brilliant source for understanding how containers developed to become such a fundamental method for transporting cargo. There is also a section that looks at 'the search for cleaner fuel at sea' which could provide insight into how the fuel of future vessels will govern the size and capacity of vessels, and what this could mean for containerisation and global container distribution in the future. The sections that discusses 'science, standards and safety' from 1850-1900 and 'regulation and technology' from 1945-2015 also demonstrate potential to greatly inform our understanding of the way that regulations have developed with different practises. This is important for containerisation because an understanding of the way that regulations have changed overtime will help to understand how new regulations can ensure the safe transport of containers on other ships that were not designed for carrying containers such as bulk carriers.

Lloyd's Register Foundation, 2021. *Information Sheets | Archive & Library | Heritage & Education Centre*. [online] hec.lrfoundation.org.uk. Available at: https://hec.lrfoundation.org.uk/archive-library/information-sheets [Accessed 15 September 2021].

This site on the Heritage & Education Centre website has a useful collection of information sheets that cover a wide range of subjects. Information sheets that would be particularly useful for this research topic would be:

10. Lloyd's Register of Shipping : source available to historical researchers
49. Online sources for the location of archival collections.

    These information sheets summarise some further resources that could give insight to the history of containerisation, including links to online libraries and other websites.

44. Making a search using the *Lloyd's Register of Ships.*

    This sheet summarises the best way to use the Lloyd's Register of Ships, which can be searched for historic container ships, to understand their development until today. Bulk carriers and their structural development can also be studied to see how they may be developed to carry containers safely in the future.

Lloyd's Register Foundation Online Register of Ships, 2021. *LRF HEC*. [online] archive.org. Available at: https://archive.org/details/%40lrfhec?&sort=-publicdate&page=2 [Accessed 15 September 2021].

This online Register of Ships could be a useful resource that gain insight to the development of container ships in the past through to the modern day. Bulk carriers can also be explored in similar detail. The above information sheet provides useful details for how to best use the Register.

LRF (Lloyd's Register Foundation) - Digitised Internal Publications

The digitised internal publications of the LRTA are a fantastic resource that hold detailed and insightful information on the development of the maritime sector since the 20th century. Below is a record of resources used and the insight gained from them.

Tozer, D. May 2011. [Container Shipping Milestones by Tozer], Lloyd's Register Foundation Digitised Internal Publications.

This timeline of containerisation indicates that, although containerised cargo was originally 'invented' as a concept in 1937 by Malcolm McLean, it wasn't until the 1960s that regulations concerning container transport arose and around 1970 when ships specifically designed for containers came into being. In this gap, containers were transported by converting ships so that they could carry cargo, e.g. in 1956, the Ideal X (a tanker ship) was converted to carry cargo on deck. Further research into this specific vessel and others converted into container carriers should prove beneficial and fruitful for informing the future of container transport on decks.

Other interesting vessels or occurrences to research that stand out in the history of containerisation and have some feature that is relevant for today include:

> The 1990 *Bell Pioneer* (current name *EGY Group*) was the first hatchcoverless design, Lloyd's Register classed.
>
> The 1999 Norasia (1400 TEU fast feeder container ship) was another hatchcoverless design.
>
> In 2009, the Asia-Europe spot box rates plunge to zero dollars. 540 container ships (11% of the fleet by number) lay idle.

In 2000, the *Ultra-Large Container Ship* (ULCS) study was published by Lloyd's Register. This study showed that largest container ships which could be built, propelled and handled by the main container terminals was 14,000 TEU capacity. This article is useful because it analyses the maximum load that container ships at the time would be able to withstand, including on-deck cargo; this sort of information would need to be re-analysed for bulk carriers being use for containerised cargo.

> "The *Ultra-Large Container Ship* (ULCS) study by Lloyd's Register, in association with Ocean Shipping Consultants Ltd, examined the feasibility of larger container ships. The starting point when considering the maximum size of a container ship must be an assessment of the capability of the container terminals to handle such a ship, taking account of the outreach of quayside gantry cranes, available berth length and water depth, and the ability of the terminals to dispatch the containers inland by road or rail (the "hinterland link") or onto feeder ships for delivery to their final destination. Then, it is necessary to consider how high the containers can be stacked in the ship. The strength of freight containers is defined by an ISO international standard, to which most containers are manufactured. With the ISO standard of strength, it is only possible to stack the containers 10 or 11 tiers high in the holds of a container ship, or the weight of the stack will crush the lowest box. On deck, the containers can be stowed 7 or 8 tiers high – beyond this the boxes may collapse when the ship rolls and pitches at sea. From this analysis we concluded that the maximum feasible size of container ship which can trade to most of the global hub ports is 14,000 TEU. Such vessels are best suited to the long-haul trades, particularly Asia-Europe."

18th September 2008. [Container Ship Speed Matters – Flexible Ships Needed in Volatile Times], Lloyd's Register Foundation Digitised Internal Publications, Lloyd's Register Press Release.

This article discusses the need for vessels that can travel at different speeds to accommodate the varying oil prices that are becoming increasingly unstable. It discusses the fact that previous ship design was specific to the stable oil industry at the time, but this is not appropriate for the fuel industry of today. We need to find ways to make ships that are flexible in size and speed to best optimise prices and economic and social demand. However, varying speed (e.g. slow steaming for lower speeds that the ship maximum) often has environmental implications that also need to be taken into account with the current infrastructure in place. This includes the emission of NO_x. If we really want to have adjustable ships that are designed for today's market, then we need to find a way to balance the economic, environmental and social requirements to create new solutions for the future.

> "By way of example a relatively straightforward calculation demonstrates that for a large container ship designed for 25 knots at 70,000kW main engine power, speed reduction to 20 knots would require just 50% power. Given that voyage time will increase as a consequence of the reduced speed, the fuel saving will be somewhat less, about 40%. So slow steaming can offer a large saving in fuel consumption; however, it can be calculated that total NOx emissions increase - by up to 40 tonnes – when steaming between 20 and 25 knots (see graphic at bottom).
>
> In addition, it is a waste of engine capacity and a capital cost penalty to carry unused power potential."

This is relevant to the container on deck challenge because it may be that, although the infrastructure of today is not designed for safely carrying containers on the deck of bulk carrier ships, this might be the push that the maritime industry needs to start designing new vessels that are more appropriate for the economic, social and environmental demands of the future and present. We could see this as an opportunity instead of a challenge.

22nd July 2010. [Lloyd's Register Delivers New Rules and Software to Support Safer, more Flexible Container Securing and Storage], Lloyd's Register Foundation Digitised Internal Publications, Lloyd's Register Group Press Release.

This article summarises the release of new regulations and a software package that enhances the current guidelines and capabilities of container securing and lashing. Applying this type of software or tailoring it to the demands of lashing containers to bulk carrier vessels could unlock opportunities to develop safe mechanisms for carrying containers on bulk carrier ships as it offers accurate calculations on the effectiveness of lashing methods, which should allow bulk carriers to be adjusted for safe lashing. The article also summarises some of the key challenges that the container shipping sector is still facing that they hope this software will bring us closer to solving or reducing. These challenges will need to be addressed carefully before containers are legally administered on bulk carriers and rules and regulations are created to govern such methods for cargo transport. If the risks are greater than those associated with containerisation and its transport today, then further legislation is necessary to reduce loss of life and other damage to people and the environment. The intention for introducing the regulations in this article are summarised as:

> "A reduced risk of losing containers overboard, with associated environmental risks and cost."
>
> "A reduced risk of loss of life or serious injury to stevedores and crew engaged in container lashing."

[Container Ships by Major Operations 1994-2007], Lloyd's Register Foundation Digitised Internal Publications.

This document summarises all of the major international container vessels from 1994 all the way through to 2007. An understanding of each of these ships and their history would give great insight to the timeline of containerisation and the development of container ships, allowing us to understand how they have developed over the years and predict what future developments to expect in order to maintain the ongoing trends. It can also give opportunity for comparison with other types of vessels over the same period of time to see variations in the development of shipping and containers.

August 2005. [Container Market Outlooks Remain Healthy], Container Ships Focus, Lloyd's Register Foundation Digitised Internal Publications.

This publication is the first issue of the LR's Container Ships Focus, which seemed an ideal resource to gain an understanding of the history of containerisation and container ships up until 2005. The first article discusses the yearly rise in demand for containerisation (approximately 10% each year). The general conclusion is that this rise has been gradual, which is why it hasn't had the same detrimental effect on the containership industry as seen over the past year. This highlights that the final straw on the camel's back that resulted in the container shortage we see today was indeed COVID-19; however, the descriptions of the constant pressure that the shipping industry has faced throughout history indicates that the more fundamental cause for container shortage (and thus this trend in shipping containers on the deck of bulk carriers) is due to the fragility of the shipping sector to begin with. The delicate equilibrium that has been maintained for decades has always been a balancing act that could easily be perturbed by seemingly small obstacles. COVID-19 and the standstill it resulted in was simply too much for the sector to withstand.

There appears to be little else in the publication that is of relevance to this review.

[Lloyd's Register of Shipping Annual Reports/Group Review (1934 - 2015)], Lloyd's Register Foundation Digitised Internal Publications.

Another source that seemed ideal for understanding the history of container ships up until now was the collection of Lloyd's Register of Shipping annual reports. These contain useful summaries of the key developments in the shipping sector each year, therefore making them a useful way to keep track of container development and note significant places in history that could inform the future. Although few reports contained information on container ships specifically, a general understanding of the delicate equilibrium of the shipping industry can be clearly gauged from these documents, which is an important factor in understanding the effect of container shortages on bulk carriers and deck container transport.

1978, [Rules and Regulations for the Classification of Ships], Lloyd's Register of Shipping, Lloyd's Register Foundation Digitised Internal Publications.

As can be seen from the history of the integration of containers, international standardisation is primary for the take-off of an innovation. It was only once a global standard of container size and strength was established that transporting cargo using containers became a feasible way for cargo to be shipped worldwide.

This set of rules and regulations from 1978 is some time after containers were initially adopted so may contain some useful information to help understand what additional rules and regulations could be

applied to bulk carriers in the future to allow for the safe transportation of cargo in containers via this type of vessel. More close reading of this source is necessary to gain more benefit.

December 2014, [Provisional Rules for Ergonomic Container Lashing], Lloyd's Register Foundation Digitised Internal Publications.

This document sets out the complete rules and regulations that govern lashing of containers ergonomically. They address ship design and layout and could contain relevant information on the topic of containerisation on decks of bulk carriers since the regulations for container ships have developed over time as a result of safety hazards and incidents. Such occurrences therefore act as an important resource: understanding why certain regulations exist for lashing on container ships will help to inform the types of regulations that should be considered for safely lashing containers on deck as well, if this becomes necessary in the future.

LRF (Lloyd's Register Foundation) Archive

Although not all of these articles can be accessed publicly at the present moment, this section summarises the documents that indicate, from their title and other accompanying information, relevance to the subject of containerisation and bulk carrier ships (its safety, regulations, previous common practises, potential for complementing container shipping with bulk carriers etc.) so that further research may conducted using these resources when accessible. Resources have been categorised in terms of content with regards to container ships, containers, bulk carrier vessels, and generic information on ship types that could shine a light on the progression of ship design more generally and how this could play out in the future development of bulk carriers and other maritime capabilities for carrying containers safely.

Container Ships & Containers

This category of articles has a clear relevance to the case study as it provides information that directly feeds into our understanding of the history of containerisation and container ships. This is important for being able to fully comprehend the trends that are being seen today and understand what the future may hold by identifying overlapping patterns that were seen in the history of containerisation and may repeat themselves in the modern world.

1966. [Ship Design: Container Ships], Container Ships & Containers, Lloyd's Register Publication Articles Archives, 100A1 No.18.

> "Research and current designs."

1968. [A Box for all Seasons], Container Ships & Containers, Lloyd's Register Publication Articles Archives, 100A1 No.20.

> "A twentieth century successor to the ancient amphora and the medieval tun.
> Page 24-32 include photos of amphorae."

December 1973. [The Quest for Speed], Container Ships & Containers, Lloyd's Register Publication Articles Archives, 100A1.

> "A description of the increase in the speed of ships, in particular container ships.
> Page 4-11 includes photos of Tokyo Bay, Benavon, Turbinia, Maureta."

Understanding how the speed of the container ship was optimised over the years could inform which vessels today offer a safe alternative to carrying containers and give insight to the potential dangers (as a result of speed of travel) of carrying containers on the deck of bulk carriers.

October 1980. [Balancing Act], Container Ships & Containers, Lloyd's Register Publication Articles Archives, 100A1.

> "Associated container transport at sea."

Undated. [Inspection of Thermal Containers 1973], Container Ships & Containers, Lloyd's Register Publication Articles Archives.

> "Recent LR work in this field."

This source may provide information on the design of specifically thermal containers and how the design may require particular safety features on the vessel of travel. This could inform the types of safety features that must be added to bulk carriers and other maritime capabilities if they are to be adapted for safely carrying containers.

Taylor, K.V, June 1975. [The Effect of Wave Energy on Ship Hulls], Container Ships & Containers, Lloyd's Register Publication Articles Archives, 100A1.

> "Reports of tests carried out on board the 'NIHON' concerning the effects of wave action on the hull of this container ship, page 30-32."

This could give details on the stability of container ships and important aspects of container staking that must be remembered for on-deck stacking as well.

October 1980. [Japanese Containers], Container Ships & Containers, Lloyd's Register Publication Articles Archives, 100A1.

> "Tsuji containers."

More detail on a specific container design.

October 1987. [Boxing Clever], Container Ships & Containers, Lloyd's Register Publication Articles Archives, 100A1.

> "Operating container liner services the East Asiatic Company way.
> There are two views obtained: from the Boardroom, and from the Bridge."

Details on container orientation and design that could be beneficial for a deeper understanding of the issue at hand.

October 1987. [Towards Bigger Boxes], Container Ships & Containers, Lloyd's Register Publication Articles Archives, 100A1.

> "Yorkshire Marine Containers is building containers larger than ISO standards under LR's Freight Container Certification Scheme."

Understanding the challenges associated with the size of contains and how the design of container ships may have influenced certain regulations and rules. These will need to be re-investigated with other ship designs in mind for the future (including bulk carriers).

2nd Quarter 1989. [Great Dane], Container Ships & Containers, Lloyd's Register Publication Articles Archives, 100A1.

> "LR is classing 12 large containerships of a unique design at Odense Lindo yard. They are the first Panamax ships to carry 11 containers abreast below deck."

New design of containers.

1991. Issue 1. [The Ultimate Container Carrier], Container Ships & Container, Lloyd's Register Publication Articles Archives, 100A1.

> "The need to speed the loading and unloading times of container ships has led to the building of the first LR-classed hatch-coverless container ships for clients Bell Lines and Nedlloyd."

Hatch-coverless designs of container ships- especially important with regards to using bulk carriers for container transport.

1993. Issue 1. [Boxing Challenger], Container Ships & Containers, Lloyd's Register Publication Articles Archives, 100A1.

> "Maersk Containers Industry A/S of Denmark is successfully challenging the domination of far eastern suppliers in the container manufacturing sector."

January 1985. [Cover], Container Ships & Containers, Lloyd's Register Publication Articles Archives, 100A1.

> "Bound for Sydney's container port, the 27,978-dwt Australian Exporter passes the magnificent Opera House; sheep graze safely a few yards from the giant Yallourn power station; LR surveyors check a pressure vessel in Adelaide."

Information on the built of container ships in the past may be enclosed.

October 1987. [Cover, New Symbol of approval for containers], Container Ships & Container, Lloyd's Register Publication Articles Archives, 100A1.

> "This issue of 100A1 coincides with the introduction of a new LR corporate identity, the principal visual element of which is this distinctive logo."

July 1978. [Surveying the Box], Container Ships & Container, Lloyd's Register Publication Articles Archives, 100A1.

> "The basic unit of the container revolution is the box itself in all its varieties. LR has certified over 250 000 of them and carries out surveys for customs approval and under the IMCO (IMO) Convention for Safe Containers."

Extremely useful information may be enclosed on the development of safe containers; this could provide helpful insight in the safety challenges that containerisation has already overcome and help

uncover the answer to whether using bulk carriers may be a regression in terms of container safety standards and regulations.

1999. [Turning Up the Volume], Container Ships & Container, Lloyd's Register Publication Articles Archives, 100A1, Issue No.2

> "The evolution of the modern-day container ship."

A summary of the development of container ships to understand how we got to where we are now as an industry. This should be insightful for a general background in the containerisation sector.

1911-12. [Shipbuilding in the USA, Annual Report], Container Ships & Container, Lloyd's Register Publication Articles Archives, 100A1.

> "Notable extension of the Society's operations in the USA, 40 vessels of 175,000 tons, 17 vessels of 63,000 tons."

January 2013. [Lloyd's Register Boxes Clever], Container Ships & Container, Lloyd's Register Publication Articles Archives, Horizon.

> "A major research project by Lloyd's Register has discovered a unique way to improve the way containers are handled and carried. It means that in future, ultra-large container ships (ULCS) using the new method could potentially load up to 19% more cargo weight.
>
> Containership owners and managers are forever seeking sleeker and more streamlined ways to load, stack and carry their boxes as vessel sizes continue to expand and economies of scale to match them accordingly.
>
> A major research project by Lloyd's Register has discovered a unique way to improve the way containers are handled and carried. It means that in future, ultra-large container ships (ULCS) using the new method could potentially load up to 19% more cargo weight.
>
> So, what will be the impact of this breakthrough technology on global ports, trade routes, suppliers and differing ship sizes and how will it affect the stowage, lashings and motions of ships coping with storms and extreme weather in mid-ocean.
>
> Then what should owners and managers do, when will the new Rules apply and should I go ahead and order ships with these new Rules in mind? We answer these and many other key questions about this unique breakthrough in the new January issue of Lloyd's Register's Horizons marine magazine."

Containers

Similar to the above category, this section holds a clear relevance to the case study, summarising resources that may contain further details on the development of containers so far. This will help to inform how containers were developed to be safely carried on container ships, and how they will need to be developed to be safe on other vessels.

Undated. [LR and Containerisation] Lloyd's Register Publication Articles Archives.

> "Development of LR's role."

October 1980. [Cover, Containers in the round], Container, Lloyd's Register Publication Articles Archives, 100A1.

> "Production of a new type of rank container has meant new industrial services work for LR in Japan. Here, R Hashiguchi, senior surveyor in charge at the Society's Sasebo office, reads a micrometre after checking shell thickness during tank manufacture."

Information on the development of a new type of container could give an understanding of how containers have been developed to the standard they are made to today, and if transport on bulk carriers will need additional safety elements to ensure that a high degree of safety is maintained.

October 1980. [Cover, Balancing the Boxes], Container, Lloyd's Register Publication Articles Archives, 100A1.

> "The LR-classed ACT 7 alongside at Zeebrugge container terminal in the course of her three-and-a-half-month Australia and New Zealand to Europe run, where fast turn-around is essential."

Bulk Carriers

This category of resources below summarises the development of bulk carriers to the vessel they have become today. This is relevant to the case study because bulk carriers are the primary alternative vessel type that is being used today to transport containers. An understanding of their design and history will help inform further risk analyses to understand the dangers that using bulk carriers for transporting containers pose today.

1991. Issue 3. [Bulk Carriers: Seeking Solutions], Ship Type/Bulk Carriers, Lloyd's Register Publication Articles Archives, 100A1.

> "Last year 12 bulk carriers sank with the loss of over 200 lives. LR conducts a study to find lasting solutions to this crisis."

A study of this incident could provide greater understanding of the safety challenges of bulk carriers more generally, and why containers-on-deck may be adding to these risks.

January 1984. [Cover, Operating Computer], Ship Type/Bulk Carrier, Lloyd's Register Publication Articles Archives, 100A1.

> "An LR surveyor checks a Honeywell TDC 2000 computer used on the coal-burning bauxite bulk carrier TNT Capricornia as part of a control monitoring, alarm and logging system."

This source may provide historic context on bulk carriers.

April 1986. [Cover], Ship Type/Bulk Carrier, Lloyd's Register Publication Articles Archives, 100A1.

> "The LR-classed 137,000-dwt bulk carrier Elsam Jylland ships it green as she sails to pick up a cargo of coal for Denmark's electricity authority."

Information on a voyage on a bulk carrier for historic context.

January 1986. [Cover, a day in the life of ...], Ship Type/Bulk Carrier, Lloyd's Register Publication Articles Archives, 100A1.

> "The work cycle of the bulk carrier starts like this: berthing at Dampier, Western Australia, the LR-classed 131,333-dwt bulk carrier China Steel Team will load iron ore for the China Steel Corporation, Taiwan."

October 1987. [Cover], Ship Type/Bulk Carrier, Lloyd's Register Publication Articles Archives, 100A1.

> "LR's total involvement in the container industry is exemplified by this ship unloading containers at Felixstowe. LR's specialist surveyors are concerned with the classification of the most modern container ships - from plan approval through construction to periodic surveys in operation. LR's Freight Container Certification Scheme is available to container manufacturers as an assurance of quality for their customers. For container crane fabricators, LR's industrial surveyors provide a third-party inspection service to any agreed international standard."

July 1995. [Bulk Carriers – an Update], Ship Types/Bulk Carriers, Lloyd's Register Publication Articles Archives, 100A1.

> A possible summary of bulk carrier development up until 1995.

Maritime Crew

One potential solution to dealing with container shortage, although more suitable for the long-term, would be to increase vessel capacity. This could be through the reduction in crew size (which could reduce the necessary space allocated for crew quarters and enable more capacity for containers). However, this clearly has ethical implications which need to be taken in to account before such decisions can be made. I searched the Lloyd's Register Foundation archive for sources that could give insight to the consequences of reducing crew size in the past, the benefits of having a large crew, how crew size is determined for different types of vessels, changes to the proportion of ship space allocated to the crew over the years and how this impacted the capacity of vessel for containers, the social effects of reducing crew capacity in terms of unemployment and whether a system with fewer crew members could be the way forward.

1964. [Limits of Acceptable Vibrations in Ships], Technical Investigations, Lloyd's Register Publication Articles Archives, 100A1, No. 13.

> "Effects of vibration on crew and ship page 4-7"

This source could give an insight into the living conditions of crew members and how it was affected by vibrations in the ship. However, it seems unlikely that the source gives any further relevant information on crew size and wellbeing, the space allocated to the crew and the capacity of the vessel to carry containers.

1991. [Revolution at Sea], Ship Type/Reefer, Lloyd's Register Publication Articles Archives, 100A1, Issue 1

> "J Lauritzen A/S has recently taken delivery of a number of reefer new-buildings that are fitted with a highly advanced computer control system and are designed to be run with a crew of six."

This article could be extremely beneficial; the summary indicates that it discusses the building of a new type of ship that is more automated and requires a smaller crew. Although the ship is not designed to carry containers, the source could still provide a really useful insight to the consequences of reducing the crew size due to the incorporation of more automated technology. Other sources that investigate this vessel further could provide more information.

January 1981. [Cover], Ship Type/Ro-ro, Lloyd's Register Publication Articles Archives, 100A1

> "Tyrusland, one of six ultra-modern roll-in/roll-off vessels owned by Brostrom Shipping Company, Sweden, and in service on the Swedish Orient Lines route between Scandinavia and the Mediterranean. These LR-classed vessels, built by Mitsui Engineering and Shipbuilding, Japan, are currently the centre of Brostroms' manning experiment, and operate with a crew of only 16."

This experiment into manning a ship could explain more about crew management the conclusions reached from the experiment could be beneficial for informing changes made to manning container ships today.

Fuelling Maritime Capabilities

Another way that container capacity on ships could be increased is by finding alternative fuel sources that reserve less ship volume whilst powering vessels to travel at sufficiently high speeds. Although a more long-term solution, this would enable more containers to be carried on board each vessel, thus making container shipping a smoother and more robust process. On the other hand, there is a large focus today on developing more sustainable powering mechanisms that reduce the environmental impact of the maritime industry, which may be a greater priority globally. Below are a few resources that focus on fuelling maritime vessels, which will be beneficial in understanding the history of powering ships and how this may affect the future of containerisation.

Undated. [Refuelling Tanks or North Sea 'Choppers'], Industrial Services, Lloyd's Register Publication Articles Archives, LR World, No.18.

> "Kerosene tanks inspected by Industrial Services, intended for refuelling helicopters servicing North Sea oil and gas rigs"

This source could give insight to oil as a fuel for ships in the past and how this may be different to today.

January 1989. [LR's in-depth Analysis of Fuel Oils], LR Departments, Lloyd's Register Publication Articles Archives, 100A1.

> "Shipowners using LR's FOBAS service are insuring themselves against expensive engine repairs, lost trading and even danger to ships, cargoes and crews."

Similar to above, this source could give insight to oil as a fuel for ships in the past and how this may be different to today.

1990. [Keeping Marine Exhaust Emissions in Check], LR Departments, Lloyd's Register Publication Articles Archives, 100A1, Issue 1.

> "Extending its research programme on fuel oil quality, engine operation, and condition monitoring, LR is investigating marine exhaust emissions."

This is a more recent article that gives insight to how sustainability and increased awareness of carbon footprint may be leading to a shift in focus in the way ships are powered and designed. This could be used to understand how this will affect containerisation in the future.

1992. [THORP: The Way Forward], Nuclear Ships & Nuclear Research, Lloyd's Register Publication Articles Archives, 100A1, Issue 2.

> "British Nuclear Fuels Ltd as developed a new Thermal Oxide Reprocessing Plant (THORP) to recycle the more radioactive spent oxide fuels from the newer reactors."

Nuclear-powered ships are being investigated and this source appears to give some very insightful information on the development of nuclear power and how this will affect container ships and bulk carriers.

1992. [Renewable Energy: Fuel for Thought], Energy (Unconventional Means), Lloyd's Register Publication Articles Archives, 100A1, Issue 1.

> "Many renewable energy projects are now moving from the realms of research into the commercial arena and LR is helping to effect this change."

This article may give insight to how more green initiatives may be leading to a shift in focus when container ships are being designed. This could be used to understand how this will affect containerisation in the future.

April 1986. [Cover], Miscellaneous, Lloyd's Register Publication Articles Archives, 100A1.

> "A vast amount and variety of hardware needs to be inspected before it can be used to extract, transport and process fossil fuels, and to generate electricity: Shell is transporting LNG from Brunei to Japan in seven LNG ships like the LR-classed Genota; a consortium including Shell has ordered seven more to take LNG from Australia to Japan - five of them to be LR classed. LR is inspecting components for nuclear reactors, like these guide tubes for Torness AGR. A resident LR surveyor is providing QA consultancy during the UK construction of the Joint European Torus. Two wind turbines on Funen belong to the Danish Electricity Authority - which also owns LR-classed bulk carriers for transporting most of its coal supplies. LR is certifying drilling and other platforms for the Morecambe gas field. For BP's revolutionary SWOPS ship, vibration tests are witnessed on control equipment."

April 1952. [Kuwait: Development of Oil Fuel], Industry Services, Lloyd's Register Publication Articles Archives, LR Newsletter, page 2.

This source could explain more on the use of oil as a fuel for ships, which can be compared to other sources, supporting our understanding of how changes to fuel will affect the structure and design of container ships or bulk carriers.

August 1954. [Australia: The Gas and Fuel Corpn. of Victoria], Industry Services, Lloyd's Register Publication Articles Archives, LR Newsletter, page 1.

> "Production of gas from brown coal."

Further insight to gas as a fuel for ships.

10th December 2009. [Research is focused on the application of nuclear propulsion to tankers, bulk carriers, container ships and cruise ships], Nuclear, Lloyd's Register Publication Articles Archives, Press Releases.

> "Research is focused on the application of nuclear propulsion to tankers, bulk carriers, container ships and cruise ships. Early in 2007, Lloyd's Register began research into the implications of nuclear propulsion for merchant ships. This initiative was built on Lloyd's Register's extensive experience in the traditional nuclear industries and from studies which led to the formation of its Rules for the Nuclear Propulsion of Ships…
>
> …Public concern for the environment in recent years has focussed on the way greenhouse gases are changing the world's climate. Although the marine industry contributes a relatively small proportion of those greenhouse gases in relation to the amount of goods and raw materials it transports, shipping's CO2 contribution from exhaust emissions is of growing concern. A number of research initiatives have been introduced to mitigate this component of emissions from slow- and medium-speed diesel engines. Lloyd's Register has been actively looking for the technological solutions to the challenges arising from ship propulsion to help the marine industry reduce its carbon footprint. Nuclear propulsion is one such technology, one that nullifies the industry's CO2 contribution."

This article is extremely relevant to the question at hand. It discusses the ongoing research in nuclear reactors on container ships and bulk carriers. The article mentions that the steadily increasing fuel oil prices could make nuclear propulsion a competitive option. It also discusses the increase in a variety of nuclear propulsion methods, from the more common Pressurised Water Reactor vessels to High-Temperature Reactors. However, the article states that if the shipping industry is heading in the direction of autonomation, this will not fit well with nuclear-propelled vessels. Furthermore, crew-training will need to be revolutionised and general education delivered to the public to ensure that the risks and environmental benefits of nuclear ships are realised.

"Ships that use conventionally enriched uranium will be able to trade for up to five years before refuelling." This could instead benefit containerisation since the fuel cost per container may actually be lower overall despite the extra space that a nuclear reactor may require. On the other hand, "refuelling process would take about 30 days for a ship featuring a conventional PWR plant, under controlled conditions" which could seriously impede on the way that containerisation is managed in the future in order to maintain a global equilibrium where containers are available in the right place at right time.

14th December 2011. [World's first LNG-fuelled tanker newbuilding delivered to Deen Shipping by Rotterdam's Shipyard Trico to Lloyd's Register class], LNG, Lloyd's Register Publication Articles Archives, Press Releases.

> "The world's first new LNG-fuelled tanker has been delivered in Rotterdam to Lloyd's Register class, heralding the start of a new era of cleaner shipping for Europe's local waterways. Chemical tanker MT Argonon to emit less Sox, Nox and particulates across Europe's inland waterways. The world's first new LNG-fuelled tanker has been delivered in Rotterdam to Lloyd's Register class, heralding the start of a new era of cleaner shipping for Europe's local waterways. The delivery of MT Argonon, a 6,100-dwt dual-fuelled chemical tanker, represents a significant milestone for the Deen Shipping subsidiary, Argonon Shipping B.V., in its pursuit of cleaner transport solutions for Europe. Lloyd's Register helped the owners and regulators to identify their risks, meet regulatory requirements and overcome the technical challenges for the precedent-setting tanker."

This article provides useful insight and indicates that, for the most part, it seems unlikely that LNG, even if widely adopted in the shipping industry, will greatly affect containerisation.

11th January 2013. [World first as LNG-powered Viking Grace is delivered], Ship Type, Lloyd's Register Publication Articles Archives, Website.

> "The world's most environmentally friendly large passenger ship, Viking Grace, was delivered at STX Finland's Turku shipyard yesterday. The world's most environmentally friendly large passenger ship, Viking Grace, was delivered at STX Finland's Turku shipyard yesterday. Apart from its unique green credentials, the vessel's two standout features are its LNG-powered Wartsila engines and its safe return to port compliance technology. Such was the vessel's much anticipated arrival that tickets for its maiden voyage on Tuesday from Turku to Stockholm were sold out months in advance. Interestingly, Viking Grace, with its almost emission-free performance, will be ideally suited to the sensitive and delicate waters of the Baltic Sea."

Although this article discusses the developments in the field of more sustainable vessels, there is little of relevance to containerisation.

11th January 2013. [The Bottom Line: Safely Transforming the Existing Fleet into Eco-ships], Lloyd's Register Publication Articles Archives, Blog.

> "Life is pretty busy right now for everybody. Most of what is keeping me awake at night (and travelling around the world talking to shipowners) is to do with energy efficiency...
>
> We think that ships already delivered or under construction can provide relatively quick payback on retro-fit investment. With the industry coming off the back of the biggest period of newbuilding in history, there are plenty of candidates for such an efficiency retro-fit makeover. Our expertise lies in providing the insight and verification needed at initial review of goals; the concept design; the detailed design process and then into the operational phase. Understanding the costs and benefits is one of the vital early steps in our review process. Don't hesitate to contact your client manager if you would like to know more or check this link.
>
> We have so much work ongoing sometimes it's hard to keep track, and sometimes unlikely areas provide opportunities to save energy and cost. For example, in the latest issue of Horizons you can read about the positive consequences of some highly technical work we have been doing to better understand the forces at play in container stacks. This work commenced as part of our LashRight programme to help with the safer securing of deck containers. But what we found was that the results will have big implications for how we think about container ship capacity. A better understanding of the forces involved has led to a re-think about where you can put heavier containers. One of the realities of container shipping today is that the declared maximum container intake is rarely used.
>
> Our findings indicate that you may be able to load a lot more cargo, more flexibly, than previously thought. So, if that's your market, please read how you can load more cargo and reduce costs – as well as your carbon footprint – on pages 3-7 of Horizons January 2013. Lloyd's Register is helping shipowners, shipbuilders and designers save energy. That's the headline – it's all about the bottom line. But we would like to help the industry do it safely as well, combining the best of traditional class with the best of the insight and expertise we can offer the industry to understand the challenges of technology and performance. Our energy can be your energy saving!"

This article indicates that there are ways for the shipping industry to achieve the best of both worlds – more environmentally friendly vessels and increased cargo loading capacity.

Online Sources

I found online sources a useful place to start this research process as it enabled me to gain sufficient background in the field of containerisation before delving into some of the more technical resources. It was also useful to read alternative opinions and gauge the general public perception on transporting containers on deck. Below is a summary of the conclusions made from information found online.

Chamber, S., 2021. *Asian dry bulk owners take the lead in accepting containers on deck - Splash247*. [online] Splash247. Available at: https://splash247.com/asian-dry-bulk-owners-take-the-lead-in-accepting-containers-on-deck/ [Accessed 14 September 2021].

As a summary of the information taken from this site, there are two key causes for the rising transportation of containers on deck:

1. Increase economic revenue
2. Shortage of containers
    a. Increase in demand (COVID-19 resulted in increased shipping as people rely on deliveries instead of accessing local resources)
    b. Difference in the quantity of imported and exported goods in different regions of the world.

As demand exceeds the supply available (a result of COVID-19 to some extent) and there is increased pressure on the supply chain to deliver greater quantities of produce, a shortage of containership is arising, which in turn is leading to companies undertaking risky activities such as storing containers on the deck of bulk carriers. Swire Bulk is among the first dry bulk owners moving containers on a fleet that is typically dedicated to bulk carrying. Pacific Basin are also offering box shipments on its fleet. On the other hand, Golden Ocean is reported to be investigating this as a source of revenue (looking at combining iron ore or coal on bulk carriers with containers on the deck). Many companies are willing to transport high-price parcels for the monetary gain, whilst many businesses need to transport their goods and are using any means to do so.

Further research points:

> "According to Alpha-liner, the biggest bulkers ever seen carrying a large number of containers were the 70,000 dwt conbulkers such as the *CAST Beaver* operated by Bermuda-based liner operator CAST, which was amalgamated into CP Ships in 1995, between North Europe and Montreal, until the early 1990s. The CAST ships could carry up to 1,463 TEU."
>
> North P&I advised that "Owners should first liaise with underwriters, and the vessel's classification society and Flag State to seek their guidance and advice as to what modifications, if any, would be required to comply with their requirements. It's unusual for a bulk carrier to be fitted out with suitable fittings, equipment and lashings to fulfil this obligation without modification and strengthening of cargo securing arrangements. Additional equipment may be required as well as a need to perform additional strength and stability assessments. Crew capabilities should be also assessed."

Multipurpose and open hatch bulk carrier markets have also been booming, sending this year's MPP rates into record territory. This practice is evidently being adopted across the shipping trade, and it is essential for safety regulations and legislation to be created regarding this mechanism for transporting containers as soon as is possible. Otherwise, the risks of such activities is likely to lead to accidents and unnecessary loss of life/environmental damage.

UNCTAD.org. 2021. *Shipping during COVID-19: Why container freight rates have surged | UNCTAD*. [online] Available at: https://unctad.org/news/shipping-during-covid-19-why-container-freight-rates-have-surged [Accessed 14 September 2021].

This article gave an extremely detailed insight to how COVID-19 became a cause for global container shortage. Understanding the cause could significantly help with understanding the consequences and how to resolve these.

> "Changes in consumption and shopping patterns triggered by the pandemic, including a surge in electronic commerce, as well as lockdown measures, have in fact led to increased import demand for manufactured consumer goods, a large part of which is moved in shipping containers."

Several national governing bodies then launched stimulus packages to boost their country's economy. Businesses began to use this source of funding to start stocking up in anticipation of COVID-19 shortages, which led to a further increase in shipping.

> "Another factor is the lack of return cargo. South American and western African nations import more manufactured goods than they export, and it is costly for carriers to return empty boxes to China on long routes."

This meant that containers ended up empty in locations where they are not required as much; Containers are especially needed in Asia and Europe but were stuck in North and South America. Thus, the container shortage wasn't due to the fact that there were not enough containers globally, but more that they were in locations where they weren't needed.

Institute of Supply Chain Management. 2021. *The current container shortage; What happened and what's next?* [online] Available at: https://www.ioscm.com/blog/the-current-container-shortage-what-happened-and-whats-next/ [Accessed 14 September 2021].

This site also gave good insight to how COVID-19 resulted in a container shortage. One of the primary ideas is understanding how delicately balanced the containership business is and how even a small disruption could be felt globally. COVID-19 is still affecting containership and its transportation today.

Usually, the constant flow of goods means that containers are constantly being moved from location to location. In Asia however, more is exported than imported and the opposite is true for Europe and America. Thus, countries like China, which export large quantities of the world's goods, usually require more containers that they have. Since it is cheaper to make more containers than it is to ship empty containers back, this is the typical practice. Due to the pandemic, however, China and other parts of Asia closed down first, creating huge challenges in the global shipping network. Once they opened up again several months later, other countries had started to close down. This meant that whilst China was now exporting all their usual goods, they were receiving even less imports because the rest of the world was at varying stages of lockdown. COVID-19 made this even worse because the virus affected the workplace and the number of workers who could legally be present for the loading and unloading

of containers at ports, and for the construction of new containers. Even now, when lockdowns have eased globally, "the world is still trying to play catch-up".

To add to the shipping challenges, many shipping companies then saw the pandemic as an opportunity to upgrade their fleet (which is difficult to do in the usual year because of the constant requirement to be using ships). This led to even greater shortages as fewer ships were available for transporting goods around the globe. The fact that there are no alternatives for sea travel (on land we have multiple modes of transport) made the container crisis worse.

Mishra, B., 2021. *How Containers are Stacked on Ships – An Insight - Sea News Global Maritime News*. [online] Sea News Global Maritime News. Available at: https://seanews.co.uk/features/how-containers-are-stacked-on-ships-an-insight/ [Accessed 14 September 2021].

This article introduced different ways for stacking containers, depending on the priority safety challenges. Understanding this is a part of understanding the history of containerisation, but also important for analysing the risk associated with storing containers on the deck of bulk carriers.

In a container ship, the stresses on the containers are greater side to side (athwartship) then fore and aft so different storage orientations and lashing rules are required for safe storage. Alternative orientations are used for preventing slipping and toppling (alternating between athwartship and fore and aft container orientation), higher tier storage (twistlock vs. auto-twistlock) etc.

***Travel, Transport and Logistics*, 2021. Container Shipping: the next 50 years. [online] Available at: https://www.mckinsey.com/~/media/mckinsey/industries/travel%20logistics%20and%20infrastructure/our%20insights/how%20container%20shipping%20could%20reinvent%20itself%20for%20the%20digital%20age/container-shipping-the-next-50-years-103017.pdf [Accessed 15 September 2021].**

The articles and websites so far read indicate that the shipping industry is a very delicately balanced trade upon which small disruptions can have large impacts. A global standstill, as was caused by COVID-19, would therefore understandably lead to a dramatic change in the way the shipping industry runs.

This led to the discovery of the afore mentioned article published by McKinsey in 2017 which discusses the past and future of containerisation. This article indicated from its title and introduction that it would provide extremely useful insight to the history and growth of the container shipping industry.

One interesting detail is how quickly containers took over other methods for transporting cargo in 1967. This suggests that there must have been a huge increase in the number of containers being created worldwide and at some point, there likely was a container shortage in some continents. Thus, this part of the timeline of containerisation is an interesting year to further discover, especially in the UK. The article mentions some insightful comments made by Sir Arthur Kirby, discussing UK's requirement to uptake this containerisation trend if the nation hopes to remain pivotal in the trade and shipping sector in the years to come.

Another interesting factor that may play a role in the future containerisation is the stability of fuel prices. The development of larger vessels would greatly benefit the stabilisation of today's container industry (larger vessels would lead to faster container transport so that the distribution of containers should even out better). However, larger vessels can only remain economically viable to construct and sail if fuel prices stay low; generally, larger vessels require less fuel per container, but the economic

margin will only stay wide enough at low oil prices, which is unlikely to be maintained over the next few years as governing bodies push for a more sustainable global economy. If this does become a reality, larger vessels could solve the current container shortage in the long-term and rebalance the container distribution worldwide.

Other Sources

Another source of guidance that was beneficial throughout the completion of this literature review was the interpretation and input of various members of the Lloyd's Register Foundation team. Below is a summary of the key take-away points that could open up different parts of the past to research into to give guidance on how to navigate this issue of storing containers on deck.

Brainstorm Meeting (14/09/2021)

Haibo Chen, a naval architect by background and risk analyst for the Lloyd's Register Foundation, discussed how, as risk analysts, it is important to zoom out and consider all the possible causes and effects before making any conclusions. Once you have an understanding of the situation as a whole, you can begin to make hypotheses and check to see if these withstand the test of time, observing whether historical evidences support or disagree with the conclusions made.

This was extremely useful advice to apply to the project at hand – thinking more carefully about the shipping and container industry today, it seems that although COVID-19 appears to be the direct cause for container shortages, the more fundamental cause is the lack of robustness to the shipping sector. COVID-19 was simply the last straw on the camel's back, leading to the shortage of containers and people trying to transport containers on bulk carriers because the prices for transporting such cargo escalated. This relates to a suggestion that Alix Mortimer made about the shipping industry being essentially patchwork, made up a lot of different groups of people making changes but without an overall governing body to ensure everything runs smoothly, with fixed rules and regulations regardless of country borders.
Additionally, in today's shipping industry China is the centre of world trade and thus, any changes in its ability to export goods has an even greater impact on the rest of the world than any other country. More generally, there are no alternatives to shipping trade at the moment (i.e. no other method that enables us to transport goods at this quantity efficiently). This makes the shipping industry all the more delicate; small disruptions can have huge consequences.

This led to two further ideas for research: a hindsight perspective could be beneficial for looking at other transport industries (e.g. transporting containers on land) and the development of alternative types of maritime cargo vessels (aside from container ships). All maritime and land capabilities will likely have been in a position at some point in time where they were a fragile addition to global transport and specific incidents led to disruptions. Understanding these would be key to understanding how containerisation will continue to develop in the future, and how this could be steered into a more robust direction.

Another avenue for research is looking at how diseases in the past have affected global shipping. Haibo mentioned that it is equally as useful to understand why similar occurrences in the past led to different consequences, because it enables the ultimate causal factor to be identified. A comparison of various scenarios that, to the face appear similar but have distinguishing elements, could be extremely useful. However, this may be a difficult lead to follow because there may not be any viruses that occurred within the lifetime of containerisation that had a similar spread across the globe nor affected as many nations as COVID-19 has.

An alternative suggestion made by Louise Sanger discussed the need to undertake an age profile of the bulk carriers being used to carry containers today. Container transport on bulk carriers is less space-effective, so to maximise their profit shipowners could need to carry dual-cargoes. Are these all appropriate for safe carriage of containers on deck. This could inform the guidance and regulations that may need to be published in the future to govern this cargo transportation mechanism.

Another idea that could be further researched to inform the safe transport of containers on deck is understanding how the load in the bulk carrier will affect the stability of containers carried above (on the deck), and whether further regulations may be required regarding this, to ensure safe and stable shipping. An empty bulk carrier will experience completely different force dynamics to one that is full, and this will directly affect the safety of carrying containers on the deck.

Brainstorm Meeting with Nick Gross (16/09/2021)

An additional factor affecting the number of containers that can be loaded onto a vessel is the view from the steering cabin, which must not be blocked in order for the crew to sail the container ship safely. This means that, alongside the physical limitations on piling containers (due to the maximum stress the container walls can withstand before buckling) there are restrictions that ensure a clear view is maintained. This leads to the question of whether automated vessels which are navigated virtually by crew could unlock greater cargo transportation. Automation will evidently have a huge impact on the future of containerisation, and further resources on automation and efficiency of the shipping sector can be found in Mina Ghosh's (a fellow intern's) literature review published alongside this review.

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