Coronavirus, Climate Change & Smart Shipping

THREE MARITIME SCENARIOS

2020 – 2050

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Martin Stopford, President Clarkson Research, 20th April 2020

Introduction

This paper started life as a presentation to Marintec China Senior Maritime Forum on 3rd December 2019. Following that event, I was invited by China's Diesel Engine Magazine to do an interview. They sent me questions about new technology and the prospects for the shipbuilding industry and just as I finished drafting answers, the coronavirus (COVID-19) pandemic appeared out of nowhere, demanding attention. Since by this time I was locked down at my farm, it was an ideal opportunity to develop the model I had been using to analyse long-term scenarios for smart shipping and climate change to incorporate the pandemic.

Shipping is a long-term business and this paper draws out three scenarios to 2050 developed with the model. Obviously, models have no special forecasting magic, but they ensure a degree of arithmetic consistency (if the equations are correct!) and sometimes highlight a blindingly obvious trend in danger of being overlooked.

In these scenarios coronavirus, climate change and smart shipping are all seen as part of the seascape which lies ahead in the voyage to 2050. In terms of technical and economic change, the three decades will be every bit as challenging for investors as were the decades from 1860 to 1890 when the maritime industry made its last major technical transition, in those days from sail to steam. Many owners continued with sailing ships, but in times like this participation in change is not optional. Like the virus, it's all a matter of time.

I would like to thank Diesel Engine Magazine for inviting me to do the interview and Seatrade Maritime for publishing the paper. Of course, these are just my personal views, not necessarily those of Clarksons. Bon voyage.

Martin Stopford

20 April 2020

Executive Summary

1. In January 2020 the shipping industry entered a new decade with weak market fundamentals and the prospect of a difficult year, with a few bright spots. But the coronavirus pandemic (CVP) was already laying the foundations for a darker scenario.
2. The answer to the question "how deep and how long?" is a trade-off. The widely adopted strategy of "lockdown" backed by fiscal measures, is launching the world economy on a precarious *tightrope walk* which has already lead to less trade. Meanwhile shipbuilders have reduced capacity, short orderbooks, and ordering is about 75% down.
3. The scenarios in this paper illustrate how this risky strategy might unfold for the maritime business. Scenario 1 goes to plan, and sea trade picks up 2023, whilst the other scenarios discuss less favourable outcomes, in which recession stretches into the middle of the decade.
4. In reviewing the shipping industry's response to the pandemic, we must remember that in the years ahead the maritime industry must also deal with climate change and the I4 digital revolution.
5. There has been much discussion of these challenges, but so far practical progress has been patchy and disjointed. By shaking up the status quo, the pandemic might be a catalyst for the radical measures needed.
6. The three scenarios also remind us that in the next 20 years the maritime industry must rebuild its cargo fleet. If this is done with the radical technologies now available, it will lead to the biggest change in ship design since steam replaced sail in the 19th century.
7. .Shipbuilders, their suppliers and their customers, will manage this transition, involving the integration of the key functional systems on board ship to incorporate various degrees of automation; ideally under industry protocols for managing "messaging" arbitration on big ships (i.e. CANbus type protocols which need to be developed).
8. The three sets of scenarios cover sea trade 2020-2050; shipbuilding requirements 2020-2050; and ship technology 2020 to 2050. Appendix 1 is a summary of the Shanghai talk and Appendix 2 contains key smart shipping slides from the presentation
9. The three *Sea Trade Scenarios to 2050* (Figure 2) start with the coronavirus pandemic (CVP), and each has a different outcome.
10. In Sea Trade Scenario 1 the global pandemic follows China's pattern. After difficult years in 2020 and 2021, maritime trade returns to normal, growing at 3.2% per annum to 2050.
11. At the other extreme Scenario 3 envisages persistent problems, a deep economic downturn which, combined with climate change measures; leads to a 15% fall in seaborne trade by 2024, followed by 0.7% pa cargo

growth 2025-2050. This scenario resembles the impact of the oil crises which triggered the 1970s and 1980s shipping recessions.

12. All three *Shipbuilding Scenarios* confront shipyards with a sharp downturn in new ship requirements over the next two or three years. Scenario 3 shows the most severe trough. But new orders placed will not follow “requirements”. It raises policy issues and counter cyclical ordering for speculative, social and strategic reasons.
13. In the long term the S*hipbuilding Scenarios* (Figure 3) point to substantial shipbuilding demand due to trade growth; slower operating speeds; and the re-design and re-engineering of cargo ship systems in response to climate change and smart shipping (I4).
14. Speed optimisation is a major design issue because, with today’s technology, slow speed is the easiest way to reduce emissions (but at the cost of more ships being needed). The integration of functional ship-board systems to increase automation and quality assurance (QA) will be equally important.
15. The *Technology Scenario* (Figure 4) suggests three "waves of development" can be used to build a fleet of robust and commercially viable ships, incorporating new and untried mechanical, electrical and digital equipment.
16. A wave of enhanced diesel ships might be followed (or accompanied) by a wave of gas and hybrid electric powered vessels; then a wave of zero carbon ships e.g. using fuel cells. Each “wave” would allow new technology to be developed and commissioned in real-world operating conditions, on a gradual but cumulative basis.
17. This approach is similar to the implementation of steam technology during the transition from sail to steam in the 19th century.
18. Finally, the emissions analysis (Figure 5) shows that in 2050 Emissions Scenario 1 produces 771 Mt of carbon, almost double the IMO target; Emissions Scenario 2 produces 321 Mt of carbon pa and Emissions Scenario 3 produces 184 Mt of carbon, both well below the IMO target of half the 2008 carbon emissions.
19. In conclusion the pandemic will lead to some sort of recession, which could be mild or severe. In this respect the future remains open. But this should not divert attention from the task of progressing the transition to smart ship design and climate friendly sea transport.
20. We know we cannot predict the future. But we can try to prepare for changes that are clearly “on the cards”. Not preparing can be riskier and more expensive than the “safe” option of doing nothing.

1. The starting point for the scenarios

Shipping entered 2020 with a mixed outlook. The world fleet grew by 4% in 2019, but analysts expected the growth rate to halve to 2% in 2020, due to lower shipyard deliveries (about 70 million dwt) and higher scrapping. But this fall in shipyard output looked likely to be matched by deteriorating demand.

World industry fell to 0.1% growth in the year to October 2019, well below the trend rate of around 3.6% pa so it was doubtful if demand would be strong enough to match the growth of supply. Meanwhile shipping was preoccupied with emission regulations, climate change and the ongoing digital revolution. But by the end of March the coronavirus pandemic had made a deep recession unavoidable, raising the questions “how long and how deep?”

2. Analysis of the Severity of Shipping Cycles 1885-2020

As we move through the coronavirus pandemic, for the shipping industry, the outcome will probably be some sort of recession, due to lower global industrial growth at a time when the business cycle was already moving towards a trough. The question is what sort of recession and how severe could it be? Market models can provide some sort of guidance, but it is also useful to start with look at the severity of previous shipping recessions to see if there is any pattern that help think through the implications of the Pandemic.

SHIP PRICES AS A MEASURE OF MARKET CYCLES

A good indicator of the severity of a recession is the fall in ship values. They dominate the balance sheet of ship owners and provide lenders with security in the event of a default. From this perspective a recession is *severe* if it results in a deep slump in ship prices over several years and *mild* if prices fall moderately for a short period, maybe a year or 18 months.

LENGTH AND DEPTH OF MARKET TROUGHS 1885-2020

The characteristics of the six most serious troughs of the new price of a handy dry cargo ship between 1885 and 2020 is shown in Table 1. Over this period the ship size increased from 3,500 deadweight to 38,000 deadweight, so the analysis of cycles in new ship prices is carried out in $/dwt (converted from UK pounds to US dollars in the early periods). In each year from 1888 to 2017, the percentage difference between the actual $/dwt and the seven-year moving average of the $/dwt was calculated, price computed. If the percentage was negative the market was regarded as being in a trough in that year.

Table 1: Analysis of shipbuilding prices in $/dwt for standard "handy" dry cargo ships 1885-2020

1	2	3	4	5	6	7	8	9
Trough duration		Cycle length			Ship Price $/dwt		Trough	
Rank (1)	PERIOD	Start	End	Years	Peak (2)	Lowest	Severity	Description
1	1930-1936	1930	1936	7	35.6	2.1	-316%	Shipbuilding boom followed by 1930s trade slump
2	1920-1926	1920	1926	7	87.8	35.2	-107%	Post WW1 shipbuilding boom, 1920-21 trade slump
3	1983-1987	1983	1987	5	560.4	297.5	-71%	2nd Oil price shock & early 1980s trade slump
4	1997-2004	1997	2004	8	512.1	387.7	-62%	Asia Crisis recession followed by dot.com recession
5	1976-1979	1976	1979	4	450	332.7	-53%	Shipbuilding boom, 1st oil price shock & trade slump
6	2009-2017	2009	2017	9	958	550	-49%	Shipbuilding boom, credit crisis & financial easing
7	11 Others	Na	Na	3.0	Na	Na	-25%	Average of 13 other cycles

Source: Various, collected by Martin Stopford

Note 1: Excludes 1913-15 cycle

Note 2: Peak price in year before the trough start

SEVERITY OF MARKET TROUGHS

From this year by year trough data, the *severity* of each trough (Table 1, col 8) was calculated by summing the percentages in those *consecutive* years in which the $/dwt price was below the seven-year trend price. The longer the trough lasted and the deeper it fell below the trend, the greater is the "severity" percentage shown in Table 1 column 8, which ranks the 17 troughs by "severity".

The *most severe recession started* in 1930 and ended in 1936. There was a shipbuilding boom 1926-1929 during which UK output increased 238%, then trade collapsed in 1931 and freight rates followed[1]. With no orders for new ships, most shipyards closed their gates[2] and the price of a new tramp fell from $37/dwt in 1929 to $2/dwt in 1933. Second hand ships were selling for even lower prices, so this was an extreme recession, with little fiscal intervention. which hopefully with today's fiscal intervention will not be repeated[3]. The severity index was -316%, an extreme score .

In second most severe was the 1920-1926 slump. This followed the 1917-1920 shipbuilding boom, set off by the very heavy losses of merchant ships during the N Atlantic war in 1917. Between 1916 and 1920 UK launches increased by 300%. But a deep economic depression in 1920-21 triggered this recession which lasted 6 years with a severity index of -107%.

In third place was the 1980s recession, which lasted five years from 1983 to 1987, with an index value of -71%. This time shipyard capacity was quite low and problem was mainly on the demand side. The 2nd Oil Crisis in 1979, started a recession which reduced sea trade by 17% between 1979 and 1983. Counter cyclical ordering prolonged the recession.

In fourth place was the 1997 to 2004 recession. Supply was not a major problem in this trough, and shipyards were very short of orders. The problem was that the Asia Crisis in 1997 was followed three years later by the Dot Com crisis. The resulting recession lasted eight (tankers had a short boom in 2000)., but was not very deep and the severity score was only -62%. Sentiment was very weak in 1999 and 2001.

In fifth place came the 1976-79 recession. This followed the great shipbuilding boom in which deliveries increased 238% between 1969 and 1973. The collapse was triggered by the economic recession following the 1st Oil Crisis in 1973, and the trough, which lasted four years from 1976 to 1979, had a score of -53%. 1

Finally, the 2009-2017 trough came sixth, This was another combination of a shipbuilding boom (shipyard output increased 250% in dwt between 2004 and 2011) followed by a demand collapse due to the 2008 Credit Crisis. But the economic crisis had limited impact due to financial easing measures and China's infrastructure initiative in 2010. Although this trough lasted 9 years, the severity score was only -49%[4].

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[1] Between 1931 and 1934 sea trade fell by 25% from 473Mt to 354Mt

[2] UK shipbuilding launches fell by 91% between 1929 and 1933 (1.5 M GRT to .13 M GT).

[3] In the UK this recession was marked by the Jarrow March of shipyard workers from Jarrow on the River Tyne to London

[4] Technically the 2009-2017 recession should be regarded as two separate minor recessions, separated by a "severity" rating in 2014 of +7%. But in view of its topicality the two recessions were run together in Table 1.

The other 11 cycles were relatively mild with a severity average of -25%.

CONCLUSIONS FROM THE TROUGH SEVERITY ANALYSIS

The message from this analysis of the most severe cycles is clear. Four of the six most serious shipping recessions/depressions of the last 135 years consisted of a shipbuilding boom followed by a severe trade recession (category 1). In the other two cases there was no shipbuilding boom, but the demand side suffered from recurrent economic problems, but the relatively mild recession dragged on (category 2). The way both categories of recession played out also depended on economic management of the demand side. The worst outcome was in the 1930s, when there was no fiscal intervention, whereas in the 2009-2017 recession the apparently toxic combination of the 2004-2011 shipbuilding "super boom", and the 2008 Credit Crisis, was moderated by government policies of financial easing.

Looking ahead, the positive message for both shipbuilders and shipping investors is that the shipbuilding industry enters this recession at the end of a long period of contraction, so we may be looking at a category 2 recession. The climate crisis could also be a positive supply side influence, because slow steaming, an attractive way of reducing carbon emissions, also reduces the delivery performance of the fleet, soaking up what would otherwise be surplus shipping capacity. So, the real focus in the scenarios going forward is on the economic management of the pandemic and continued focus on climate change. I4 and new propulsion technology will also create new opportunities for adventurous investors.

A CLOSER LOOK AT FREIGHT MARKET TROUGHS 1970-2020

Table 1 provides a statistical account of the severity of troughs, but little insight into how they developed financially. Figure 1 aims to fill this gap by comparing dry cargo costs and revenues over the last 50 years. It shows an *area chart* of estimated monthly costs for a Panamax bulk carrier between 1970 and February 202 (OPEX, interest; bankers spread and depreciation)[5]. The chart compares these costs with *market earnings,* which is shown by the solid line. When the

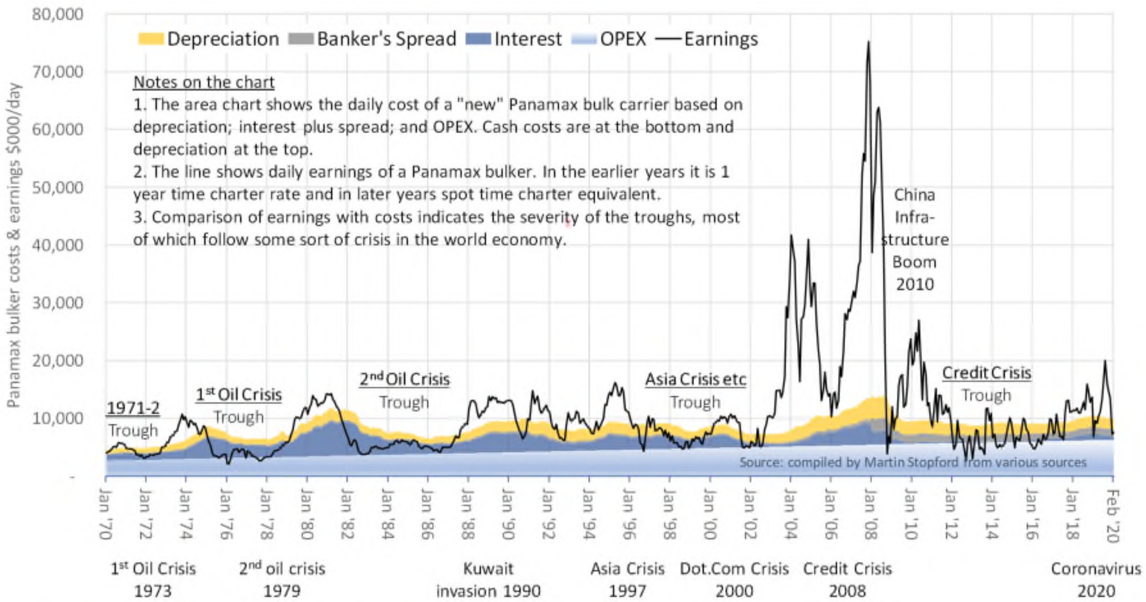


Figure 1 Panamax bulk carrier shipping market cycles, comparing costs and revenues 1970-2020

[5] This data series is pieced together from various sources and is not precisely accurate, but is probably "good enough for jazz". Ship costs are not a precise science and not well documented.

black line is above costs investors are making money and when it below, they are not covering costs, since cash coming is not enough to cover debt or depreciation. I have followed all these cycles over the years, and I would say Figure 1 gives reasonable account of what happened.

The most serious trough we identified in Table 1 was in the 1980s between 1983 and 1987. Figure 1 shows that during this long period earnings never covered interest. This long, deep recession unfolded year by year. Nobody expected the world economy and the oil trade to collapse in the way they did, due to a behavioral change by power stations. A lesson to remember.

The next most serious trough was the recession between 1997 and 2004, triggered first by the Asia crisis, followed shortly afterwards by the Dot.com crisis. Figure 1 shows this had a different character from the 1980s – it was long but not so deep. Over the eight years, earnings were occasionally enough to cover costs, but mostly well below them. It was a discouraging time for investors, but not as brutal as the 1980s.

The third serious modern recession in Table 1 ran from 1976 to 1979. It lasted only four years, but it was deep! Earnings spent most of that time falling on in line with operating expenses. But many owners still had timecharter income, so financial pressure was not as severe as the 1980s.

Finally the 2009-2017 recession was another that dragged on discouragingly, but interest rates were low and there was some cash flow

The conclusion is that although market troughs are variable and sometimes unexpected, they do conform to market fundamentals. Shipbuilding super-booms make them worse and good economic management helps. Today with limited shipbuilding capacity, the nature of the economic crisis and the way it is managed will make a big difference. The scenarios in this paper are intended as the starting point for thinking through what the supply-demand permutation might be this time. Which, after all, is what shipping investors are paid to do (when they do occasionally get paid!).

3. Influences on the forthcoming recession

For shipbuilders the impact of the pandemic will not just depend on the virus. The impact of the various revolutionary technical changes facing the industry will also be important. There are five factors, three economic and two technical: -

1. The impact and timing of the corona virus pandemic on the ship demand cycle.
2. The ongoing impact of climate change regulations on ship demand. Economic
3. Shipbuilding new orders, prices and capacity management.
4. The timescale for introducing zero carbon ship propulsion systems.
5. The timescale for digital technology in ships, companies & logistics. Technology

The first three variables are concerned with the economic and regulatory framework within which the marine industries will operate in the coming decade and the last two with the new technology that is available or must be developed to deal with the challenges raised in items 4 & 5.

This technical *revolution* is particularly challenging because for the last 50 years, shipbuilding technology has not changed very much, and designers could rely on "last done"[6]. But in the coming decade shipyards and their suppliers must offer designs involving new digital and low carbon technology. This will not be easy, because shipping is a technically conservative industry, and for good reason. No shipowner wants the risk of un-tried technology on ships operating in remote parts of the world. Before the pandemic shipbuilders were facing change on a scale not seen since the fossil fuel revolution in sea transport 200 years ago. In a long cycle business like marine shipbuilding and engineering it is important to continue to work towards longer term goals.

> *In recent decades shipbuilders and shipping companies needed few research, development and design resources. They could rely on "last done" when tendering. But that is no longer the case. In the coming decade shipyards and their suppliers must be able to offer designs involving new technology,*

4. Pandemic Scenarios and the technical revolution

As a framework for answering the questions raised by The Diesel Magazine, I constructed a series of scenarios which capture the possible impact of the five issues outlined above[7].

- The *first* section below describes three seaborne trade scenarios which treat the pandemic as the dominant short-term cyclical issue; and climate change as the main long-term issue. The three scenarios explore how these very different aspects of maritime transport demand may develop.
- The *second* section uses the sea trade scenarios to estimate the requirement for new ships. It calculates "expansion demand" to grow the cargo fleet and "replacement demand" to replace ships scrapped due to age or obsolescence.
- The *third* section develops technical scenarios for building a new fleet of ships incorporating technology capable of meeting IMO 2050 carbon emissions targets, subject to the technical constraints faced by shipyards and equipment manufacturers.

5. Three Seaborne Trade Scenarios

Figure 1 shows the three scenarios of how trade might develop in the short run due to coronavirus (Scenario 1-Mild; Scenario 2-Extended; and Scenario 3-Severe) and in the long term due to climate change regulations between 2020 and 2050 and Smart Shipping(Scenario 1-Trend; Scenario 2-Soft; Scenario3-Slump). The coronavirus Scenario 1 is combined with Climate Change Scenario 1, and so on for the other scenarios. Scenario 1 combines the upside cases and Scenario 3 the downside cases (what happens in the real world is a different matter!).

[6] Each new generation of merchant ships was slightly bigger than its predecessor, and there were improvements to on-board equipment, but the basic technology of the ships delivered today is much the same as 40 years ago when I was in shipbuilding. Shipbuilders and shipping companies needed few research and development resources

[7] . I used my modelling system to make these scenarios internally consistent and to highlight specific challenges which the scenarios suggest.

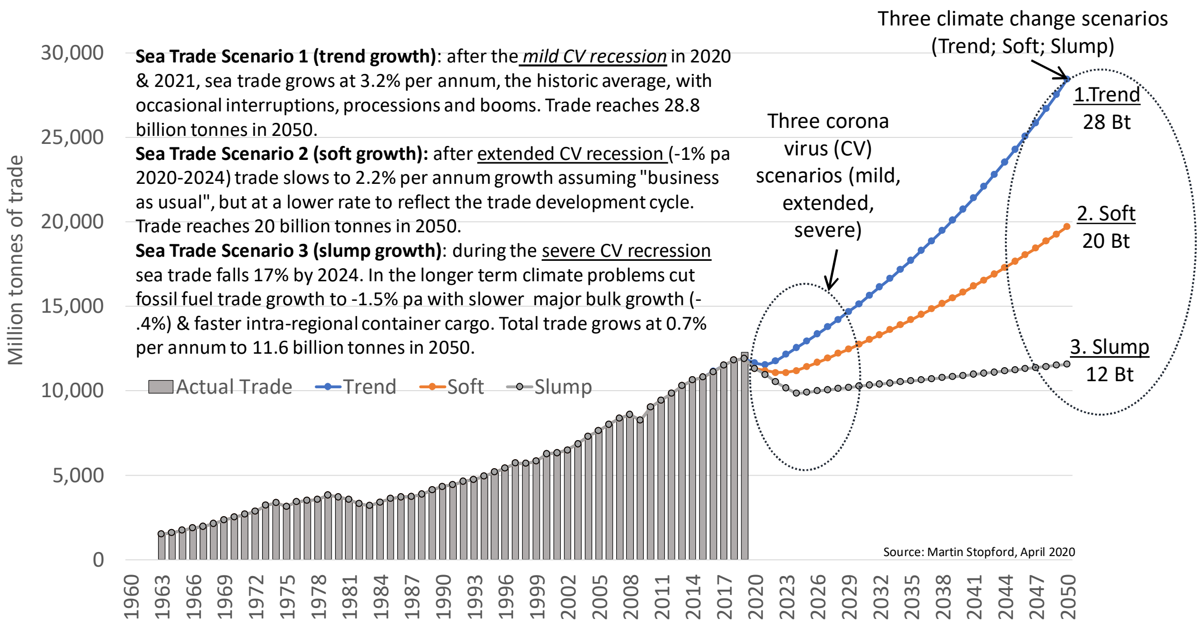


Figure 2: Three sea trade scenarios of corona virus & climate change developments 2020-2050

The coronavirus scenarios involve three different visions of how the pandemic might develop. Scenario 1 describes a "*mild case*" in which the progress of the virus across the world follows a similar pattern to China. Economies take hit a from the fiscal program in 2020-21, but sea trade grows by 2% in 2022. In Scenario 2 the recovery drags through into 2022. The fiscal consequences and logistics problems of getting business back to normal become much more severe. Sea trade falls by 1% a year in 2021 and 2022, with zero growth in 2023. Scenario 3 envisages a longer and deeper recession in which sporadic repeated lockdowns cause lingering economic problems and fiscal budgets are under extreme pressure. The trade recession lasts three years (this case was based on the early 1980s shipping recession). To summarise: –

SEA TRADE SCENARIO 1 (TREND GROWTH):

This scenario assumes a relatively mild CVP downturn in 2020 & 2021. New cases generally peak four or five weeks after lockdown, followed by a phased return to normal business eight to ten weeks later. China is back to work in summer of 2020. Europe and USA see infections peak in late-April and social measures are progressively relaxed in May and June. The fiscal measures (15-20% of GDP) get businesses back to work reasonably within budget and by year end economies are working again. Testing, treatments and inoculation prevent further major recurrences and credit issues are successfully managed. But the problems of global supply chains for materials and products probably lead to lower trade volumes in 2020/2021, recovering briskly to 2% growth in 2022. Beyond that, sea trade grows at 3.2% per annum, the historic average, reaching 28.8 billion tonnes in 2050.

SEA TRADE SCENARIO 2 (SOFT GROWTH):

In this scenario containment is effective in Europe & USA but the virus proves hard to shake off, with infections re-occurring over the late summer. Businesses operate later in the year, thanks to the fiscal support, now well over budget, but not business as usual. This expensive and patchy recovery drags through winter, and it is 2023 before the major G7 economies are back onto an even keel, with adequate hospital facilities to treat the critical cases, supported by testing, and transparent "immunity identification" and inoculation. The decline in global economies carries on throughout the year, with weak commodity demand. In 2024 sea trade finally picks up and from 2025 onwards grows at 2.2% per annum. This long-term scenario reflects the higher cost of low carbon transport; reduced transport of fossil fuels; and some reduction in the heavy industrial end of the business. Sea trade reaches 20 billion tonnes in 2050.

SEA TRADE SCENARIO 3 (SLUMP GROWTH):

Finally, in scenario 3 the lockdown restrictions do not work fast enough in Europe and USA and high or recurrent infection levels continue. By late summer the lockdown becomes very problematic as governments face funding problems, as the continued partial shutdown eats deeply into the real economy. Virus related problems drag on, compounded by problems in the real economy as businesses struggle to get re-established. Tourism and business travel recover slowly, as do public gatherings of all sorts. Global oil trade falls steadily. By 2024 sea trade has fallen 15%.

The macro economics of this downturn were not analysed, but the driving force is that repetitive or ongoing partial lockdown funded by fiscal programs rises way above the original 15% to 30% of GDP prove difficult to manage and have limited success in stimulating the demand upturn needed to kick-start recovery. Lack of inoculation and reliable testing lead to behavioral problems.

For shipping, this recession is like the 1980s but not as bad as the 1930s. How it would develop deserves more attention than I was able to give it in the time available. Zero interest rates might give it a different dynamic. In the long term (i.e. to 2050), changing transport and travel behavior, combined with climate pressures, cut fossil fuel trade growth to -1.5% pa and major bulk growth by -0.4%. Faster growth of intra-regional container cargo, as supply chains shorten is another possible change. Total trade grows at 0.7% per annum from the trough to reach 11.9 billion tonnes in 2050.

The impact of these three scenarios is highlighted in Figure 2. In terms of shipping markets, Scenario 1 might have an impact like the credit crisis in 2009, whilst Scenario 3 resembles the depression triggered by the second oil crisis in the early 1980s. The impact of these scenarios for ship owners would depend on both fiscal measures and interest rates which would reduce the financial stress for leveraged companies.

6. Three Shipbuilding Demand Scenarios

The three shipbuilding scenarios shown in Figure 3 were developed from the trade scenarios in Figure 2, by applying various assumptions about the performance of the fleet under different circumstances. Note that the historic data 1964-2019, shown by the blue bars, represents shipbuilding deliveries, but the forecasts are based on the “requirement” for new ships derived from *expansion demand* (due to the growth of trade) and *replacement demand* (due to the demolition driven by the ageing of the fleet, or possibly obsolescence). This “requirement” is not an indicator of deliveries, which are determined by orders, which in turn depend on investor sentiment and sometimes government policy. “Requirement” is, strictly speaking, just the extra tonnage needed to service trade. How and when that capacity arrives is a different matter.

The main variable driving it is the speed at which the fleet operates (note the emissions scenarios discussed in Section 8 do not take account of auxiliary engine consumption and the

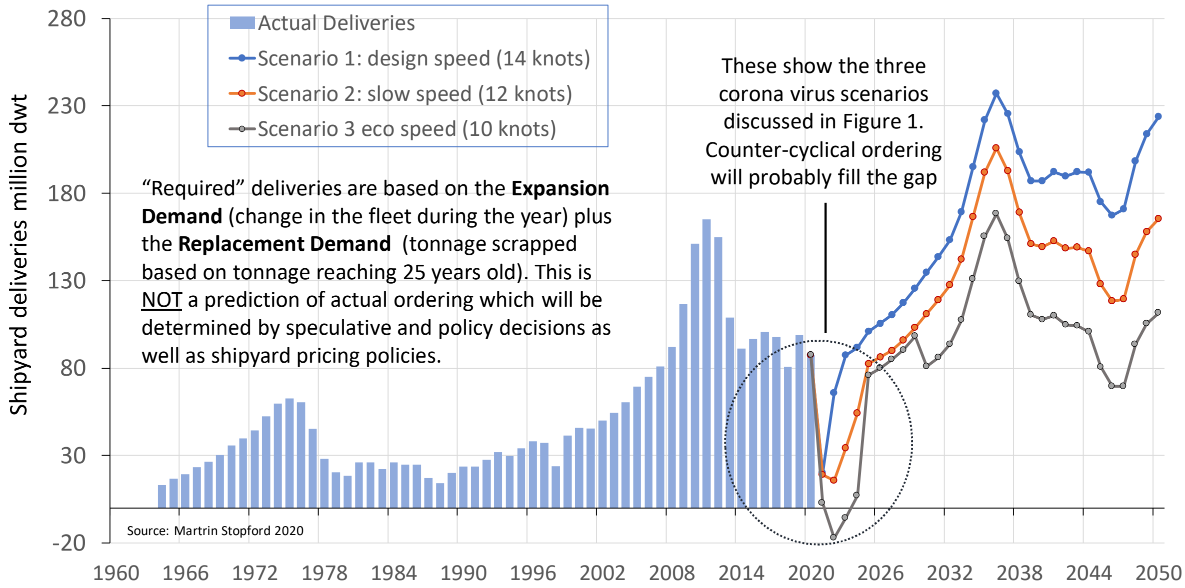


Figure 3: three shipbuilding scenarios showing actual deliveries to 2019 and "required" deliveries scenarios 2020-2050

"newbuilding requirement" is a calculation and is not the same as "orders placed" which depends on investor behaviour). Three speed scenarios were used, and average ship size was assumed to increase by 40% between 2020 and 2050: –

SHIPBUILDING SCENARIO 1 (TRADE SCENARIO 1, DESIGN SPEED, FLEET REPLACEMENT):

This scenario is the most manageable one for the shipbuilding industry, and after a relatively mild downturn caused by the CVP, the requirement for new ships incorporating the latest technology grows very rapidly. It assumes that throughout the period the merchant fleet operates at its design speed, which is assumed to be 14 knots (note that over the last decade the fleet has been operating about 2 knots below the design speed).

This scenario shows a short sharp contraction in new building requirement during 2021, following which the newbuilding requirement grows towards a 250 million deadweight peak in the early 2030s. This peak is due to 3.2% pa trade growth and replacement of the ships built in the 2009-2013 boom. Since this scenario involves trend trade growth and the fleet operating at its design speed, it would rely heavily on zero-carbon propulsion to avoid breeching the IMO 2050 carbon target. The shape of the peak requirement would also be modified if there was heavy obsolescence or recession driven demolition during the 2020s.[8]

SHIPBUILDING SCENARIO 2 (TRADE SCENARIO 2, SLOW SPEED, FLEET REPLACEMENT):

In shipbuilding scenario 2 the fleet slow steams at 12 knots based loosely on recent market practice. This produces a 14% reduction in fleet transport capacity compared with Scenario 1, and a 38% reduction in fuel consumption (and emissions) produced by diesel engines. In the short term it is based on the more extended coronavirus downturn built into Trade Scenario 2, and once that is over, trade grows at 2.2% per annum and the fleet operates at 12 knots. This scenario suggests a severe downturn in shipbuilding demand over the next two years, shown by

[8] Age -based forecasts of this sort can be misleading because of the difficulty of knowing exactly when surplus capacity will be scrapped. For example similar analyses of the demolition of VLCC's built in the 1970s boom proved misleading because some were scrapped in the 1980s during the depression; others were scrapped in the 1990s during a difficult market; but the remainder went on to trade up to 30 years.

the red line in Figure 3. But after that the shipbuilding requirement picks up, peaking at 200 million tonnes in the early 2030s. This demand is mainly due to the need to replace ships built during the shipbuilding super boom 2010 to 2015 and the slower operating speed. Early scrapping during the coronavirus recession, or due to technical obsolescence in the 2020s, would change the shape of this curve. Counter-cyclical ordering will play an important part in determining how the early years of this scenario develops for shipyards and owners.

SCENARIO 3 (TRADE SCENARIO 3, ECO-SPEED, FLEET REPLACEMENT):

Shipbuilding scenario 3 the fleet slows to an eco-speed of 10 knots, reducing the transport capacity of the fleet by 17%, other things being equal, and achieving an additional 40% reduction in fuel consumption and emissions compared with Scenario 2. In the earlier years operating at the lower eco-speed could reduce the transport capacity of the fleet below the level of transport demand. But the coronavirus recession alleviates that pressure.

Scenario 3 produces a more severe recession in the early 2020s, due to the deep CVP driven downturn in the world economy. Shipbuilding demand does not recover until 2025, reaching a peak of 160 million deadweight, roughly the same as in 2011. As in the other scenarios this peak is due to replacement of the ships delivered in the 2009-2012 boom and the increased deadweight capacity of ships needed by the fleet operating at only 10 knots. In Scenario 3, if past recessions are any guide, counter-cyclical ordering by investors or governments is likely to play an important part in determining how the early years of this scenario develops for the shipyards and owners. Technology driven orders might motivate this sort of activity.

Overall the three shipbuilding scenarios highlight risks facing the shipbuilding industry during the coronavirus pandemic, and demonstrate the levels of shipbuilding capacity needed in the following decade for fleet replacement; to compensate for slower operating speeds; and to build the low emission ships needed to meet climate change objectives. Counter-cyclical investment will clearly be a major issue. Since these involve unpredictable behavioral variables, they cannot be modelled precisely. But they raise issues which should be considered when developing strategy.

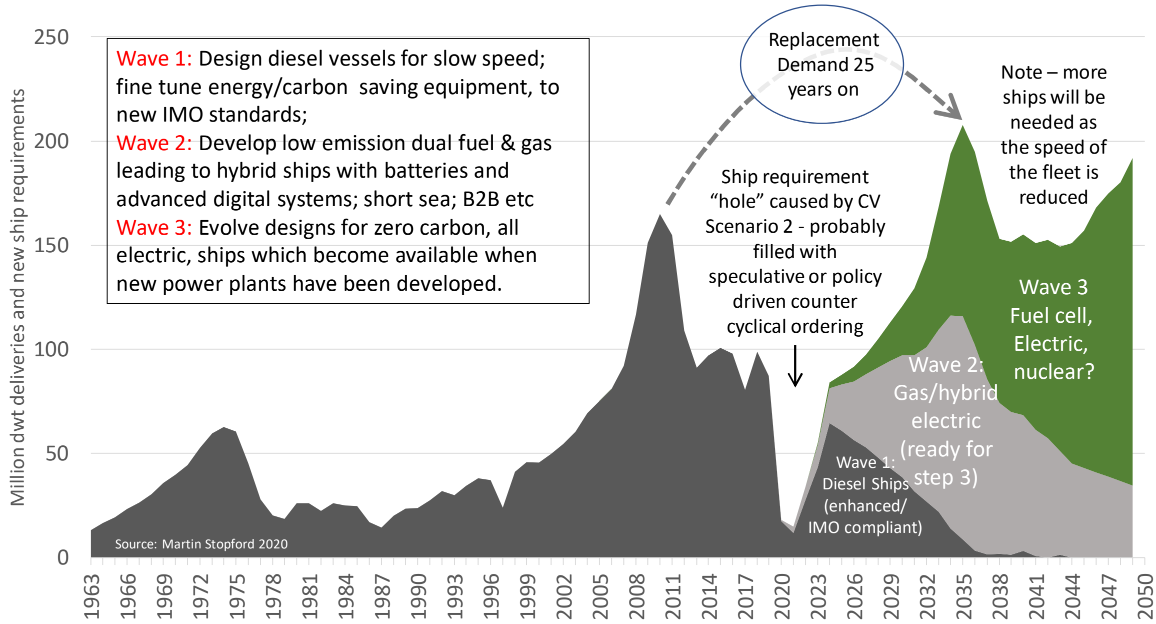
7. Three Waves of Technical Development

Figure 4 illustrates how the technical challenges facing the shipbuilding industry in the coming decades could be met, starting from Trade Scenario 2 (the "soft" trade scenario) and Shipbuilding Scenario 2 (the slow speed scenario). Under this scenario the "requirement" for new ships falls over the next two years and then climbs to a peak of about 200 million deadweight in 2035. In practice ordering will probably not follow the "requirement" estimate closely because of counter-cyclical ordering by investors taking a long-term view.

Table 1 World merchant fleet May 2019 by main propulsion type

Engine Type	Number	Mill Dwt	Av dwt	% Number
Diesel 2-Stroke	25,109	1,783	71,009	78%
Diesel 4-Stroke	5,385	55	10,289	17%
Diesel Electric	1,198	33	27,812	4%
Steam Turbine	306	26	84,005	1%
Non Propelled	170	23	132,374	1%
Hybrid Mech./Elec.	105	8	72,962	0%
Combined	13	1	99,505	0%
Gas Turbine	14	0	14,217	0%
Batteries & Diesel	18	0	3,932	0%
Nuclear	7	0	7,547	0%
Steam Reciprocating	2	0	2,686	0%
Grand Total	32,341	1,929	59,656	100%

From file in market data fleet (owner)
Source: world fleet over 5000GT



Please note that this is a scenario to illustrate the way things might develop, not a forecast, it will almost certainly be wrong!

Figure 4: Technology scenario 2 to reach IMO 2050 CO2 target (based on trade scenario2 and shipbuilding scenario 2)

The key investment issue is the propulsion system of the ships built in the coming decade. Today over 99% of the world cargo fleet over 5000 gross tonnes (GT) relies on fossil fuels for propulsion (see Table 1). Of this 78% is two stroke diesel engines; 17% is four stroke diesel; 4% diesel electric and 1% steam turbine. The only non-fossil fuel driven ships in this size range are seven nuclear icebreakers. The IMO regulation requires emissions to be less than half the 2008 level by 2050. Although emissions are not precisely quantified, this would mean a reduction from around 900 million tonnes of carbon (the approximate 2008 level) to around 450 million tonnes of carbon in 2050.

Gas and hybrid propulsion vessels would be an important testing ground for developing designs that, despite their technical sophistication, are cheap, reliable and commercially robust enough to be successful in the bulk and liner trades.

By 2050 Scenario 2 requires 2.7 billion deadweight of new ships. The problem for investors is that no zero-carbon propulsion system is available for commercial cargo ships. In future the most likely solution would be fuel cells generating electric energy from hydrogen or ammonia. But electric power plants of this sort are not expected to be commercially available until the late 2020s. In addition, supplying and delivering "green" hydrogen or ammonia bunkers (i.e. produced without carbon emissions) will be difficult and expensive since clean, green fuel of this sort will be much in demand on land. So meeting the carbon challenge must involve a phased approach, in which design innovation is introduced in three Technology *Waves 2020-2050* shown in Figure 4.

TECHNOLOGY WAVE 1:

This wave starts with the chasm in new building requirements between 2020 and 2024, and the possibility of covering this with counter-cyclical ordering deserves careful attention[9]. The first

[9] This is not a prediction of what will be ordered. On several occasions in the past when shipbuilding requirement has slumped in this way, investment has continued, driven either by liquidity; counter cyclical ordering, or the

wave must inevitably involve the production of diesel ships. Diesel engines are highly efficient and with no viable zero carbon alternative, the most effective option is to continue investing in diesel engines, whilst using digital I4 technology to improve the performance of the whole shipboard platform.

This will involve a substantial re-engineering of on-board functional systems[10], including the introduction of digitally integrated operating systems for the eight major functional areas on the ship, linked by controller area network technology, like the CANbus F2 systems currently used on many other transport vehicles.

Another challenge will be to convince investors that they will be allowed to trade diesel-powered ships long enough to depreciate them. If these problems can be resolved, this period of development would not be lost time, it would create the technical framework for moving on to Wave 2 which involves gas and hybrid vessel propulsion systems and ultimately Wave 3 which probably involves all-electric ships using fuel cells and batteries in some form.

TECHNOLOGY WAVE 2:

This technology wave involves gas and hybrid powered vessels, which starts in the early 2020s and continues until the end of the period. Pricing will play an important part in determining the way in which this wave develops. Gas and hybrid vessels using batteries represent an important testing ground for developing designs that, despite their technical sophistication, are cheap, reliable and commercially robust enough to be successful in the bulk and liner trades. Initially they are likely to be more expensive than conventional vessels, and the lower carbon emissions savings of about 20 to 30% would need to attract sufficiently high timecharter rates to compensate.

TECHNOLOGY WAVE 3:

The third wave comprises the zero carbon propulsion systems which are currently only just off the drawing board, and face scalability problems. First generation commercial fuel cell and battery propulsion might be available in the mid-2020s. Developing a bunker network would also take time due to technical and safety problems in distributing these dangerous commodities. Finally, the propulsion systems and bunkers are likely to be much more expensive than hydrocarbons. So, investors will face difficult decisions, whatever they do. Indeed, difficult choices might prove to be the theme of the 2020s for investors.

On a positive note, the technology wave scenario in Figure 4 would reduce carbon emissions to 328 million tonnes by 2050, well below the IMO target of around 450 million tonnes. By 2050 the whole diesel fleet would be phased out, but under Scenario 2 this would have been done in an orderly way which allowed investors to depreciate their ships over their normal operating life, since there are no new diesel ship deliveries after 2030. There would, however, still be a fleet of gas and hybrid vessels in operation. The cost new ships, both in terms of acquisition cost and operating cost, has not been examined in detail. That is for another day!

desire to get the latest technology, during an era of technical change. Once this trough is over, the chart shows three waves of investment.

[10] The functional systems include engine, auxiliary power, auxiliary machinery, ballast & trim, navigation, cargo handling, IT & communications, and maintenance.

8. Carbon footprint of the three scenarios

Finally, the three scenarios produce very different results in terms of the carbon footprint of the merchant fleet as can be seen in figure 4. Scenario 1, which assumes 3.2% trade growth and 14 knots operating speed produces carbon emissions of 771 million tonnes in 2050, well above the IMO target of around 450 million tonnes of carbon emissions. But the other two scenarios do

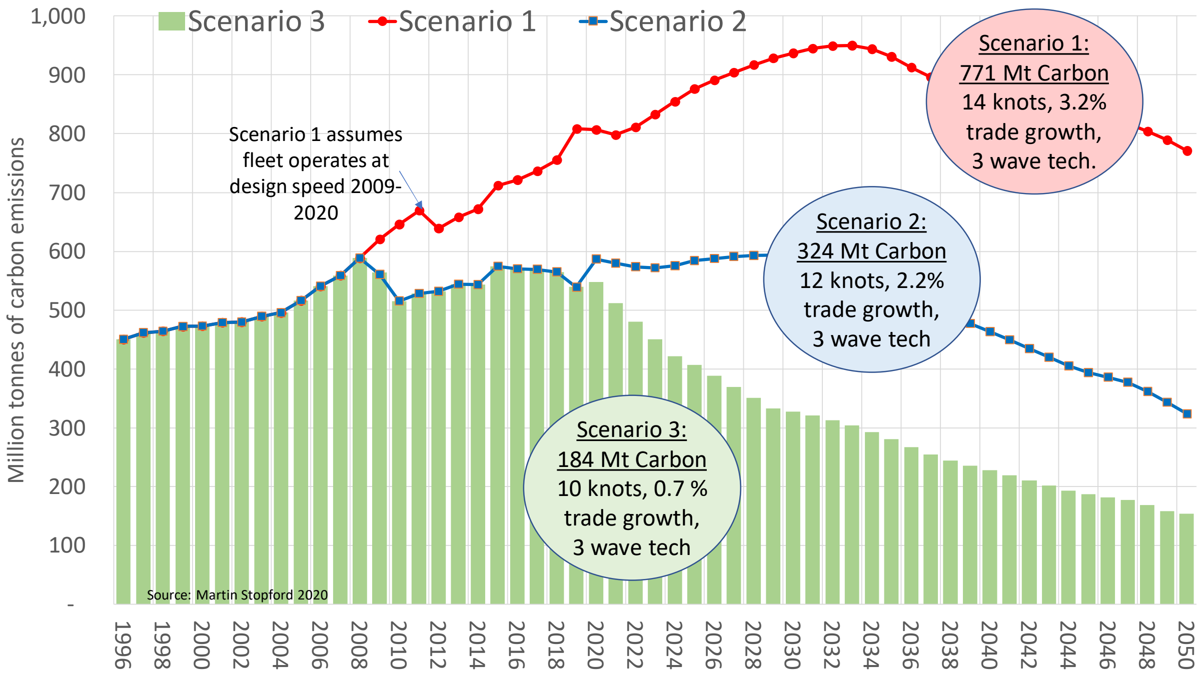


Figure 5 : Carbon emissions for scenarios 1-3 based on trade, shipbuilding & technical scenarios

much better. Scenario 2 reduces carbon emissions to 324 million tonnes in the 2050 and Scenario 3 produces carbon emissions of 184 million tonnes. All these scenarios depend upon the three waves of technical development described in Figure 4. Of course, these improvements are only partly achieved by new technology. Slower operating speeds and lower trade growth play a major part.

Martin Stopford
martin.stopford@clarksons.com
20 April 2020 -

Appendix 1 Summary of paper presented in Shanghai 3 Dec 2019

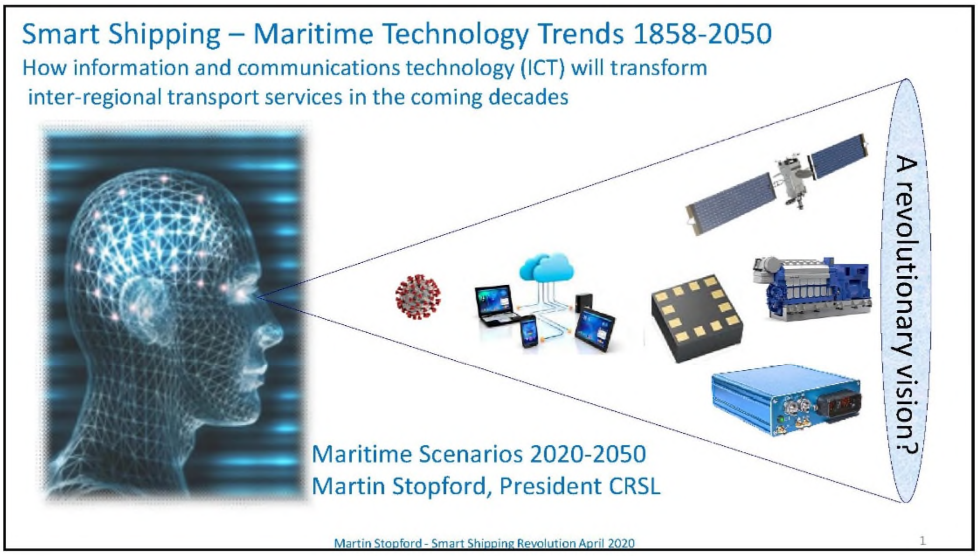
Paper presented by Dr Martin Stopford, non-executive president, Clarkson Research at Marintec 40th Anniversary Senior Forum, Shanghai, 2nd December 2019

Dr Stopford's paper will focus on the way seaborne trade will develop in future, given the challenges presented to the industry by the "climate emergency" and digital technology. Substantial investment will be needed to build ships capable of achieving lower, and eventually, zero emissions. In addition, during the coming decades, the shipping and shipbuilding industries must invest heavily in digital systems to improve transport efficiency, safety, reliability and the provision of low-cost Business to Business (B2B) transport.

The presentation will discuss strategies for cutting carbon emissions by 2050. It will also review the application of digital systems to ships. If shipbuilders follow the example of the car industry, as Dr Stopford believes they should, they will need to apply Control Area Network (CAN) protocols to the management and automation of on-board systems. All this will call for major investment by shipbuilders and shipping companies. In shipbuilding this will require "super-companies" large enough to research, develop and apply this radically new technology to ship production, in co-ordination with their customers, the suppliers of marine equipment. The regulatory framework will also play a major part in ensuring the success of this innovative investment.

Appendix 2 Summary smart shipping technology slides 2020-2050

Appendix 2: Maritime technology 2020-2050 20/04/2020



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1. Vision – revolutions happen when there is a better way : Over the last 20 years communications and digital technology have advanced to a point where they can be used in business to improve the way sea transport is organised and managed. This is already happening on land. Some of the changes which might occur are listed in this chart.

1. **Seamless** cargo transport services between all parts of the world, integrated with suppliers and receivers
2. **Fast, reliable & flexible** services with fewer accidents
3. **Cost savings** of 30% in real terms as QA works, lower emissions and better focus on providing what customers really want
4. **Big companies** have cost advantage & providing customer-responsive transport service levels. Maybe small companies too
5. **Professional teams** run big fleets as "transport factories" providing fast, flexible, cheap transport
6. **QA:** Use of deep learning software & robotics make QA systems work throughout the transport chain
7. **Unmanned ships** in suitable trades & semi-manned ships in many others with zero tolerance

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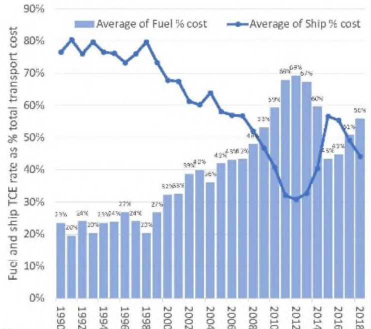
Appendix 2: Maritime technology 2020-2050 20/04/2020

2. Speed & Size Still Crucial: Slower speed reduces carbon emissions, but uses more ship capacity. Figure 1 shows since 2008 bunkers cost more than the ship, so slowing is good economics too. Figure 2 shows that ship size doubled since 1996. But the economies of scale chart in Table 1 shows that the benefits are bigger ships diminish with size, so making smaller ships bigger yields better results. That would be relevant in developing intra-regional trade in future.



Message 1: bunker costs impact on every aspect of the design and operational economics of new ships. Fuel costs have increased from 20% to over 50% of transport costs, mostly in the last decade. A change on this scale calls for a fundamental rethink of the way merchant ships are designed and built.

Figure 1: Fuel has increased from 23% to over 50% of total cost

Table 1: Bulk carriers - new prices October 2019

Dwt	Price/dwt	Price $M	Index/dwt	Saving/dwt
38,000	626.3	23.8	100%	
62,000	416.1	25.8	66%	-34%
81,000	343.2	27.8	55%	-12%
180,000	280.6	50.5	45%	-10%
Source: Clarksons SIW				

Message 2: The merchant ship economies of scale curve (EOS) is asymptotic, so the cost gain per dwt diminishes as the ship gets bigger. As the average ship size approaches 60,000 dwt, the economic benefits of building bigger are diminishing as fast and the external costs of operations are increasing.

Figure 2: Average size of merchant ship up 57% in 22 years

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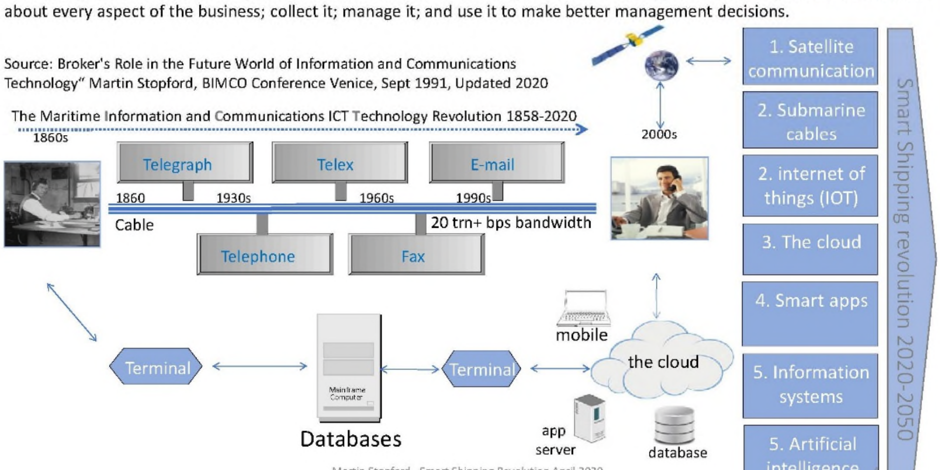
3. Digital communications: are not revolutionary in shipping – it started in 1858 when the first deep sea cables were laid! As comms improved, shipping changed. But today we have a "step change" in the technology our ability to generate information about every aspect of the business; collect it; manage it; and use it to make better management decisions.

Source: Broker's Role in the Future World of Information and Communications Technology" Martin Stopford, BIMCO Conference Venice, Sept 1991, Updated 2020



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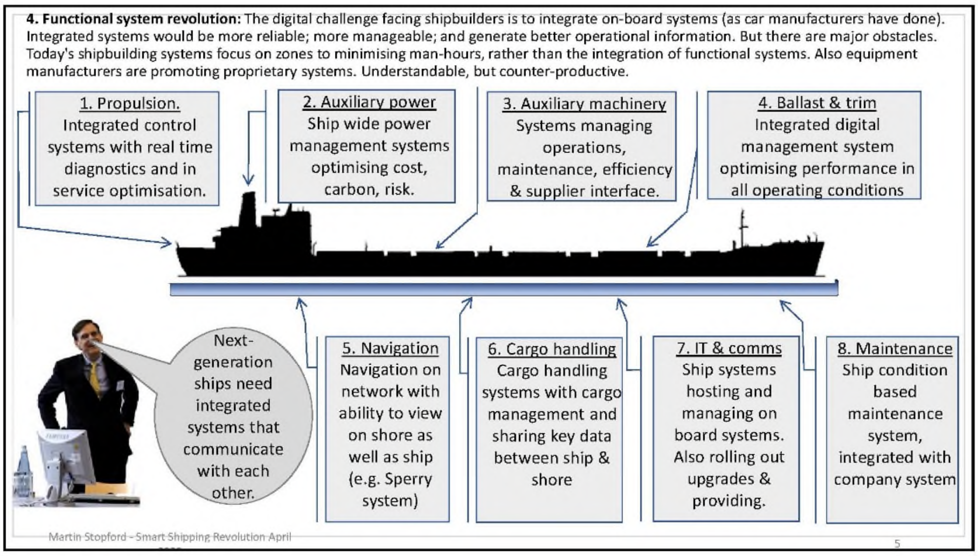
Appendix 2: Maritime technology 2020-2050 20/04/2020



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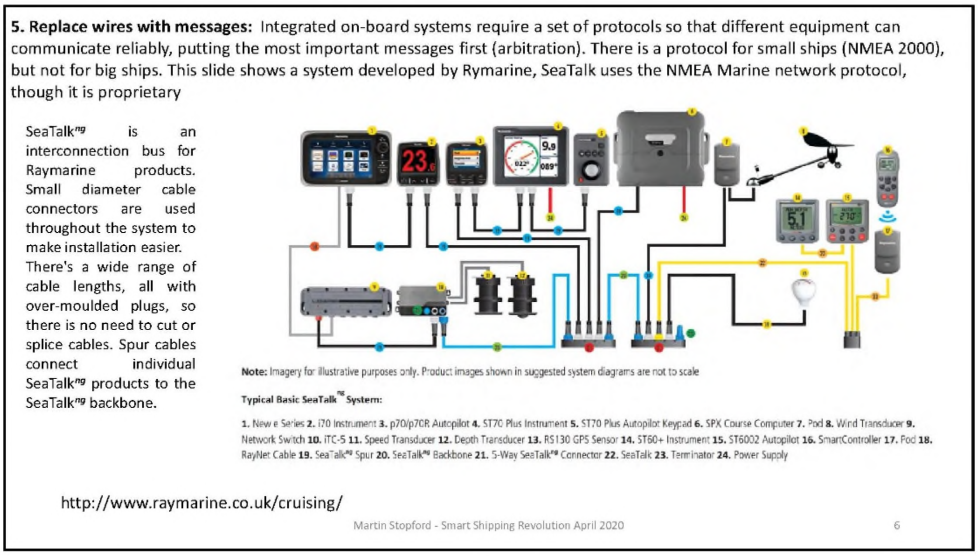

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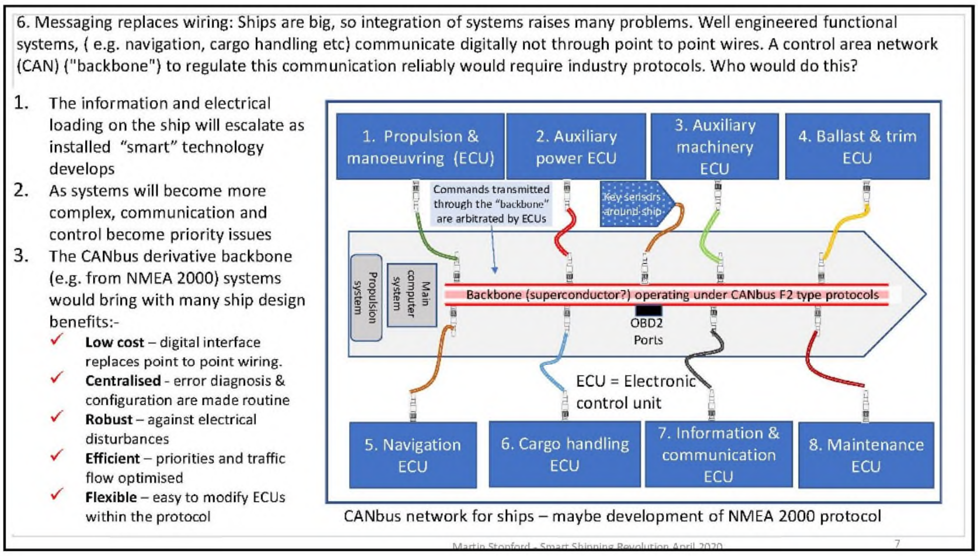
Appendix 2: Maritime technology 2020-2050 20/04/2020



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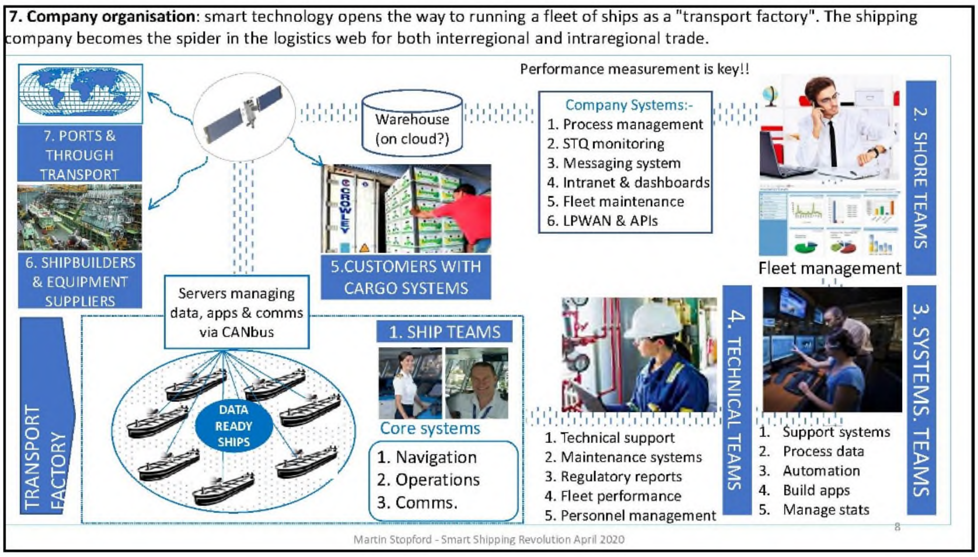

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