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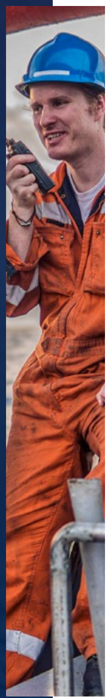

Seafarers *and* digital disruption

The effect of autonomous ships on the work at sea, the role of seafarers and the shipping industry.

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This study has been prepared by HSBA Hamburg School of Business Administration for the International Chamber of Shipping.

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Lead Author: Prof. Dr. Max Johns (HSBA).

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1. Lead Questions

This paper will focus on potential social and practical consequences of autonomous shipping and digitalization on seafarers.

This Hamburg School of Business Administration paper was commissioned by the ICS Labour Affairs Committee to identify and highlight issues which may have consequences for seafarers as a result of possible digital disruption onboard ships. It will also serve as a basis for further discussions, research and strategy building.

The goal is to define essential developments in line with other bodies of ICS that derive from:

- digitization and digitalization of ships and their systems,
- digital transformation of ship operations,
- increased autonomy of ships and their systems,
- the newly emerging trend of cooperation between shore-based operating centers (**Remote Operating Centres, ROCS**) and ship-centered input.

The paper enables a discussion in a structured manner about effects on:

- the regulatory environment
- training of new skills
- re-skilling
- manning
- awareness of security considerations
- the social environment and
- all aspects of labour relations
- Seafarer Welfare (Mental and Physical)

Remote Operating Centers

Decision making on board ships would be increasingly co-operative with ROCs.

2. Some essential Definitions

This paper does not invent or create new definitions but rather draws upon existing work. The last 48 months have seen an increasing number of articles and presentations on “autonomous shipping”, digital disruption and digital transformation in shipping. They have worked with fluid definitions and overlapping notions.

The maritime industry finds itself, as many other industries and namely all other transport industries, in a state of digital transformation. A part of this transformation is the prospect of more autonomous operations of the ship as a system. This report

AL 0 Manual	No autonomous function	All action and decision-making performed manually	Human controls all actions
AL 1	On-board Decision Support.	All actions taken by human Operator, but decision support tool can present options.	Data is provided by systems on board.
AL 2	On & Off-board Decision Support.	All actions taken by human Operator, but decision support tool can present options.	Data may be provided by systems on or off-board.
AL 3	'Active' Human in the loop.	Decisions and actions with human supervision.	Data may be provided by systems on or off-board.
AL 4	Human on the loop, Operator/Supervisory.	Decisions and actions are performed autonomously with human supervision.	At high impact decisions human Operators can still intercede and over-ride.
AL 5	Fully autonomous.	Rarely supervised operation.	Decisions are entirely made and actioned by the system.
AL 6	Fully autonomous.	Unsupervised operation.	Decisions entirely made and actioned by the system during mission.

points out that "autonomy" is not necessarily "unmanned" and that levels of autonomy won't be static (Maersk 2017).

As a starting point, this report utilizes the definition of "autonomy levels" that have been developed by Lloyds Register (Lloyds Register 2016), (Lloyds Register 2017) and cover broadly ship design and ship operation. This approach defines six levels for autonomous ships in its ShipRight procedure guidance and takes particular note of remote operation in the later version (Lloyds Register 2017). The guidance describes autonomy levels (AL) ranging from 'AL 1' through to 'AL 6' which denotes a fully autonomous ship with no access required during a mission. The definition is just one of many (Finland 2018), but provides a helpful framework for this report for understanding and mapping the consequences in various aspects of the human aspect of maritime trade[1].

The differentiation between ship operation in varying levels of control is important and has led to the six aforementioned "**Autonomy Levels**" (AL).

Even though the proposed model of autonomy levels is necessarily rooted in a rather classical definition of the term "crew" as ***"…suitably certified staff physically located on board the ship, according to the ship's Minimum Safe Manning Certificate and in accordance with the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)"*** (Lloyds Register 2017) and one of the downsides is that it implies a hierarchical and cumulative

Autonomy Levels

Lloyds Register defines six levels of autonomy for merchant ships.

[1] Alternative definitions are given by SINTEF et.al. (SINTEF 2017). Finland provided an analysis of definitions for different concepts and levels of autonomy n MSC 99/5/6, covering work from Bureau Veritas, LR, the Norwegian Forum for Autonomous Ships (NFAS), Ramboll – Core, Rolls-Royce, UK Marine Ind. Alliance).

[2] Proposed by DMA in MSC 98

development process, this concept will be a starting point. Additionally, it was agreed at the IMO during MSC 99 that a specialist working group would look at the definitions of autonomy and the framework required for the regulatory scoping exercise (IMO 2018/May). This went back to a proposal from DMA et.al. (Danish Maritime Authority DMA 2017)[1].

A higher Autonomous Level (AL) system may use a lower AL system as part of its reversionary control and a complex system may be a combination of multiple systems at different levels. In most stages the vessels are not entirely autonomous but are remote-operated and/or guided and/or supported by humans on and off board.

Other definitions put slightly different emphasis on the role of autonomy and manning levels, the interaction between on-board and shore personnel and levels of control (Rødseth, MASRWG 2017).

[1] Proposed by DMA in MSC 98

3. Status of Digitization and Digitalization

Current research distinguishes clearly between digitization and digitalization. The former describes merely the transformation from analogue means to digital. Scanning a piece of paper or a photograph is a process in digitization. Bringing a chart from the original paper to an ECDIS system belongs to the same sphere.

Supply-chain. *Maritime transport is part of the wider supply chain which is digitalized.*

Digitalization describes the transformation of process and models due to digital changes and - possible - disruptions. If a navigator can use ECDIS and receive additional support by added data and decision-relevant input (weather data, currents etc.) the process is digitalized. While digitilization affecting the larger **supply-chain** is not considered here, this paper focuses on developments on and around the vessel.

The increasing use of digital elements on board ships allows for machines to interact and to act more independently. This may push the boundaries of decision processes on SOLAS ships. It provides possibilities for greater safety (collision avoidance, improved visibility etc.) which can generally put the crew out of harm's way (Krohne 2017). Digital management tools can make the equipment more reliable if methods like predictive maintenance and detailed monitoring can be used. However counter arguments cover increased cyber risk which in turn will lead to further cost. But challenges go beyond cyber security. For example, can a company guarantee a safe working environment for personnel on board if the capabilities of the technology cannot be verified? Eventually, machines will be able to match human experience in most areas if they can accumulate experience and combine data in a way that goes beyond human capacity.

Logistics operations play out in a highly networked multi-modal chain. The level of autonomy increases also.

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Machine learning.
Machines can accumulate experience and patterns over longer time than humans.

Finally, ship operation can become more efficient in a networked environment. Data from one's own ship can be combined with many other data sources and with the correct calculations lead to reduced fuel consumption, optimized port calls and routes. **If machines learn** centrally and build on a multitude of experiences they may advance exponentially while human experience has to be reacquired over and over again.

Ship operation in a networked environment may eventually enable a move to a more centralised planning of ship operations and movements based on a multitude of data provided by planning throughout the logistics chain and taking into account historical as well as predictive data. This flow of information will allow greater transparency between the charterer and the ship-owner. It is unclear to what extent this may materialize in the current competitive climate of shipping. Digital disruption may also lead to increased concentration.

Smart shipping opens opportunities to grow

This increase in the use of digital elements aboard ships is a key theme used by supporters of technology in shipping such as Martin Stopford in the theory of "Smart Shipping" which advocates the need for a focus on technology in shipping to help it grow. As discussed it creates the ability to better monitor performance and the data collected as part of post event forensics may help to prevent future failures and business interruption (Eason 2016). On the other hand: technology can be used to store especially repetitive experiences and provide opportunities to learn from them beyond the individual horizon. According to the autonomous levels AL 0-6 it will depend specifically on ship types and trade lanes:

- how many crew will still be needed on board
- when a crew may be needed, for instance especially close to shore
- which parts of crews as we know them today with qualifications according to **STCW** in its current form will be needed
- if bridge and machine functions will develop separately and if new functions will be created
- which crew functions may move in part or entirely to shore-based facilities.

STCW.
Long-standing international rules for training and watch-keeping will have to be adapted carefully.

The most frequent source of errors and cause for accidents are reported to be human failures. However, it would be trivial to assume that the human element is about failure. Countless safe voyages and avoided accidents are due to the positive contribution of humans. Humans on board enable ships to sail, they are not a problem. It must also be considered that autonomy will never completely remove "human error" as it will purely be shifting it to other areas such as the shore based controllers and the hardware and software designers. Some could argue this may result in a potential increasing likelihood of human error as these people would have considerably less maritime experience making them potentially more risk prone.

Human capital is better invested to enhance productivity by interpreting data, avoiding repetitive tasks and reducing the impacts of human error on productivity.

Eventually, any additional level of autonomy needs to make economic sense. Redundancy of permanent crew on board, additional payload and reduced safety features need to make up for additional technical equipment and connectivity and for potential costs incurred in modifying or building brand new vessels (Stones 2016).

4. Status of Autonomous Shipping/Ships

Currently all means of transport undergo an accelerated development toward automation and automated movements. It has been established for railways and the aerospace sectors. With great public attention within the automotive industry while the maritime industry receives less attention. Vertically, automation has been established at various points in the logistics chain, particularly in warehousing.

Today (late summer 2018) autonomous shipping has gone beyond the theoretical stage. Advanced demonstrations and real-world deployments are increasing. Systems small vessels below 24 meters have reached their 2nd or 3rd or later generation (Dan Hook 2017), especially in the realm of remotely operated vessels. The first autonomous ships will be deployed in a narrow timeframe. Some players claim to have already autonomous ships in operation. (Paton 2018) Some people argue that as per the LR definitions that all ships afloat have some level of autonomy, so technically - partly - autonomous ships are already in operation in various incarnations.

Supportive digital elements have a long tradition on board merchant vessels. Most commentators suggest that they will tip the balance towards autonomy and remotely controlled vessels. Some observers see already by 2022 “large scale minimally manned and unmanned ships at sea” (Dan Hook 2017), especially as a standard, common tool in offshore construction and surveying and for scientific purposes. Other groups see an “operating autonomous maritime ecosystem” by 2025 (DIMECC 2016). Some caution against extrapolation of these developments to the global fleet is advisable, given the significant variation in the characteristics of different sectors and trades.

ROCs have been in use for several years

Liner shipping companies (such as Maersk, CMA CGM and Hapag-Lloyd) as well as Cruise Operators have established Remote Operating Centres (ROCs) for their

Yara Birkeland: Prototypes of autonomous ships have left the theoretical stage and are being tested.

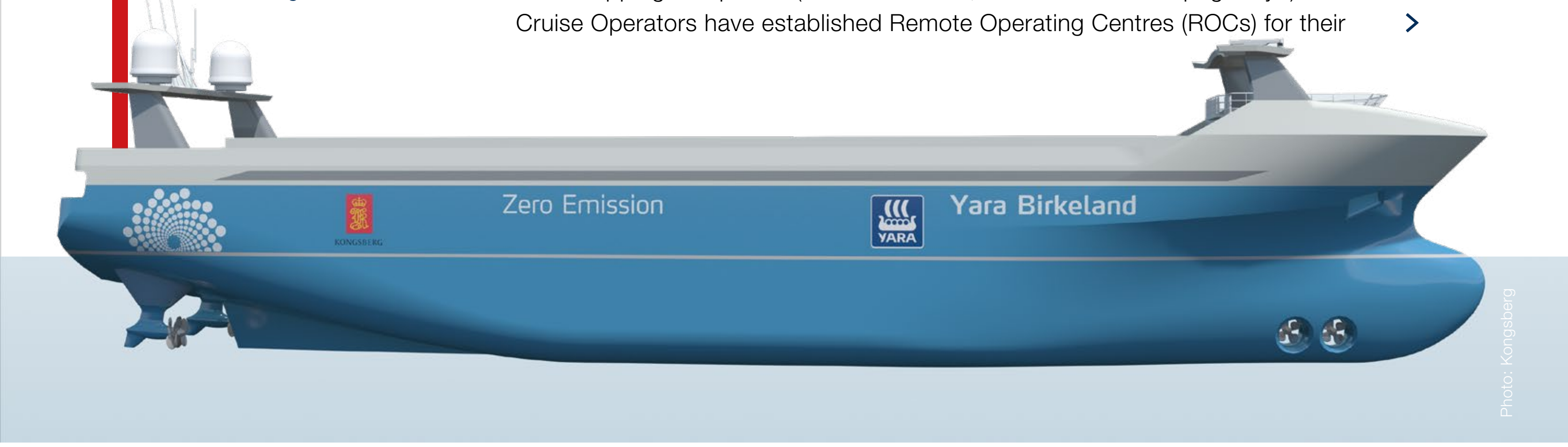


Photo: Kongsberg

Photo: Rolls-Royce plc

There are many steps from remote-controlled vessels to partly or entirely autonomous ships.

fleets for a number of years. These collect at least as much data as has been collected on the bridge in real time and currently assist the crew on board which operates the vessel. The assistance can already now go deep into AL 3 and even AL 4. It does not take much to fathom a switch in operational activity: the shore based centers may take over **routine** operations of the ship while the ship-based personnel are assisting.

Equally the military do deploy unmanned vehicles in the maritime theatres, including the US Navy's programme on unmanned ships such as the Sea Hunter project. (DARPA - https://www.darpa.mil/news-events/2018-01-30a) However; some previous studies had been providing rather less enthusiastic outlooks, like the MUNIN project (MUNIN 2016).

In several countries the industry is forming groups and research alliances to jointly approach possible disruptive changes in the shipping industry, i.e. in China (Yan 2018), Australia (Judson 2017), Finland (DIMECC 2016), Norway (NTNU AMOS 2016), UK (UKMIA 2014), and internationally (Rødseth, INAS International Network for Autonomous Ships 2017). Several countries designated test areas for sea trials (Norway, China et.al.), others intend to do so (Germany et.al.). South Korea and Denmark signed an MoU for the co-operation and promotion of e-navigation and the development of advanced technologies to be utilised by autonomous vessels. It shall result in a small-sized unmanned vessel by summer 2018. Japan plans to commercialize unmanned vessels on a larger scale from 2025 with the specific aim to circumnavigate the shortage of seafarers (Nikkei 2017).

The push for automation is being spearheaded by industry but is heavily supported by governments attracted by the benefits of encouraging new technology and the creation of new companies, jobs and capital. In Europe there are test areas in Norway, Finland and the UK, while China has made the news by unveiling the largest current test area which is 771 square km large (Chen 2018).

One of the most widely reported projects is the "Yara Birkeland" which is supposed to be commercially operational by 2020. Others comprise ASTAT in Trondheimsfjorden, Hrönn and a passenger ferry in Trondheim harbour. Also, the Chinese alliance for unmanned ships is expecting to launch the first commercially viable unmanned ship in October 2021.

Routine.
Shore based centers can become partners to provide routine operations and free ship-based personnel for challenging assignments.

Non-classical shipowners enter the fray

Already today's tests show that interest in autonomous shipping is particularly large from non-classical shipowners. Component manufacturers in particular in conjunction with data aggregators and **data-owners** may see opportunities and possibilities and could thus outmaneuver classical shipping companies which may be seen as producers and providers of such data (GMF 2018). Joint ownership of new types of partners, technical operation and separate ownership structures of different parts of ships are possible. Service and leasing of various high-tech components may again re-define important roles on and around ships. As demonstrated by the Yara Birkeland tests, where a global agricultural firm is the party which has commissioned and is running the project, there is a potential that the push into automation will take on the character of those leading the charge. This could lead to a scenario where the introduction of technology into the shipping industry is dictated by manufacturers and cargo owners. These new and returning players may initially overlook the needs and concerns of certain groups of interested stakeholders who will be directly affected by automation

Data-owners.
Owners of ship specific data may be in a key position to be the future ship-owners.

- such as seafarers. Their natural focus may not be on the human involvement in routine operations of technical assets. When focusing on the impact of automated ships on seafarers it is important to consider a paradigm shift triggered by new asset holders. They may bring an entirely new perspective into the equation between technical assets and human operation, away from routine tasks and towards high level problem solving and mastering of unusually complex situations.

Embracing change means redefining the "seafarer"

Disregarding the traditional role of seafarers with a disruptive approach is easy for start-ups and newcomers. If companies with a legacy of seafarers in well-established roles consider a disruptive approach, they will have to redefine roles, communicate, train and re-train their employees. They will also have to carefully compare the commercial viability of technically disruptive projects.

For those wishing to foster and encourage the use of automation in the industry, an area to address is the fears of stakeholders and long held attitudes which mistrust technological change and the claims of those who espouse its benefits. A prime example of this is The Nautilus Telegraph, which in its February 2018 issue, reported on the feedback that it had received when it launched a survey and study with over 1,000 members from 21 unions within the Nautilus Federation. The majority of feedback suggested that automation was seen a threat to maritime professional's jobs and that unmanned/ remotely controlled vessels presented a safety threat at sea (Hand 2018) (Nautilus 2018). The study argued that the rush by manufacturers and maritime nations into investing capital and time into researching autonomous systems and digitalization for ships has meant that so far important social and hu-

In coastal shipping and harbour operations remote controlled ships become a common sight.

Photo: Rolls-Royce plc

man issues such as skills are being neglected. The article ended by calling for work to be carried out to examine ways in which maritime skills can be protected and enhanced by new technology. (Linington 2018)

No reason for fear of job losses

The attitude of Transport Unions was further reflected at MSC 99 with the International Transport Federation (ITF) in joint effort with the International Federation of Shipmasters' Associations (IFSMA) publishing Paper 99/5/1. This paper took a very dim view on autonomy as most readily shown by proposal 8 from the document. It called "To protect the **safety** of shipping and the marine environment from the risk of unregulated activities, as well as risk of collision between conventional ships and remotely controlled or unmanned ships, affirmatively establish by circular, or other means, that remotely controlled or unmanned ships are not in compliance with existing international regulations, and not permitted to operate on international voyages until an international regulatory framework governing their operation has been adopted and is in effect." (ITF/IFSMA 2018) This proposal was violently opposed by the majority of delegates present but has shown the combative approach that the unions may be heading towards in regards to autonomy.

Safety.
Most accidents have human causes. But autonomous ships are not automatically safer.

In the same study, more than 80% of seafarers voiced their anxiety about possible job losses with the advent of automation. This view shows that automation is very likely to face opposition from seafarers and their unions who believe if introduced in a manner which focuses primarily on the rush to be first and cost cutting for the sake of cost cutting that it will affect livelihoods and safety, if changes are not communicated properly. This view also helps feed into another challenge that automation will face, gaining public acceptance, which will help influence the decisions made by lawmakers and regulators when considering creating and amending regulations which will shape how autonomy will be implemented into international deep-sea shipping.

The Nautilus study however admitted that many (about two thirds) of its respondents consider that new technologies could improve safety and working conditions by reducing workloads, easing administrative burdens, improving predictive and preventive maintenance, and providing improved standards of information to officers. A view mirrored by other maritime experts, especially because "new technology has rarely been used" to address the workload of the crew, "more often it is merely adding to the problem". (KNect365 2018)

Trained seafarers can become smarter with remote support

With support for a more 'hybrid' approach to operations in which 'smart' systems work in a supporting capacity alongside trained seafarers who remain in control (Dickinson 2018) a future hybrid and upskilled role for seafarers is emerging.

Global regulation.
A tight network of accepted regulations can help to avoid irrational redundancies.

The tight **global regulation** for shipping, its network of control and widespread acceptance suggests that shipping should be able to avoid irrational mistakes of the past such as when firemen accompanied diesel locomotives still decades after steam engines had been abandoned (UPI 1985), (Reynolds and Schansberg 1991).

This paper aims to factually consider the human factor by avoiding gut-feeling and focusing on analysis. Thus, it focuses on the impact of automation on the labor-market for seafarers utilizing scenarios and estimating the upskilling needed for the human factor.

Experienced seafarers will be needed in more shore-based job formats than ever before. Successful careers will be based on seatime.

Photo: ismotionprem – stock.adobe.com

5. Scenario Analysis: Seafarer Job Market

The essential question for seafarers, shipowners and crew managers is if the need for qualified seafarers will decline. It is important to understand which qualifications will be needed. The job market looks bright, but training is crucial.

As a starting point, it is essential to look at the total number of oceangoing commercial vessels in operation globally (see figure 1).

The graph illustrates that in little more than two decades the absolute number of ships has increased by more than 80%. The obvious correlation with world GDP, world trade and maritime trade in general has been investigated for some specific markets like containerships. The following graph relates fleet growth and seaborne trade (see figure 2).

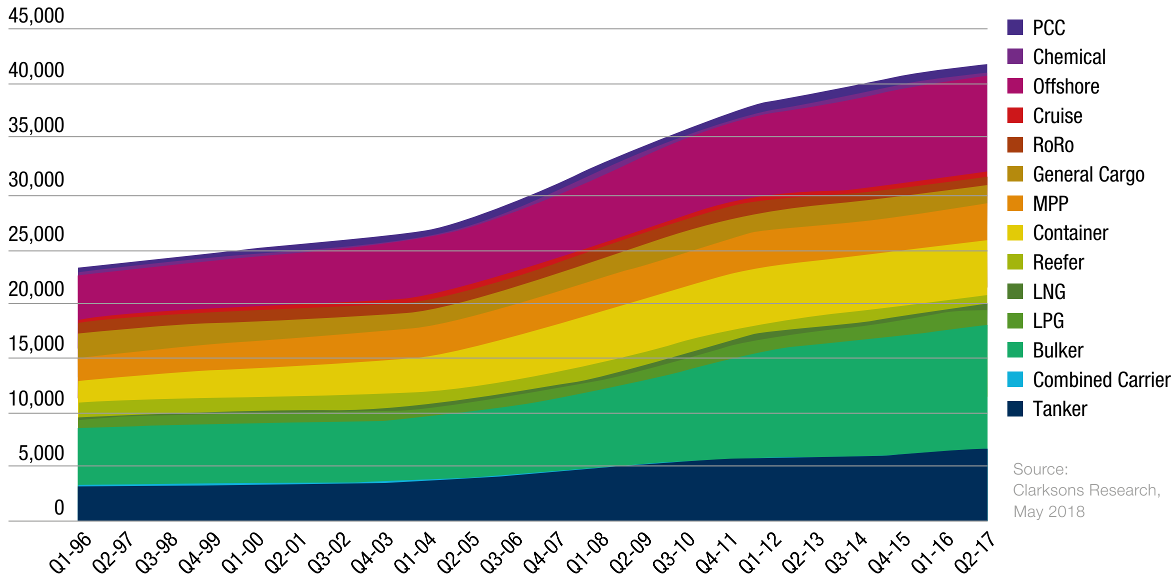
The almost perfect correlation is remarkable as the growth per ship is often thought to be of significant influence. As seaborne trade is predicted to grow year-on-year until 2021 by almost 4 percent, it is safe to assume that the trend shown will continue.

Correlating compound annual growth rates of world GDP (setting 1995 as an indexed 100) shows the expected effect of vessel growth graphically stronger (see figure 3).

However, the main result is a very strong correlation between main economic trends and fleet growth in absolute numbers.

The next important data set is the number of seafarers that the growing fleet will demand and the supply of seafarers in the past and future. The ICS/BIMCO

Figure 1: Number of ships worldwide (> 500 gt, oceangoing)



Source: Clarksons Research, May 2018

ICS/BIMCO.
Two global shipping associations provide the most authoritative data on employment on board ships.

Manpower Report provides the most authoritative data in the domain and has been undertaken since 1990. The latest edition of the five-year study was published in 2016 (**ICS/BIMCO** 2016).

According to the report, the forecast growth in the world merchant fleet over the next ten years, and its anticipated demand for seafarers, will likely continue the trend of an overall shortage in the supply of officers. This is despite improved recruitment and training levels and reductions in officer wastage rates over the past five years. The report predicts a shortage of 147.500 officers in 2025, which is more than 18% of the global demand for officers on ships.

The figures from the report show clearly that those seafarers with higher qualifications will move into a very comfortable labour market situation where demand will strongly outstrip supply.

For ratings the situation is less clear as in 2015 there were indications of at least a balanced market if not the possibility of an oversupply of ratings on the global scale (see figure 4).

Officers have a high job security

The underlying analysis of ICS/BIMCO proposes that the demand for officers will increase by around 10 percent every five years, while the supply remains relatively stagnant. Envisaging an almost 20 percent undersupply of officers is objectively no reason to worry about job security.

As described, even more optimistic scenarios suggest only a small number of hybrid, remote controlled or automated ships in the next few years. Realistically, automated or semi-automated ships will be rather small, operate firstly in tightly controlled waters close to shores and often be supported by remote control.

Even if in a most optimistic scenario by 2020 (in only two years' time) some 100 ships will be operated autonomously, this has no effect on the job market.

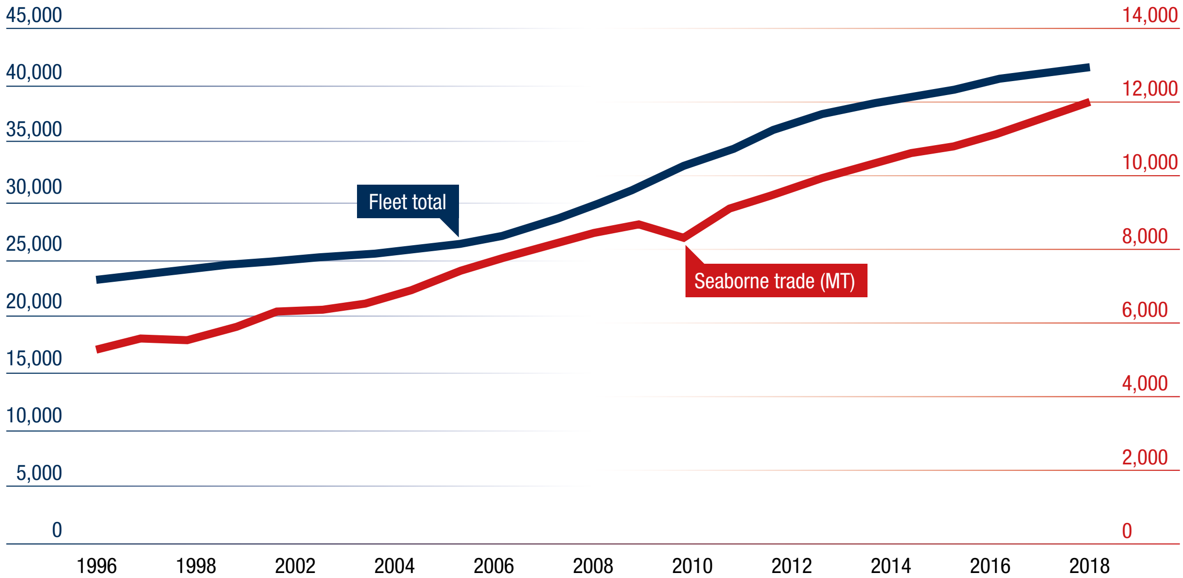


Figure 2: Despite ever larger ships the trend of the increasing global fleet is unbroken.

Source: Clarksons Research, May 2018

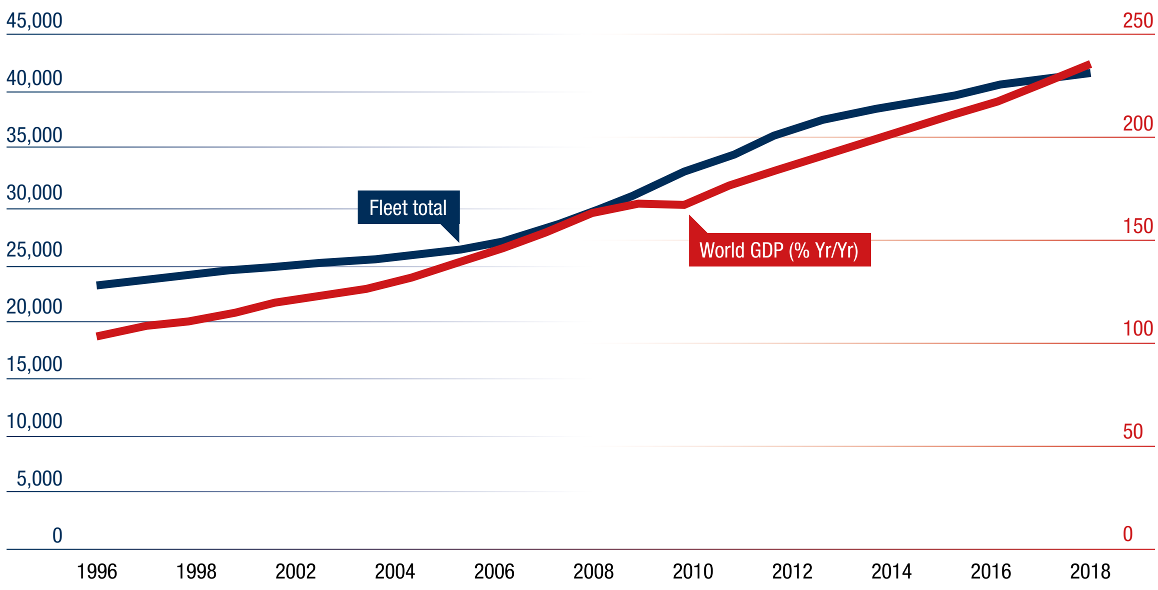


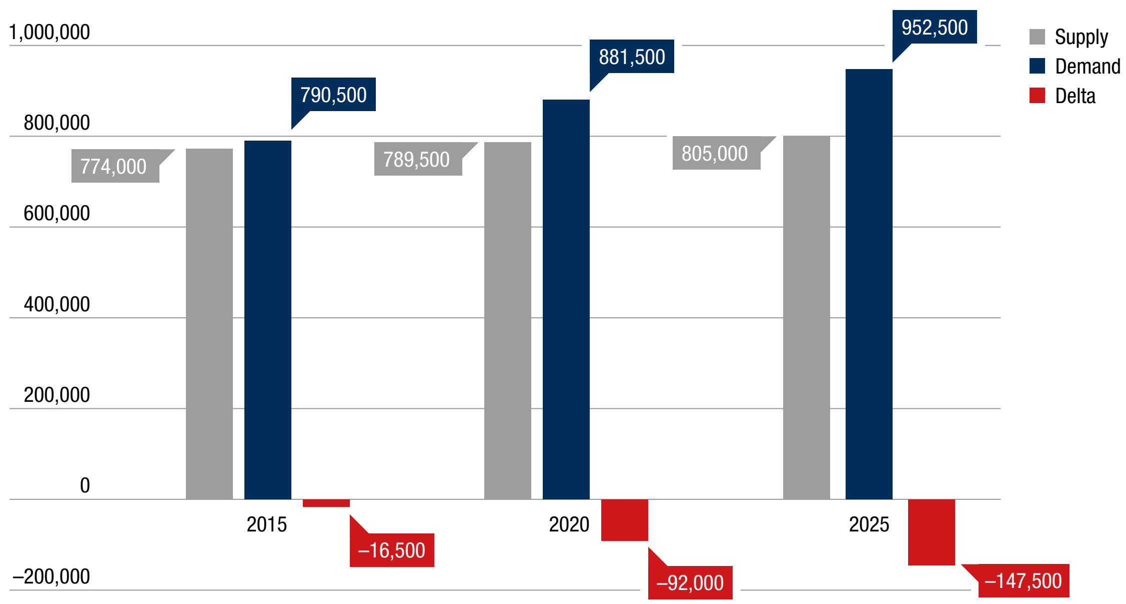
Figure 3: The world fleet develops in close correlation with the continously increasing world GDP.

Source: Clarksons Research, May 2018

If by 2025 very optimistically some 1000 ships will be fully autonomous and some further 2000 vessels semi-autonomous, this may possibly reduce demand for seafarers by 30.000 – 50.000. However, at the same time the need for highly skilled remote-operators, pilots of a new kind and riding gangs will be needed to keep ships operational.

As Kevin Tester put it: "Autonomous ships are more likely to alter jobs rather than eliminate them and […] this, combined with the creation of new types of jobs, will lead to greater prosperity in the long run." (Tester 2017)

Figure 4: ICS/BIMCO forecast a large shortfall of seafarers in the coming decade.



Source: ICS/BIMCO Manpower Report 2015

6. Regulatory and Legal Environment

There is little disagreement that digitalization will unlock opportunities or bring even disruptive change to the maritime industry based on technical developments around ships as assets and through the enhanced interconnectivity of "things".

Before any of the developments can leave sheltered testing grounds the maritime community needs to define a reliable regulatory environment (Lakeman 2017). This is not least important in order to allow assets to be insured. The government of Canada has asked the IMO Legal Committee to undertake a similar exercise (IMO 2018). This exercise is supported by a submission to MSC by ICS (ICS 2018).

Regulators need to define equivalency between human driven action and machine-driven action. There are clear similarities with legal discussions on road transport, only that the maritime world needs to be regulated globally through IMO[3] (Veal, Unmanned Ships on the IMO Work Agenda. 2017). Only national pilot projects may need additional flexibility.

It also appears that automation of road transport is being carried out with far greater optimism despite the looming potential for job losses. The US Department of Transportation defines its work in an investigation on automatic driving in road transpiration: "Save lives, prevent injuries, and reduce economic costs due to road traffic crashes, through education, research, safety standards, and enforcement activity." (Transportation 2017)

Boundaries of the crew will blur

Besides the obvious technically driven repercussions, the regulatory environment also needs to envisage conventions like STCW and MLC, 2006. Particular thought needs to be given to essential notions like the "seafarer" if borders between shore-driven and board-driven vessels blur (Veal and Tsimplis, The integration of unmanned ships into the lex maritima 2017).

CMI.
International maritime lawyers and the IMO investigate the legal framework around autonomous ships.

The Comité International Maritime (**CMI**) has investigated with its national affiliates the current regulatory environment for unmanned autonomous ships and provided an information paper to the 99th session of the Maritime Safety Committee of the IMO (CMI 2018). The legal overview delves into questions of what constitutes a ship, the possibility of a Master who is not onboard, and the constitution of the crew. Can anyone who is thoroughly involved in the operation of the ship (through remote controls) become permanently or temporarily part of the crew?

Central to several questions is the idea of "manning" as enshrined in a variety of maritime conventions and contemporary applications. Additionally, manning levels, responsibilities of the master and human presence on board will have effects on the existing insurance regimes and application of regulatory frameworks like Hague and Hague-Visby Rules (Carey 2017).

Numerous law associations have hinted at a possible openness in the regulatory environment, cautioning that the "unmanned ship must be at least as safe as ships operated by a qualified crew" (CMI 2018, p. 8). Whilst this is a valid caution, it may

[3] Law Firm Ramboll Core has been tasked by Danish DMA with the scoping exercise. A preliminary overview in: (Core 2017).

be too early to assume that the current level of safety is the appropriate minimum standard.

Another IMO body, the Legal Committee, has decided at LEG 104 to undertake its own regulatory scoping exercise. The IMO has also announced that is has commissioned a secretariat taskforce which covers four committees (LEG, MSC, MEPC and FAL) to explore autonomy.

While the subject gains traction, national governments typically refer to the IMO as the entity to revise the respective rules. In this respect the German government answered a query by some Parliamentarians (Germany 2018).

Broadband communication will be essential for remote supervision in combination with cyber security.

Photo: Rolls-Royce plc

7. Seafarer Welfare (Physical and Mental)

An area which is currently getting limited attention due to the newness of automation in shipping is the effect it may have on seafarer welfare, both physical and mental.

The idea that autonomy will lead to an increase in safety and cut down on accidents at sea, potentially saving lives is one of the main arguments for autonomy in ships but there is concern from seafarers that the mental impact of health is not being addressed.

There are concerns that as the number of people on board the vessel decreases, their functions are taken by machines, and the physical demands decrease, mental demands will increase. This will result in less social interactions between those remaining, leading to issues like loneliness (Adamson and et.al. 2018) and potentially depression.

Additionally, there are concerns that this continued increase in technology has led to a decrease in manning, which has the potential of affecting minimum safe manning levels (Grey 2018). However, any adaption of manning levels would be carefully filtered through international bodies and closely monitored by a variety of stakeholders. Work and rest hours would continue to be ruled by MLC, 2006, national legislation and collective bargaining agreements.

Many seafarers from developing countries may find it difficult to get work ashore in their home countries. Ratings rely on the remuneration they receive to support both their immediate and also extended families and therefore are extremely concerned that their jobs may disappear with automation. Many ratings join the profession following in the footsteps of their parents and grandparents and are therefore concerned that this career path may not become available for their offspring in the future. It is extremely important to reassure them that there will still be work available on board which their future family members can apply for but they need to be mindful that the type of work available may differ to that which they do today.

8. Lessons from Other Industries

A large body of research is occupied with the future of work in the digital context. The inherent debate focuses on the amount of work that remains for humans, its difficulty and its distribution.

A paper from the University of Oxford has shaped the recent debate with a strong argument that automation will result in less work (Frey and Osborne 2017). Others argue that automation may even result in more work (Nedelkoska and Quintini 2018).

Seafarers offer their skills to a global market. They are used to competition across borders as there exists a globally defined skill level. The regulatory framework is given by international conventions such as STCW and MLC, 2006. Studies by Cameron (Cameron 1987) and Rodrik (Rodrik 1999) have established that people are more inclined to compete in open markets if they can fall back into some safety net.

This can consist of a national safety net with unemployment benefits such as some European states provide. It can also consist of a comparatively high skill set which offers job opportunities outside the original industry. The latter would apply for many seafarers from so-called labor supply countries such as the Philippines, Myanmar, India, Ukraine and China.

Automation creates new but different jobs

Ample experience has been gathered, analyzed and interpreted from historical antecedents when automation and machine autonomy has entered entire industries. Well-documented are the large-scale job losses in car manufacturing which could be replaced with new and higher skilled jobs. However, often new job opportunities did not go to people who had previously lost jobs.

In Germany, where in 2018 some 1,7m people work in the automobile industry, this figure has remained stable with an increasing trend during the last four decades. At the same time, large scale automation and robotic production have been introduced since the first production robots in 1972 (Fersen 1986). The public debate and the discourse between the social partners often used the “**unmanned factory**” as the metaphor for significant job losses. As similar statistics show for other car-producing countries, the ascent of automation did not destroy jobs but shifted them.

A report from Ficci-Nascom and EY estimates, that in the booming Indian automotive sector 14.3m jobs will be available in 2022 (Ficci-Nascom, EY 2017). However, 60-65% of these jobs will require entirely new skill sets as compared to 2017, underlining the historical findings. Another study (MHP Management, Hochschule Reutlingen 2017) comes to similar results, estimating that by 2030 some 46% of jobs (in 2017) in the automobile industry will be eliminated.

Equally, office workers around the world seemed at the brink of extinction, when computers were introduced on a large scale in the 1980s. However, this trend of “dematerialisation” did not happen in the form envisaged. Computers have rather become a window to the internet and enabled – among others – a paradigm shift towards the networked economy.

Unmanned factories.
In the automotion industry jobs have not been destroyed but shifted.

Creative and social skills in demand

About a quarter of all current job profiles and almost half of all jobs across all industries were acutely in danger, detected Frey and Osborne in 2013 (Carl Benedikt Frey 2013). They focused especially on progress of artificial intelligence in a wide range of non-routine cognitive tasks and conclude: “Our model predicts that most workers in transportation and logistics occupations, together with the bulk of office and administrative support workers, and labour in production occupations, are at risk.” At the same time, they also see new jobs emerging, but with a strong bias towards the extreme ends of the qualification ladder, more high-skilled and more low-skilled jobs, concluding: “For workers to win the race, however, they will have to acquire creative and social skills.” (Carl Benedikt Frey 2013, 45).

Guy Ryder, head of the International Labour Organization (**ILO**) in Geneva is optimistic about the balance of jobs gained and lost when he draws a historical lesson from automation: ***“… we know that after a period of turbulence and adjustment we actually came out better off than we started – more jobs, better quality jobs, higher standards of living.”*** (Ryder 2018)

ILO.
The International Labour Organization expects turbulence but eventually more and better jobs.

Photo: ©heatray - stock.adobe.com

Communication will be one of the most important competences for any future seafarer in a technology driven ship operation.

9. Consequences for Employers and Seafarers

Digital change for seafarers will not be a zero/one alternative. Current trends and developments indicate towards a gradual shift. Additional automation will not be disruptive but a further development on a continuum as experienced for decades.

Crews on board may shrink, few vessels will be entirely autonomous in the next decade or two. With an overall increase of the world fleet, at least the number of officers on board will remain stable. At the same time the number of "crew" on shore in supporting functions will increase, possibly significantly.

This leaves valuable time to adapt training patterns and re-train experienced seafarers with digital competencies. Boston Consulting Group (BCG) has developed a framework for shipping companies to embrace digitalization. They underline the need to implement and publicize "a strong digital foundation across the organization … to attract the right digital talent in shipping to help keep the business growing and running more effectively." (BCG 2018)

Though the main aim of the BCG-study is on digitalization of the land organization, it hints that the seagoing talent-pool will be crucial for a successful digitalized shipping company. Only one part will be the pure technical transformation with automation as one ingredient. The other part will be profound change-management through communication.

A portion of this communication may occur in formal labour relations, the major part will have to take place inside each company. A broad survey of IMarEST within the industry shows that currently only 15% believe that crews are prepared for "smart shipping", especially autonomous elements (Tester 2017). Part of this is clearly a knowledge and training gap, part is perception.

Business models.

Introduction of autonomous ships will depend on viable business models.

Automation can reduce occupational risks

Automation has the potential to increase safety for crews and passengers further and safeguard the environment. Shipping bears occupational risks due to the particular nature of work on board. Even though these occupational risks have been closely observed and successfully dealt with in order to reduce accidents: it can be assumed that less crew on board will put fewer lives at risk.

Technical implementation and integration of digital technology and its legal framework appear today as technicalities of different and complex degrees that will be solved rather sooner than later.

Commercial implementation will depend on the viability of **business models** based on more technology and less involvement of persons on board.

Digital transformation.

Digitilization towards autonomous ships will be a seemless process.

Dealing with the "human element" on board, this paper reveals some first answers to the initial questions:

1. **Digital transformation** will be a seamless process rather than a disruptive one.
2. There will be no shortage of jobs for seafarers in the foreseeable future.
3. There will be considerable additional jobs ashore.
4. There will be significant training needs.

However, the following questions will be at the core of future discussions:

1. What work needs to be done on board?
2. What work can be done remotely?
3. Where should larger amounts of data be assembled, ashore or onboard?
4. Which work requires permanent staff on board?
5. Which work can be achieved by riding gangs?
6. What will be the differences between ship types and trades (i.e. Shortsea, Deepsea, Harbour Operations, Ferry, Cruise).
7. Is today's staff suitable for new electronic and data-driven tasks on board?
8. How can staff be trained to obtain new skills?
9. Will the existing mindset/culture within the industry have to be confronted and changed?
10. Will existing skills be able to be passed on to a new generation to avoid skill erosion?
11. Will compulsory sea time still be relevant for operators?
12. How much increased awareness will crew have to have in regard to cyber security?
13. What are repercussions for CBAs and labor relations in general?
14. Will pay scales and pay logic have to be redefined?
15. What safeguards should be considered for seafarer welfare?
16. What will be the impact on seafarers' mental health if crew numbers fall?
17. Will Safe Manning Levels as set out by SOLAS and the MLC be affected?
18. To what level of autonomy is actually required/ needed by the end users (shipping companies)?

Photo: Handelskammer Hamburg/Daniel Sumesgutner

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HSBA HAMBURG SCHOOL OF
BUSINESS ADMINISTRATION

Adolphsplatz 1 | D-20457 Hamburg |

+49 40 36138-700 +49 40 36138-751 info@hsba.de www.hsba.de