European Maritime Safety Agency

EUROPEAN MARITIME SAFETY REPORT 2022

EMSA

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EMSA

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Commissioner's Welcome

It is my pleasure to present this first edition of the European Maritime Safety Report (EMSAFE), published by the European Maritime Safety Agency (EMSA). Even more so as it coincides with the 20th anniversary of the Regulation that led to the creation of EMSA.

We created EMSA to ensure high, uniform and effective maritime safety. Today the Agency has become invaluable – from its advice and technical expertise to training activities and operational services.

I cannot over-emphasise the importance of maritime transport for the EU economy. It ensures we have food, energy and commodities. It also carries the lion's share of European imports, and our exports to the rest of the world. Ever since the Minoans of Crete first shipped copper to Egypt, maritime transport has been a catalyst for economic development and prosperity in Europe. But these gains must never come at the expense of safety. This is why we are constantly improving safety legislation and promoting high-quality standards. We want to eliminate sub-standard shipping, reduce the risk of serious maritime accidents and minimise the environmental impact of maritime transport on our marine and coastal areas.

Since the turn of this millennium, and thanks to hard work by many, maritime safety has improved. Oil spills are just one example: we have seen no significant accidents for 20 years now. Fatalities and serious incidents are also thankfully rare. However, a single maritime accident can have a catastrophic impact, and there is certainly no room for complacency.

The level playing field between Member States, made possible by EU-led, uniform implementation and enforcement of international conventions and rules on flag, port and coastal State responsibilities and obligations, have further boosted safety. So too have newer, better-built vessels, digitalisation and automation, and a more robust regulatory and enforcement environment.

Adina Vălean
EU Commissioner
for Transport

Global shipping is undergoing a transformation on many fronts. Digitalisation, automation, sustainability and resilience in times of crisis are both challenges and opportunities. They are also challenging traditional thinking and methods.

While environmental concerns attract a lot of attention, safety will always be a top priority. And there is certainly no contradiction between maritime safety and environmental protection. At their most basic level, sustainability and safety are about the same thing: reducing the risk of damage. We must and will continue to work on both, and proactively. We simply cannot wait for accidents to happen and then respond.

The EMSAFE report provides a factual overview and analysis covering a broad range of maritime safety topics, from maritime transport to fishing vessel safety. As the Agency acts as a repository of knowledge and data, the report brings together information from the various databases that EMSA hosts. The result is an interesting assessment of the current safety situation.

I hope that the report will help to increase understanding of the safety-related challenges and opportunities facing the maritime sector, through its overview of EU and international standards and rules, and its in-depth analysis of key technical areas and progress to date. It is only by understanding the current situation and what we have done to get here that we can avoid repeating the mistakes of the past.

Foreword

It is my great pleasure to present the first edition of the European Maritime Safety Report (EMSAFE); the first report of its kind, and one which reflects the paramount importance of safety to the maritime transport sector here in the EU and worldwide. Safety is quite simply the indispensable factor in shipping. It is the element without which nothing else works and on which everything depends.

For this reason, EMSAFE is a crucial document. Developed here at EMSA in close collaboration with the European Commission, Member States, and industry stakeholders, it also benefited from an open, transparent, and inclusive public consultation process, which encompassed a wide range of maritime organisations and bodies from across the activity spectrum of the sector, including shipping companies, classification societies, trade unions, insurers, the cruise industry, researchers, and developers. These contributions are testament to the vital nature of safety in every aspect of the maritime world and the commitment of all to ensuring the highest standards.

EMSAFE clearly shows the impact of the collective body of international maritime safety legislation across the entire maritime transport environment here in our European Union. The implementation of this legislation, thanks to the efforts of all stakeholders involved – from Member States to industry – has borne, and continues to bear, fruit. The development and implementation of rigorous safety standards, an efficient and effective Port State Control system, and the assessment regime for Recognised Organisations, are just three examples of how the framework of EU legislation has made a real and lasting difference to maritime safety as a whole in European waters and beyond, as well as delivering value for industry, EU citizens, and the marine environment by promoting quality shipping.

Maja Markovčić Kostelac
EMSA Executive Director

EMSA is a core part of this framework; we were founded twenty years ago as a support to the European Commission and Member States, and since then, our tasks and responsibilities have evolved and grown. As the legislators intended, we have made a significant contribution to safer seas in Europe, and in the future, we will continue to do so.

There are more safety challenges ahead, as EMSAFE makes clear, and more work for us both now and in the future. Passenger ship safety is firmly in our focus, as is fishing vessel safety, and we look ahead to three forthcoming important legislative revisions; those of the Port State, Flag State, and Accident Investigation Directives.

EMSA is committed to full supporting all stakeholders as they address pressing future issues, and devise solutions to sustain the maritime sector in the future. This also includes emerging safety challenges, like those associated with alternative fuels and autonomous shipping. EMSAFE is intended to be a recurrent publication; tracking developments in maritime safety as they happen, identifying gaps, and pointing towards viable solutions as shipping sails forward into the future.

Acknowledgements

The European Maritime Safety Report (EMSAFE) was prepared by the European Maritime Safety Agency (EMSA). Its development was coordinated internally by a Task Force made up of staff from all departments of the Agency.

The Task Force gratefully acknowledges the input from several maritime stakeholders, especially the European Commission (EC), the Member State Administrations, the European Community Shipowners' Association (ECSA), the International Association of Classification Societies (IACS), the European Transport Workers' Federation (ETF), SEA Europe, INTERTANKO, the Waterborne Technology Platform, the Cruise Lines International Association (CLIA) and the International Union of Marine Insurance (IUMI) whose comments were particularly helpful during the development and consultation phase.

Executive Summary

The European Maritime Safety Report (EMSAFE) has been prepared to give the first factual analysis of the maritime safety landscape in the European Union (EU). This first edition of the report, prepared by the European Maritime Safety Agency (EMSA), provides a comprehensive and factual overview of a wide range of maritime safety topics, as well as an in-depth analysis of specific technical areas.

Overall, it can be concluded that the EU has developed a robust maritime safety system. However, many challenges lie ahead of us. One thing is certain – lessening our safety efforts cannot be an option. On the contrary, to avoid a return to the era of sub-standard shipping which manifested itself in accidents like that of the Erika, or the Prestige, the EU should continue investing in and reinforcing its maritime safety framework. The strong safety framework constructed over the past two decades by the maritime community, national administrations, shipowners, shipyards, equipment manufacturers, recognised organisations, and port state control functions, among others, is a legacy that should never be lost. EMSA, in the year of its 20th anniversary, is proud to have contributed to this effort, and is committed to continue to provide full support to the EU maritime community, now and in the future.

The EU Member State fleet

The size of the EU Member State fleet is an important indicator of its relevance within the global maritime transport sector; its distribution per ship type helps to focus safety efforts on specific areas of concern. Passenger ships currently make up 19% of the fleet; they represent the highest proportion of all ship types within the sea-going fleet (excluding fishing vessels), of which 45% are RoPax. Their average age is approximately 28 years, the oldest of all major ship categories.

The EU Member State fleet represents around 18% of global tonnage (GT), which in itself encompasses over half of all RoPax and high-speed craft (HSC) in the world by GT. Both of these ship types have been accorded dedicated instruments in the EU legislative acquis, recognising both their specific characteristics and their role in transporting millions of passengers every year through EU waters.

The growth of the EU fleet, both in number of ships and in tonnage, is lower than that of the global fleet. For example, an overall increase of 3.4% has been observed in the number of ships registered to EU Member State flags in the last 5 years, showing a slower increase than that of the world fleet, which grew by 7%.

EU Shipbuilding and marine equipment manufacturing

In 2020, 8% of all new build activity in the world, based on the number of ships, was generated by shipbuilding industry in Europe, corresponding to 3% of the worldwide gross tonnage built in that year. Almost half of this figure is related to the construction of cruise ships. With Asian countries entering the cruise shipbuilding market, the future of EU shipyards, and the associated economic activity that they support, is in doubt.

Contrary to this, the European marine equipment industry is a world leader in a wide range of products, with a global market share of 35%. However, these EU manufacturers could be affected by decreasing shipbuilding activity in the EU.

Maritime traffic and safety

The EU's waters are among the busiest in the world, something that has a direct impact on maritime safety, with more than 680,000 calls to EU ports in 2020. Nearly a quarter of all ships that visited EU ports over the past five years were flagged to non-EU Member States, almost all (92%) registered to countries under the Paris MoU white list, i.e., with good safety records. During that period, only 5% of non-EU Member State-flagged ships visiting ports here were registered to countries with some safety issues (listed in the Paris MoU grey list) and only 3% were registered to countries with more significant safety issues (listed in the Paris MoU black list). The top three non-EU Member State-flagged ships visiting EU ports came from Panama, Antigua & Barbuda, and Liberia.

The interchange of information is essential for safety. The main challenges here include the reduction of the number of mis-declared hazardous materials (hazmat) cargoes and the operationalisation of a true European Maritime Single Window to increase the data quality, facilitate cooperation, and reduce administrative burdens.

Seafarers and safety

Qualified seafarers are essential to ensuring the safety of ship operations and are vital for the future of the maritime sector. There are currently approximately 330,000 masters and officers holding certificates of competency that allow them to serve onboard EU MS flagged ships, close to 40% of them from non-EU countries. However, the age profile of seafarers is increasing, and recruitment and retention of those who work on board ships remains a challenge for the future.

The seafaring profession is one of the toughest in the world, and the contribution of sailors to the global economy should not be underestimated, especially in crisis situations like that of COVID-19, which also demonstrated the vulnerability of their conditions. Long days at sea, often in bad weather conditions, together with intense activity in port, contribute to physical and mental fatigue. Port state control (PSC) inspections show that around 25% of all deficiencies found are related to the human element, most of them within MLC Title 4 which deals with healthcare, safety protection and accident prevention among seafarers. In addition, increased automation on ships is bringing new challenges to the profession.

Ship safety standards

The cycle of proposing, discussing, approving, and implementing new safety requirements is a complex and lengthy process. For example, the issue of fire on RoPax vessels was first highlighted in 2015 after the Norman Atlantic disaster, in which 11 people lost their lives. The new standards developed to tackle this problem are only likely to become mandatory in 2026.

In most cases, the upgraded standards are not applied retroactively, due to their disproportionate economic and technical impact, meaning that safety changes can take decades to impact on the fleet. A good example is the damage stability requirements for passenger ships. An analysis of the EU Member State-flagged fleet shows that almost 40% of the passenger ships currently in operation were built before 1990. Since then, the damage stability requirements have been significantly upgraded three times.

Fire safety on RoPax, the carriage of alternative fuelled vehicles on ships, the interface between the ro-ro industry and road transport, the lack of harmonisation of fire safety standards for materials other than steel, small passenger ships, fires on containerships, the increase of automation, and the general adoption of the e-tag for marine equipment are some of the challenges that will be faced in the near future.

Fishing vessels

There are close to 75,000 fishing vessels registered in the EU-27. They present a high vulnerability to accidents, in that 50% of all the accidents involving fishing vessels are either very serious or serious, whereas the average for all ship categories is 27%. In addition, even though fishing vessels represent 17% of the total number of ships involved in accidents reported, the number of fishing vessels lost represents more than 55% of total number of lost vessels, a trend observed in recent years.

The international convention dealing with the safety standards of fishing vessels, the Cape Town Agreement, is not yet in force. At EU level, Directive 97/70/EC establishes minimum safety requirements for fishing vessels above 24 metres in length (3% of the fleet).

Enforcement

The implementation of maritime safety legislation in the EU is the responsibility of Member States in their capacities as flag, port, and coastal States. Notable here is the work done by all port state control (PSC) inspectors in the EU, with more than 14,000 inspections carried out each year. At least one deficiency is found in one out of every two inspections, and more than 50% of all deficiencies recorded are safety-related (falling under the International Convention for the Safety of Life at Sea (SOLAS)). Deficiencies related to fire safety are most frequently reported, regardless of ship type. For example, 39% of the SOLAS deficiencies found on RoPax ships are related to fire safety, a percentage similar to that found in the special regime inspections for RoPax and high-speed craft (HSC), where almost 40% of deficiencies found relate to fire safety.

In addition, several thousand flag inspections are carried out each year, but as there is no centralised database of this activity, it is not possible to analyse the deficiencies found.

Flag States are delegating more and more competencies, especially in the execution of statutory surveys, to recognised organisations (RO). This means that part of the knowledge and experience of EU Flag States is effectively being outsourced, which reinforces the importance of retaining centralised EU expertise. There are in total 12 recognised organisations in the EU, regularly assessed by EMSA on behalf of the Commission, out of around 100 operating globally, which should be overseen by the relevant recognising flags. The IMO audits of flag states (IMSAS) show that, with respect to the delegation of authority to RO, the most recurrent findings are related to weaknesses in the administration's oversight programme. In addition, according to a submission to the IMO from the Paris and Tokyo MoU, it can be concluded that this oversight is not carried out effectively by a number of flag states, resulting in certain instances of underperformance by organisations, with the subsequent consequence of having lower safety standards in practice.

At EU level, EMSA visits Member States on behalf of the European Commission to verify the implementation of EU maritime legislation in areas like marine equipment, the loading and unloading of bulk carriers, accident investigation, PSC, vessel traffic and monitoring systems, etc. This has resulted in more than 300 visits which are followed up with corrective measures. In addition, these visits promote the establishment and interchange of best practices.

When accidents happen

Regardless of all the mechanisms set up to prevent them, accidents still happen. Over the past five years, an average of 3,200 accidents occurred annually onboard ships. These accidents all fell under the scope of applicable EU legislation which excludes, among others, fishing vessels of less than 15 metres in length. Serious and very serious accidents represented 24.9% and 2.4%, respectively, of all accidents reported. In 2019, 71 people lost their lives and almost 1,000 people were injured in these accidents.

Therefore, it is essential to maintain an appropriate safety net to respond to accidents. Places of Refuge are one of the tools available in the EU to accommodate ships in distress. The EU Guidelines on Places of Refuge are regularly tested through table-top exercises organised by EMSA and the European Commission to ensure readiness.

Search and Rescue, under the remit of Member States, is another essential element of accident response. The extended use of new technologies, like RPAS and satellite-based Earth observation services, could support the work of the relevant authorities in this field.

Forthcoming safety challenges

Efforts to reach emission targets as part of the European Green Deal should go together with efforts to keep ships safe, especially given that the use of new fuels (LNG, hydrogen, LPG, methanol, ammonia, and biofuels) and power technologies (batteries and fuel cells) comes with associated safety risks.

Moreover, the shift to alternative fuels is not limited to maritime transport. Here in the EU, alternatively fuelled vehicles have increased in number by 29% between 2019 and 2021, meaning that both passenger and cargo ships need to prepare for the safety risks of transporting these vehicles.

In addition, autonomous ships not only offer new opportunities for industry, but also bring challenges in the regulatory field (including the need to develop a legal framework, terminology, liability, standards, among others) and the technological field (the decision systems to replace the critical decision-making of the crew in avoiding collisions, reacting to, and avoiding, bad weather conditions, cyber security, etc.). Nevertheless, the automation of ships will be gradual, with remotely controlled, highly autonomous ships sailing on the same routes and calling at the same ports as traditionally manned ships. Difficult-to-predict challenges may arise in terms of surveys, manoeuvres at sea and in port, and the qualifications of those on board, among others.

1. Overview

1.1 Introduction

This is the first edition of the European Maritime Safety Report (EMSAFE), published by the European Maritime Safety Agency (EMSA). The report provides a comprehensive and factual overview of a wide range of maritime safety topics, as well as an in-depth analysis of specific technical areas.

EMSAFE looks at the development, application and status of relevant EU and international safety standards, with the aim of promoting critical thinking and identifying possible areas for improvement. Overall, the report is intended to contribute to a greater understanding of the safety-related challenges and opportunities facing the maritime sector, by bringing together a set of key technical data related to the safety of ships and their operation in the EU.

EMSAFE combines information from all the databases hosted by EMSA, thus offering the possibility of cross-analysing data and obtaining detailed insights into the status of maritime safety in the EU.

Maritime transport accounts for more than 80% of world merchandise trade by volume [1] and plays a key role in the EU's economy [2] . In 2019, 3.587 million tons of goods[1] were loaded and unloaded at EU ports (6% more than in 2016), while in the major EU ports, 37% of all trade volume corresponded to domestic and intra-EU transport.[2] In addition, more than 418.8 million passengers embarked and disembarked passenger ships at EU ports in 2019[3], 13% more than in 2016. Both the world fleet and the EU Member States-flagged have been growing to match the global demand for maritime transport.

Fishing vessels are also a key consideration. The maritime fishing sector is a major supplier of food, responsible for almost 17% of the global population's protein intake. However, this occupation is considered to be the most hazardous in the world, according to estimates by the International Labour Organization (ILO) and the Food and Agriculture Organization (FAO). While the problem has a strong social component especially in developing countries, it may also be linked to the safety and operation of the more than four million fishing vessels that exist worldwide. At EU level, fishing vessels present the greatest vulnerability to accidents, as shown in this report.

Both fisheries and maritime transport are part of what is known as the blue economy. Both these activities make use of ocean resources for economic growth, depending in turn on the reliability of ships and the maritime transport network. In some cases, in peripheral Member States, the blue economy exceeds 5% of the national Gross Value Added (GVA). Moreover, according to the European Commission, a sustainable blue economy in the EU is essential for the achievement of the objectives of the European Green Deal. Therefore, economic activities and environmental protection must go hand-in-hand, with decarbonisation made possible through the expected uptake of alternative fuels and energy technologies [3].

Similarly, at their most basic level, sustainability and safety perform the same task: saving costs for the environment and society. As outlined in the Sustainable and Smart Mobility Strategy [4], the European Commission remains focused on enabling safe, secure, and efficient maritime transport with lower costs for businesses and administrations.

In general terms, safety is the state during which the risk of harm to persons, or damage to property, is reduced or maintained below an acceptable level [5]. While transport safety is reflected outwardly in the number and severity of the accidents that happen, for each transportation mode there is an additional set of safety performance indicators which need to be monitored and developed to allow for the identification of problems at an early stage, as well as an understanding of what can lead to safety concerns. In this sense, maritime safety deals not only with the reporting and analysis of maritime accidents but also with safety standards, ship inspections, traffic patterns, working conditions and other relevant elements which may be causally related to safety incidents.

1 Country level - gross weight of goods handled in all EU ports at https://ec.europa.eu/eurostat/databrowser

2 EU level - gross weight of goods handled in main ports, by type of traffic at https://ec.europa.eu/eurostat/databrowser

3 Passengers embarked and disembarked in all ports by direction – annual data at https://ec.europa.eu/eurostat/databrowser. It should be noted that the Eurostat data on passengers of cruise ships could have been underestimated, e.g., data on cruise passengers was not reported by 2 MS. In addition, it is worth mentioning that the Eurostat definition excludes cruise passengers who disembark and re-join the same ship before it leaves the port.

Throughout this report, the term maritime safety is used interchangeably with safety at sea, and therefore includes safety of navigation, the human element, the technological and operational safety of ships and the safety of people in distress. It also refers, unless stated otherwise, to all ships used in maritime activities of a commercial nature, including shipping, fisheries and offshore industry. Unless specified otherwise, the terms 'Europe' and 'EU Member States' refer to the 27 Member States of the European Union, plus Iceland and Norway (the EFTA[4] coastal states). The UK is not included in the data presented unless otherwise stated.

It is appropriate that this report is published on the 20th Anniversary of the Founding Regulation of the European Maritime Safety Agency. The Agency was set up by the EU to ensure a high, uniform, and effective level of maritime safety, maritime security, prevention of, and response to, pollution caused by ships and to contribute to the overall efficiency of maritime traffic and transport. In doing so, EMSA serves the EU's maritime interests for a safe, secure, green and competitive sector.

1.2 Design, registration and operation of a ship

From the moment a shipowner decides to build a ship, maritime safety becomes a key part of the equation. The type of ship and the area of its operation, whether international or domestic, oceanic, or coastal, are key elements which influence its design and the applicable safety standards. Therefore, this section provides a non-exhaustive list of examples of ship designs, as well as their main characteristics.

Just as people have nationalities, so too must ships be registered to a country. This registration, i.e., the state in which the ship will be flagged, is essential in determining the legislation that applies to it. The state behind the flag can be a member state of the International Maritime Organisation but will only be subject to the Conventions that the state has ratified. In addition, if the state forms part of a supranational or international governmental organisation, such as the European Union, it will be subject to additional legislative requirements. Should the ship be operating in a certain region, like the United States of America or the EU, there will also be specific requirements, regardless of its flag.

4 The European Free Trade Association

The legislative puzzle to which a ship is subject is associated with a complex inspection and survey system.

Nevertheless, a ship is merely a piece of metal without qualified personnel to operate it; the crew is fundamental to the running of a vessel, both operationally and from a safety perspective. The mental and physical wellbeing of crew members, so often tested by the demands of life at sea, are essential to keep on-board safety at the appropriate level. Although there have been some improvements in the working conditions for seafarers, in particular after the adoption of the Maritime Labour Convention in 2006, more work remains to be done here, as Section 2.1 of this report (the Human Element) outlines.

1.2.1 Design

The concept of a ship starts with its design, the main elements of which are determined by its intended use, which in turn will determine its typification. The areas that impact safety onboard include the ship's stability, its structural integrity, fire prevention and response, navigation, and life-saving appliances, all of which must be taken into account in the design process.

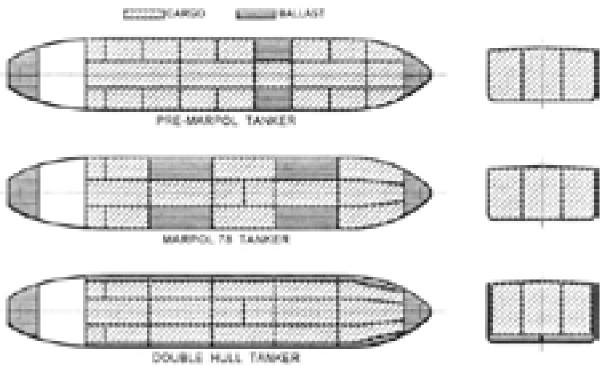
At the design stage, the naval architect will draw up plans, ship specifications and other technical documents in line with international regulations and standards. For all ship types, design features are introduced to accommodate the specific risks inherent in the ship's intended function or area of operations, some examples of which are presented in the next section.

1.2.1.1 Tankers

Tankers carry liquid cargo in bulk. The consequences of their cargo being spilled at sea or potential fires/explosions due to the low flashpoints of their cargo are two of the specific risks associated with this type of ship. Therefore, several safety requirements only apply to tankers, in terms of their fire safety or structural elements. One of these is the double hull requirement, introduced in the wake of several high-profile oil spills including the Erika in 1999 and the Prestige in 2002, both of which severely affected the EU coastline. Although the double hull had been mandatory for tankers above 5,000 DWT since 1993 through the International Convention for the Prevention of Pollution from Ships (MARPOL), the phasing out of single hull tankers was further accelerated as a consequence of these major oil spills in EU waters.

Other examples include: the introduction of inert gas systems to avoid explosions in the presence of flammable gases inside tanks; the introduction of emergency towing arrangements; and the specific International Convention for the Safety of Life at Sea (SOLAS) requirement for every oil, chemical or gas tanker of 10,000 GT and above to have back-up steering gear, to ensure control in the event of a mechanical failure. In the figure below, the evolution of tanker hull design is presented visually, following the introduction of additional safety requirements.

Figure 1: Hull design of tankers under safety requirements.



Source: Lamb T (ed) (2003), Ship design and construction. SNAME, New York (revision of the book: D'Arcangelo AM (ed) (1969) Ship design and construction. SNAME, New York)

1.2.1.2 Ro-Ro passenger ships (RoPax)

Roll-on, roll-off passenger ships (RoPax) have very distinctive design characteristics, due to the nature of their operations. Their internal and/or weather decks have no vertical subdivisions; the lack of any physical barrier allows vehicles to be loaded and unloaded from these ships in a very short space of time. In essence, these decks act very much like indoor garages, and frequently have both stern and bow doors to enable freight to be handled on a drive-through basis.

While very practical from an operational perspective, Ro-Ro decks and their openings present specific risks, among which is an increased criticality of fires and flooding. Unlike in other ship designs, there is no vertical bulkhead to limit the damage of a fire, or the effects of flooding. There are more than 1,000 ships of this type which operate regularly in EU waters and which are flagged under EU Member State flags. These ships, together with hundreds of non-EU Member State-flagged RoPax, transport hundreds of millions of passengers in the EU each year. Accordingly, these ships require and receive special attention by the relevant inspection authorities.

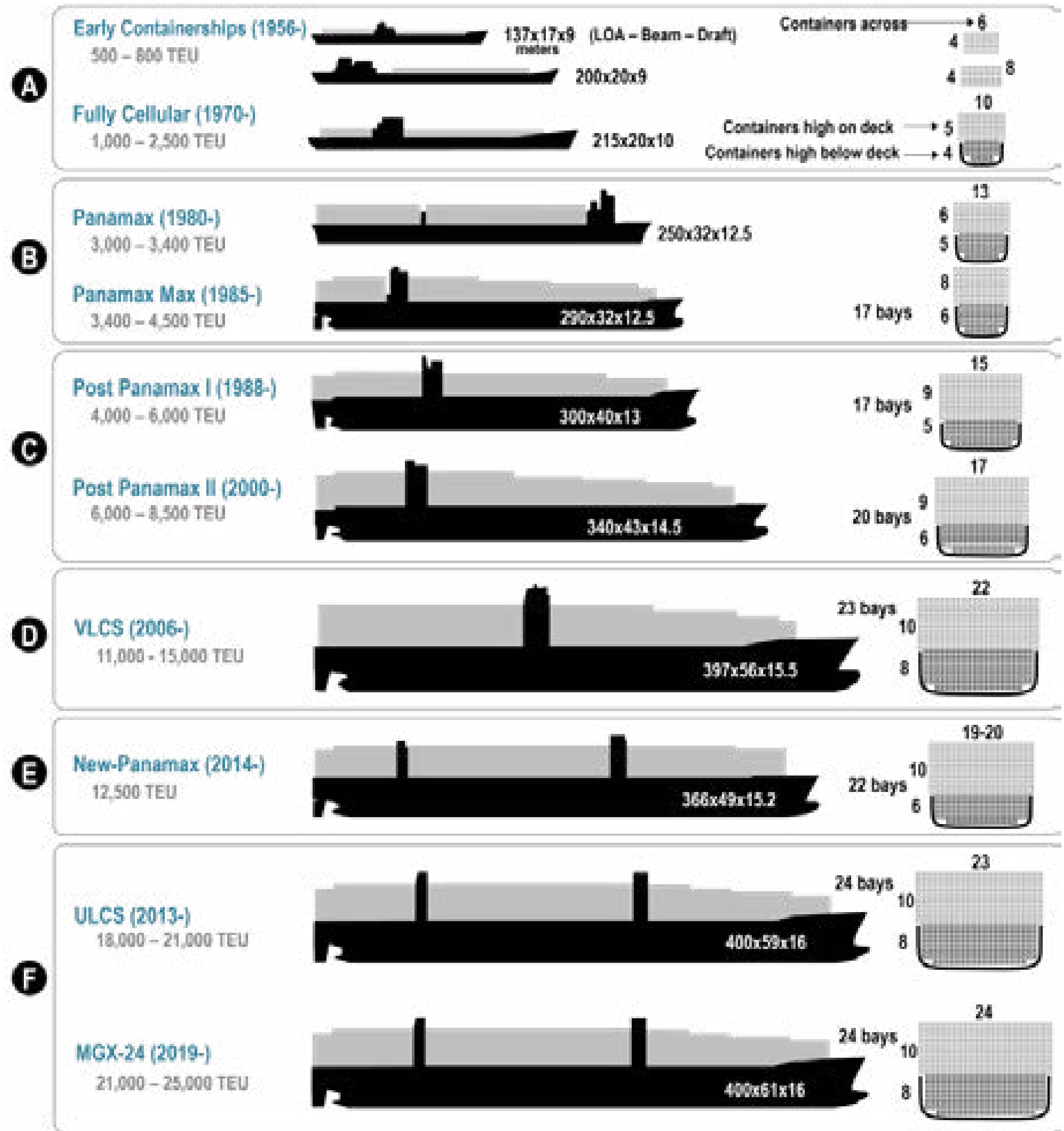
Image 1: Ro-ro passenger ship - main deck openings and superstructure.

Source: Karolis Kavolelis/Shuttterstock

1.2.1.3 Containerships

Growing transport demand has greatly influenced the size of containerships (see Figure 2, below). As their size has increased, so too have the design and safety challenges that they present; meaning that their design has had to be adapted. To comply with the forward visibility line requirement in SOLAS V/22, the superstructure has changed from a one-aft to a two-island structure. The breadth of these ships has gradually expanded, with the maximum length kept at around 400 metres. However, cargo securing procedures are still essentially manual, and, with little evolution in the last 30 years, these tasks are becoming physically more demanding. Also, the containers themselves are tightly spaced, which makes fires hard to detect, control and extinguish due to the sheer size and configuration of these ships.

Figure 2: Size evolution of containerships.



Source: J.-P. Rodrigue, "The Geography of Transport Systems", Hofstra University, Department of Global Studies & Geography, 2020. [Online]. Available: https://transportgeography.org/contents/chapter5/maritime-transportation/evolution-containerships-classes/. Any third party reproduction of this visual must be authorised by the copyright holder.

Note: All dimensions are in meters. LOA: Length overall. The loads displayed on deck represent maximal possible loads, which would involve a large share of empty containers. Containerships usually carry less containers because of weight restrictions and lack of demand.

1.2.1.4 Bulk carriers

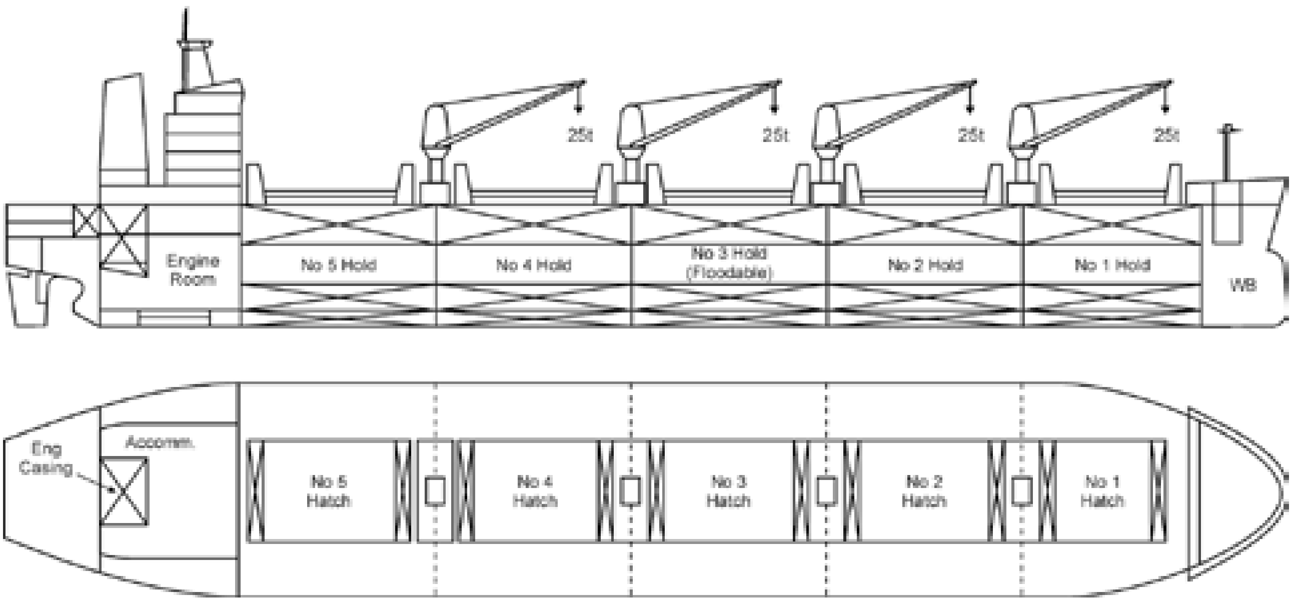
Bulk carriers also exist in a broad range of different sizes, from 10,000 DWT to over 80,000 DWT. Their evolution in terms of design has been mainly driven by the need for efficient loading and unloading. All bulk carriers have transverse bulkheads between their holds, which divide the ship into watertight compartments and provide additional transverse strength to the overall structure. The sequence involved in the loading and unloading process as well as coordination with the terminal are key concerns in avoiding potential stability and structural problems. Cargo liquefaction, whereby dry bulk cargo with a high moisture content is liquefied due to external pressures thereby creating stability problems, is one of the specific safety problems of this type of ship and is responsible for 61 deaths in the last 10 years globally [6].

1.2.2 Construction

Throughout the ship design and construction process, a chain of entities and bodies is responsible for ensuring the safety of the vessel. The ship owner's internal culture and safety management systems are critical in ensuring the safety of the vessel, while the shipyard and its personnel, who deal with everything from the ship's design and technical aspects, to production and quality management, play a vital role in ensuring the safety of the ship. Flag authorities are responsible for certifying the safety of the ships from construction, while Classification Societies verify the correct application of their own rules for classed ships from design and construction. The objective of ship classification is to verify the structural strength and integrity of essential parts of the ship's hull and its appendages, and the reliability and function of the propulsion and steering systems, power generation and those other features and auxiliary systems which have been built into the ship to maintain essential services onboard.[5] Classification societies were created in the 18th century as the only bodies which 'classified' ships according to their safety, allowing insurance fees to be assigned on this basis. It was only later, in the 19th century, that the flag state became involved in safety, following the initiative of a British Member of Parliament, Mr Samuel Plimsoll, who introduced the maximum load line of ships through the so-called Plimsoll line, which is still in use today.

The construction of ships is a broad and complex process that starts with the signing of the shipbuilding contract. It is during construction that the safety of material and equipment purchased is verified. The keel laying date, an important milestone for the applicability of safety legislation, marks the start of the construction process.

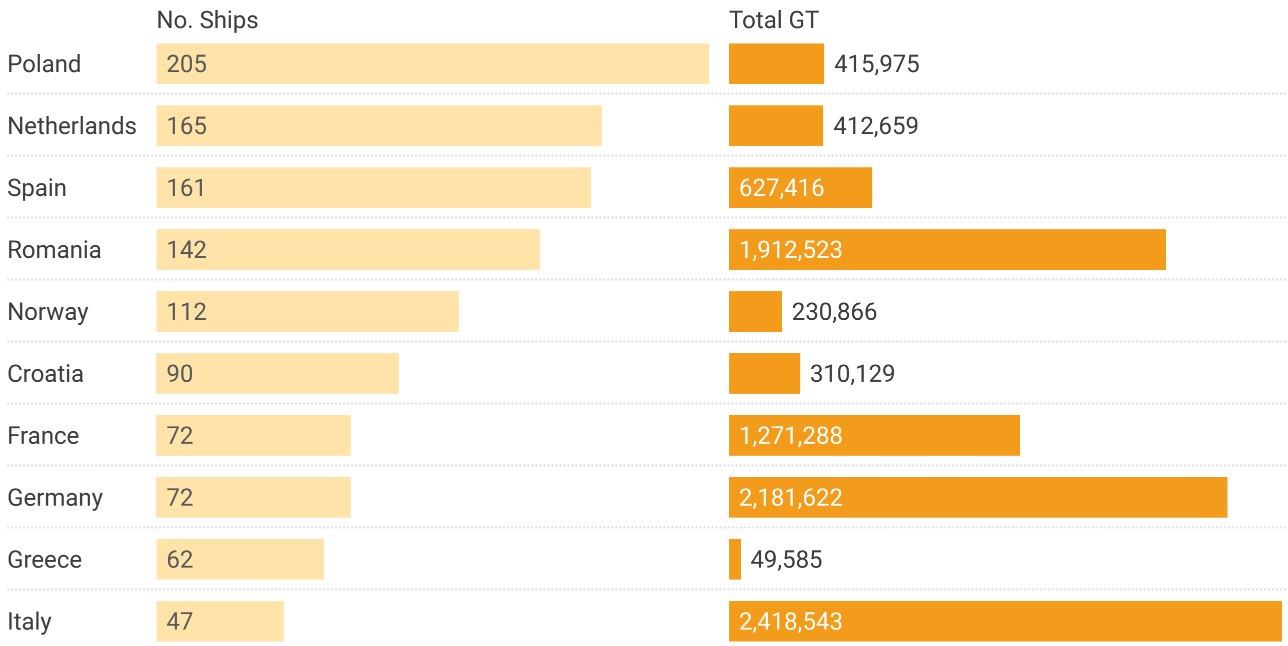
Figure 3: General arrangement of bulk carrier.



Source: Rémi Kaupp for the original drawing, Calips for clean-up, CC BY-SA 3.0

5 https://www.iacs.org.uk/media/3784/iacs-class-key-role.pdf

Figure 4: Top 10 EU countries where ships were built over the last 5 years: newbuilds per number of ships and total GT.



Source: EMSA Services

In 2020, European based shipyards were responsible for 8% of newbuild activity in the world based on the number of ships, corresponding to 3% of the worldwide gross tonnage built in that year. In the 5-year period between 2016 and 2020, the EU countries where the highest number of ships were built were Poland, the Netherlands, Spain, Romania and Norway (Figure 4) representing 66% of all new builds in European shipyards over that period. However, Italy and Germany constructed the largest ships (mainly cruise ships) accounting for 43% of the total gross tonnage (GT) built in Europe, or on average over 30,000 GT and 50,000 GT per ship constructed in those countries, respectively. The pre-pandemic cruise ships represent 80% of the value of the order book in Europe.[6]

Figure 5 shows how the shipbuilding industry was divided up in terms of type of vessel constructed in the past five years.

The share of the EU shipbuilding industry globally is very low, especially compared to its share in terms of maritime transport and ship ownership as indicated in section 1.4 and has been decreasing over the years[7].

Conversely, the European marine equipment industry is a world leader for a wide range of products with a market share of 35%.[8] However, the decreasing market share of EU shipyards in global shipbuilding has also had a negative effect for EU manufacturers; on the one hand it has put stress on EU manufacturers mainly or solely serving EU shipyards with the decreasing demand whilst, on the other hand, EU manufacturers active globally have become more on mainly dependent on Asia where are large number of ships are now built.

1.2.3 Flagging and registration

In the initial stages of the construction process, the ship must be registered and given a nationality that registers proof of its ownership. The country of registration is called the flag state[9], and each country can have more than one register with different tax or labour regimes. Crucially, the country of registration of the ship does not need to be the same as that of the ship owner The selection of the register is made by the owner based on considerations such as risk management, countries where the ship is expected to operate, contractual issues with the operator (which can be a different company), tax regimes, etc.

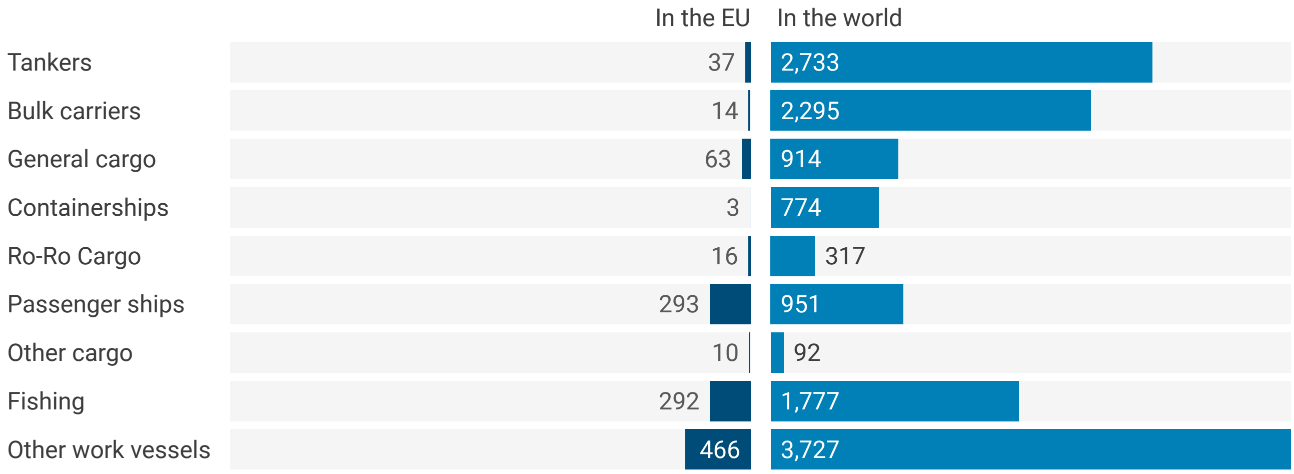
6 https://europe.cruising.org/knowledge_hub/euractiv-fit-for-55-debate/

7 According to EMTER, between the years 2000 and 2008, the annual average number of individual newbuilds in the EU represented roughly 20% of the worldwide annual average number of newbuilds.

8 https://ec.europa.eu/growth/sectors/maritime/shipbuilding_en

9 UNCLOS Articles 91 and 94.

Figure 5: Number of newly built ships by ship type in the EU and worldwide in the past 5 years.



Source: EMSA Services

Each flag state has its own requirements and conditions for allowing a ship to fly its flag and be registered under its nationality. The ship operates under the law of the country where it is registered, including national labour law. Accordingly, countries with more relaxed safety requirements and minimal national labour and environmental regulations can use these factors to be more competitive in the market using, for example, the minimum level of manning that a ship needs to decrease the operating costs but creating safety gaps due to shorter resting times, increased fatigue, etc.

As indicated before, flags can have more than one register with different admission rules. Registration is a complex matter with many specific issues that may not match the specific categories presented. Therefore, the types of registers identified below are a simplification which may not reflect all possible cases:

- Closed registers: national registries for ships owned, operated, and manned by nationals of that country.
- Open registers: open to shipowners with nationalities other than that of the flag state.
- Secondary registers: to compete with open registers, some countries, including EU Member States, created a secondary register with more flexible legislation in terms of taxation, or country of origin, or the crew nationality, while still keeping safety standards and working conditions at an appropriate level.

Whichever scheme is chosen, before entering into operation the ship is subject to certification schemes that verify that national and international safety standards are met. Certification is obtained through inspections that start with the verification of the technical drawings during the design stage, and that continue during the construction phase.

The flag state exercises regulatory control over the ship and is required to inspect it regularly under its safety requirements and certify compliance with regulatory standards. Flag states may delegate that duty to recognised organisations (RO), which are classification societies carrying out a different set of tasks. If the requirements set by the flag state are met, a certificate of registry is issued.

As indicated before, classification societies inspect and survey vessels to verify that the technical standards for the design of structures and outfitting – not explicitly specified in international legislation – are met during construction and commissioning. A certificate of classification is then issued and is required for the registration of the ship.

1.2.4 Operational life

During its operational life, the ship is periodically subject to several inspection regimes including statutory (flag/RO), port State control (PSC), Class, special regimes (RoPax and High-Speed Craft) and private schemes. Inspections may be planned or unplanned, depending on the case, upon arrival to port.

There are also company-based schemes and industry accepted vetting programmes for particular ship types, which are not certification systems required by legislation, but act as risk assessment tools for charterers and ship operators. This helps to avoid the use of ships with sub- or lower levels of safety standards. One example is the tanker industry's self-regulating framework, which directly ties the commercial viability of tankers to the various statutory and industry standards implemented. Tankers, in general, are subject to an additional layer of quality assurance through the vetting framework prior to cargo transaction with charterers. Both operator and tankers are evaluated and/or screened against indicators set out by the Oil Companies Marine Assurance Criteria. One of the fundamental factors in this process is the physical inspection, which is conducted according to the OCIMF's Ship Inspection Report Programme (known as SIRE).

At the end of an operational life that on average lasts 25 to 30 years, most ships are dismantled for their parts or for the extraction of raw material. Ship recycling yards are mainly located outside the EU [7].

1.3 Regulatory framework

There is a complex regulatory framework around maritime safety which is composed of international, regional, and national layers, with different rules of applicability and associated inspection regimes. The application depends not only on the ship's type and characteristics, but also on the type of voyage it undertakes. International voyages are those in which the port of origin and the port of destination are in different countries. A domestic voyage is one where the port of origin and port of destination are in the same country, regardless of whether international waters are crossed when in transit. An intra-EU voyage – a voyage between ports of different Member States – is therefore considered an international voyage.

Shipping in the EU is mainly subject to three regulatory layers: international, EU and national.

1.3.1 International rules

As shipping is inherently international, its safety is regulated in the first instance by an international layer. The International Maritime Organization (IMO) is the dedicated agency of the United Nations (UN) which sets the main safety, security and environmental standards for shipping at a global level. The IMO basically provides a framework where states can meet and cooperate to agree on technical matters affecting international maritime trade.

While all EU Member States are members of the IMO, the European Commission has observer status as an intergovernmental organisation. EMSA contributes to the IMO as part of the European Commission delegation and provides technical input on specific topics with a view to facilitating cooperation and amending the relevant Conventions where appropriate. The main safety Convention at international level is SOLAS (Safety of Life at Sea), which came into being following the Titanic disaster in 1912.

EU Member States and the European Commission participate in the main committees that are responsible for the technical discussions at IMO for the adoption of relevant legislative measures and amendments to international conventions. In particular, all Member States take part in the Maritime Safety Committee (MSC), the functions of which include "aids to navigation, construction and equipment of vessels, manning from a safety standpoint, rules for the prevention of collision, handling of dangerous cargoes, maritime safety procedures and requirements, hydrographic information, log-books and navigational records, marine casualty investigations, salvage and rescue and any other matters directly affecting maritime safety" [8].

The International Labour Organization establishes complementing standards to IMO regarding the human element. Particularly, the Maritime Labour Convention covering minimum working and living rights is one of the pillars of the international regulatory regime for quality shipping.

The instruments developed by the IMO play a vital role in the implementation of the provisions of the United Nations Convention on the Law of the Sea (UNCLOS), the main framework convention for rules governing the use of the oceans and their resources.

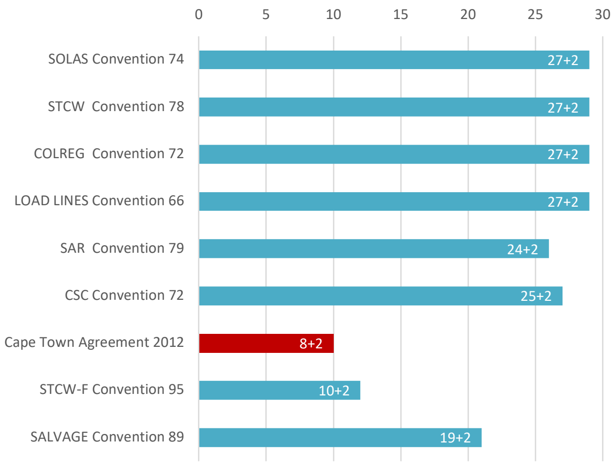
The principal international conventions relating to maritime safety are described in Table 1 along with the domain to which they refer, their general application and exceptions.

Table 1: List of the main international conventions related to maritime safety.

Regulation	Safety domain	Application	Exceptions
Maritime Labour Convention (MLC)	Safety of people onboard.	All seafarers and all ships.	Ships engaged in fishing or in similar pursuits and ships of traditional build. Warships or naval auxiliaries.
International Convention for the Safety of Life at Sea (SOLAS)	Construction, outfitting and operation including fire safety, lifesaving appliances and radio communications, safety of navigation, carriage of cargoes.	Ships engaged in international voyages (Chapter V on navigation also applies to domestic voyages).	Cargo ships with GT<500. Ships not propelled by mechanical means. Wooden ships of primitive build. Pleasure yachts not engaged in trade. Fishing vessels. War ships.
International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)	Qualification of seafarers.	Seafarers on seagoing merchant ships.	
Convention on the International Regulations for Preventing Collisions at Sea (COLREG)	Safety of navigation.	All ships at sea and in all the waterway in connection to the sea.	
International Load Lines Convention (ILLC)	Construction: Structure, subdivisions, and stability.	Ships engaged on international voyages.	New ships with length <24 m. Existing ships with GT<150. Pleasure craft not engaged in trade. Fishing vessels. War ships.
International Convention on Maritime Search and Rescue (SAR)	Safety of people in distress.	SAR services provided by Parties to the Convention.	
International Convention for Safe Containers (CSC)	Cargo.	New and existing containers used in international transport.	Containers specially designed for air transport.
Torremolinos International Convention for the Safety of Fishing Vessels – Cape Town Agreement (NOT IN FORCE)	Construction and outfitting, including lifesaving appliances and radio communication.	New seagoing fishing vessels > 24 m in length.	Vessels exclusively used in sport or recreation, processing of fish or other living resources of the sea, research and training or fish carriers.
International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F)	Qualification of fishing personnel.	Fishing personnel onboard fishing vessels of 24 m in length and above.	
International Convention on Salvage	Safety of people in distress.	Whenever judicial or arbitral proceedings related to matters within the Convention are brought in a State Party.	Fixed or floating platforms or mobile offshore units in expedition. Warships or other vessels owned or operated by a State engaged on non-commercial voyages.

Of the previous conventions, the Torremolinos International Convention for the Safety of Fishing Vessels, implemented through the Cape Town Agreement, has not yet entered into force, as described in greater detail in Section 2. The minimum number of ratifications necessary for a convention to enter into force is established in the convention's articles and the EU Member States have a key role in this process. For example, for STCW-F only 15 ratifications were required, out of which 12 were accorded by EU countries. Figure 6 below shows the level of ratification of the EU and EFTA coastal Member States of the main conventions:

Figure 6: Number of EU + EFTA coastal Member States ratifying the main IMO safety conventions.



Source: EMSA based on IMO data

Worldwide, the main safety convention - SOLAS 74 - has been ratified by 167 States and covers 98.89% of the world merchant tonnage. A similar percentage is covered by two other essential safety conventions, COLREG and the International Load Lines Convention.

1.3.2 EU legislation

The EU, on certain occasions, adds safety requirements for those ships flagged in EU Member States (e.g., marine equipment, recognised organisations, safety management systems) or operating to/from EU ports irrespective of the flag (e.g., damage stability of RoPax, passenger registration requirements, special survey regime for RoPax and high-speed craft). In addition, the EU has enforced legislation with respect to fishing vessels by making the IMO Torremolinos Convention (which is not in force at international level) mandatory and has developed safety legislation applicable to domestic passenger ships, which are, generally, out of the scope of international instruments.

Notable too is the Committee of Safe Seas and the Prevention of Pollution from Ships (COSS) at EU level. This Committee, which includes representatives of the EU Member States and is chaired by the European Commission, deals with wide-ranging aspects covered by EU maritime legislation, including ship safety, marine equipment, qualification and certification of seafarers, as well as other issues. Its decisions have an important impact on safety, including the recognition of classification societies and the acceptance of exemptions for domestic passenger ships.

The EU legislative framework is explained throughout the report for each safety topic and is summarised in Annex 1.

1.3.3 National legislation

In general, national legislation covers all the gaps not already covered under the other regulatory layers. This includes, among others, domestic cargo ships, fishing vessels below 24 m in length and sailing ships.

1.3.4 Guidelines and best practices

Apart from international, European and national legislation there are other forms of standards and best practices often developed by industry associations that aim at covering any regulatory gaps. Those are often a result of collaboration between multiple stakeholders such as manufacturers, shipyards, classification societies, shipowners and operators, and represent efforts for harmonisation when international regulations are not yet in force or not designed for prescriptive implementation. To a large extent, they also serve as a basis for the development of those regulations.

For example, several guidelines are being developed for the use of alternative fuels and powering technologies for which regulations are still under development, such as the Handbook for Hydrogen-fuelled Vessels published by DNV-GL, a result of the Joint Industry Project MarHySafe.

Other examples of industry guidelines are included in the sections ahead.

1.4 Maritime transport in the EU

The most important element to consider when analysing the level of maritime safety in the EU is the fleet. The number of ships is an important factor for those authorities whose role it is to assign proportionate resources, as is an understanding of the likelihood of an accident occurring. Ship type also has a bearing on maritime safety, as the consequences of accidents and the prevention and response measures differ greatly depending on the ship type involved; the implications for a large passenger ship and an oil tanker are not the same, for instance.

This section analyses the relevant fleet for maritime safety issues in the EU. It is made up, on the one hand, of the fleet whose safety level is under the direct responsibility of EU Member States, i.e., those ships flying the flag of an EU Member State, regardless of the location in which they are sailing, and on the other hand, of the fleet calling at EU ports, regardless of their flag, as accidents usually happen in the vicinity of the coast, given the heavier traffic density and shallower waters.

Trends have been included to understand the past and present situation as well as to try to establish how to prepare for the future, support decision-making, revise legislation and improve implementation.

1.4.1 EU Member State fleet composition

The fleet information presented next focuses on ships in service as of 31 December 2020. It includes the 27 EU Member States, Iceland, and Norway but excludes fishing vessels, unless otherwise stated, as these are analysed separately.

The vessel groupings considered are based on EMSA's database, which uses commercial shipping data of ships with IMO number (100 GT and above). Information was retrieved from this database for all ships except fishing vessels. For these types of vessels, the European Commission's DG MARE database was used for this report as it contains extensive information on the whole fishing fleet.

In summary, the main ship groups used are the following:

Table 2: Main ship groups used to categorise the fleet.

GROUP	DESCRIPTION
Tankers	Including liquefied gas tankers, oil tankers, chemical and other liquid tankers such as water tankers.
Bulk carriers	Including bulk dry, bulk dry/oil, self-discharging bulk dry and other bulk dry carriers.
General cargo ships	Including general cargo, palletised cargo and deck cargo ships.
Container ships	Fully cellular container ships and fully cellular with ro-ro facility container ships.
Ro-Ro cargo ships	Including Ro-Ro cargo ships, vehicles carrier, container/ro-ro cargo ships and landing craft.
Passenger ships	All passenger ships including RoPax and HSC, passenger/container ships and passenger/general cargo ships.
HSC	High Speed Passenger Craft.
RoPax	Passenger/ro-ro cargo ships and passenger/landing craft with are not HSC.
Other cargo ships	Refrigerated cargo ships and other dry cargo ships such as livestock carriers, barge carriers, heavy load carriers and nuclear fuel carriers.
Fishing vessels	Including fish catching ships and others such as fish factories, fish farm support vessels and live fish carriers.
Other work vessels	All offshore, research, towing/pushing, dredging and other activities.

1.4.1.1 Number of ships registered under EU Member State flags

The size of the EU Member State fleet is an important indicator of its relevance within the world maritime transport sector. Its distribution per ship type helps to place the safety focus on the specific areas of concern. In Table 3, the number of ships registered under EU MS flags per ship type, except fishing vessels, are represented, including their evolution since 2016.

The ship types representing the largest proportion of the EU MS fleet (not including fishing vessels), are other work vessels (30%) followed by passenger ships (19%) and tankers (17%) of which, respectively, 45% are RoPax and 45% are chemical tankers.

Table 3: Number of ships registered under EU MS flags per ship type (excluding fishing vessels) and fleet evolution over the past 5 years.

Ship type	2020	2016-2020	
Other work vessels	3,919	3848	3919
Passenger ships	2,450	2157	2450
Tankers	2,265	2202	2265
General cargo	1,634	1583	1634
Bulk carriers	1,290	1456	1290
Containerships	1,058	982	1058
Ro-Ro Cargo	400	364	400
Other cargo	82	71	82
Total	13,098	12663	13098

Source: EMSA Services

Table 4: Number of ships in the world per ship type (excluding fishing vessels) and fleet evolution over the past 5 years.

Ship type	2020	2016-2020	
Other work vessels	34,512	31995	34512
Tankers	16,641	15122	16641
General cargo	14,832	14546	14832
Bulk carriers	12,347	11325	12347
Passenger ships	7,910	7105	7910
Containerships	5,313	5073	5313
Ro-Ro Cargo	2,891	2740	2891
Other cargo	1,214	1230	1214
Total	95,660	89136	95660

Source: EMSA Services

The category 'other work vessels' which includes tugs and barges, etc., usually work in ports in sheltered waters and are therefore not a priority for this report. It is relevant to note that the average age of chemical tankers is approximately 12 years and that of passenger ships is approximately 28 years (see Figure 7 for more information on age distribution).

In terms of trends, an overall increase of 3.4% has been observed in the number of ships registered to EU Member State flags in the last 5 years.

Per ship type, there has been a general increase in the size of the fleet since 2016, except for bulk carriers where there has been a decrease of 11% in the number of ships. Specifically, in the category of passenger ships there has been an increase of 14%. However, this increase in the number of passenger ships has not been accompanied by a decrease in their average age, which was approximately 28 years in 2016. This means that, in addition to the new builds, older ships from non-EU MS flags are being incorporated into the fleet.

This information can be analysed from a broader perspective by comparing it with the fleet evolution at global level (see Table 4).

There has been an increase of approximately 7% in the global fleet[10], effectively double that of the EU MS fleet, where the increase was 3.4%. The proportion of the EU Member State-flagged ships versus the global fleet dropped from 14.2% in 2016 to 13.7% in 2020.[11]

In the tables below, the fleet of passenger ships and oil tankers is further divided into sub-types:

Table 5: Number of tankers registered under EU MS flag and fleet evolution over the past 5 years.

Tankers type	2020	2016-2020
Gas tankers	337	291 … 337
Oil tankers	881	836 … 881
Chemical tankers	1,022	1052 … 1022
Other tankers	25	23 … 25

Source: EMSA Services

Table 6: Number of passenger ships registered under EU MS flag and fleet evolution over the past 5 years.

Passenger ship type	2020	2016-2020
Ro-Pax	1,109	1000 … 1109
HSC	218	187 … 218
Others	1,123	970 … 1123

Source: EMSA Services

10 It is important to note that in the dataset the information on flag is available for 91% of the world fleet.

11 The EMTER European Maritime Transport Environmental Report (EMTER) jointly produced by EMSA and the EEA in 2021 indicates that this proportion is 17.6% based on DWT [7]. This percentage is nevertheless different, due to the fact that in EMSAFE the fishing fleet is dealt with separately, and also due to the effect caused by the withdrawal of the United Kingdom from the EU.

Looking at Tables 5 and 6, it can be concluded that, since 2016, only chemical tankers have decreased their share in the EU MS fleet. Gas tankers, HSC and passenger ships which are neither RoPax nor HSC have all increased their share by more than 15%. This is congruent with the increasing use of LNG in the EU. As can be seen in Annex 2, around 60% of the passenger fleet is concentrated in 4 countries: Norway (19%), Greece (14%), Italy (14%), and Croatia (10%).

These numbers can also be put into perspective by comparing them with the global figures:

Table 7: Number of tankers in the world per tanker type and fleet evolution over the past 5 years.

Tankers type	2020	2016-2020
Gas tankers	2,077	1857 – 2077
Oil tankers	8,675	7826 – 8675
Chemical tankers	5,717	5276 – 5717
Other tankers	172	163 – 172

Source: EMSA Services

Table 8: Number of passenger ships in the world (RoPax, HSC and others) in the world and fleet evolution over the past 5 years.

Passenger ship type	2020	2016-2020
Ro-Pax	3,228	2924 – 3228
HSC	671	539 – 671
Others	4,173	3790 – 4173

Source: EMSA Services

1.4.1.2 Size of ships registered under EU Member State flags

The previous analysis only considers the number of ships. However, the size of these ships is also important, providing as it does an indication of transport capacity. In general, in the maritime transport sector, size is measured in Gross Tonnage (GT). By the end of 2020, the total gross tonnage of ships registered under EU Member States flags amounted to over 250.9 million, 17.8% of GT worldwide.

Table 9: GT of ships registered under EU MS flags per ship type (excluding fishing vessels) and fleet size evolution over the past 5 years.

Ship type	2020	2016-2020
Tankers	83M	76.2M – 83M
Containerships	61.1M	50.1M – 61.1M
Bulk carriers	55.7M	61M – 55.7M
Passenger ships	18.2M	15.4M – 18.2M
Ro-Ro Cargo	13M	11M – 13M
Other work vessels	9.5M	7.9M – 9.5M
General cargo	9.3M	8.1M – 9.3M
Other cargo	969.7K	806.1K – 969.7K
Total	250.9M	230.5M – 250.9M

Source: EMSA Services

Table 10: GT of ships in the world per ship type (excluding fishing vessels) and fleet size evolution over the past 5 years.

Ship type	2020	2016-2020
Bulk carriers	485.4M	426.6M – 485.4M
Tankers	449.1M	384.4M – 449.1M
Containerships	251.8M	216.2M – 251.8M
Other work vessels	61.4M	52.3M – 61.4M
General cargo	57.4M	52.8M – 57.4M
Ro-Ro Cargo	49.6M	48.9M – 49.6M
Passenger ships	44.4M	38.8M – 44.4M
Other cargo	8.8M	8.9M – 8.8M
Total	1.4B	1.2B – 1.4B

Source: EMSA Services

From the tables, a similar tendency can be confirmed to that of the number of ships; whereas the global tonnage has increased by 14.5% in the last five years, the EU Member State tonnage growth has been lower, at 9%. The proportion of the EU Member State tonnage in relation to the global equivalent has dropped from 18.7% to 17.8%.

RoPax and HSC with EU Member State flags represent around 30% of the world fleet of those ship types but more than 50% in terms of GT. This means that, on average, the RoPax and HSC registered to EU Member State flags are the largest in the world.

Table 11: Percentage of EU MS flagged vessels worldwide per ship type as divided up into number of ships and gross tonnage.

	No. of ships	GT
Ro-Pax	36%	57%
HSC	32%	51%
Passenger ships	31%	41%
Ro-Ro Cargo	14%	26%
Containerships	20%	24%
Chemical tankers	18%	20%
Gas tankers	16%	18%
Oil tankers	10%	18%
General cargo	11%	16%
Other work vessels	11%	15%
Bulk carriers	10%	11%
Other cargo	7%	11%
Other tankers	15%	4%
Total	**14%**	**18%**

Source: EMSA Services

1.4.1.3 Fleet owned by EU registered companies

Ships can be owned by a company registered in an EU Member State but still fly the flag of a non-EU country. From a safety perspective, the ownership of the ship is also important as the owner often plays a key role in maintaining an appropriate level of safety. The following table includes the comparison, per ship type, of the percentages of EU Member State-flagged fleet vs EU Member State-owned fleet:[12]

Nearly the entire EU Member-State owned fleet of passenger ships is flagged in the EU (31%, corresponding to 40% of the worldwide passenger transport capacity). The situation is different for cargo ships, however, with 20% of the world's containerships registered under an EU Member State flag, and 35% owned by EU-based companies. European owners also control around a third of the world's gas and chemical tankers. In total, 20% of the world fleet is in EU hands. This means that, from a global safety perspective, the performance of EU owners plays a key role in the safety of these ships.

Table 12: Percentage of ships worldwide by number of ships as divided up into EU MS flagged vessels and EU owned vessels.

	EU MS flagged ▼	EU owned
Ro-Pax	36%	40%
HSC	32%	32%
Passenger ships	31%	32%
Containerships	20%	35%
Chemical tankers	18%	28%
Gas tankers	16%	28%
Other tankers	15%	18%
Ro-Ro Cargo	14%	16%
General cargo	11%	18%
Other work vessels	11%	14%
Oil tankers	10%	19%
Bulk carriers	10%	26%
Other cargo	7%	19%
Total	**14%**	**20%**

Source: EMSA Services

12 The dataset has information on the ship's ownership country for 96% of the world fleet.

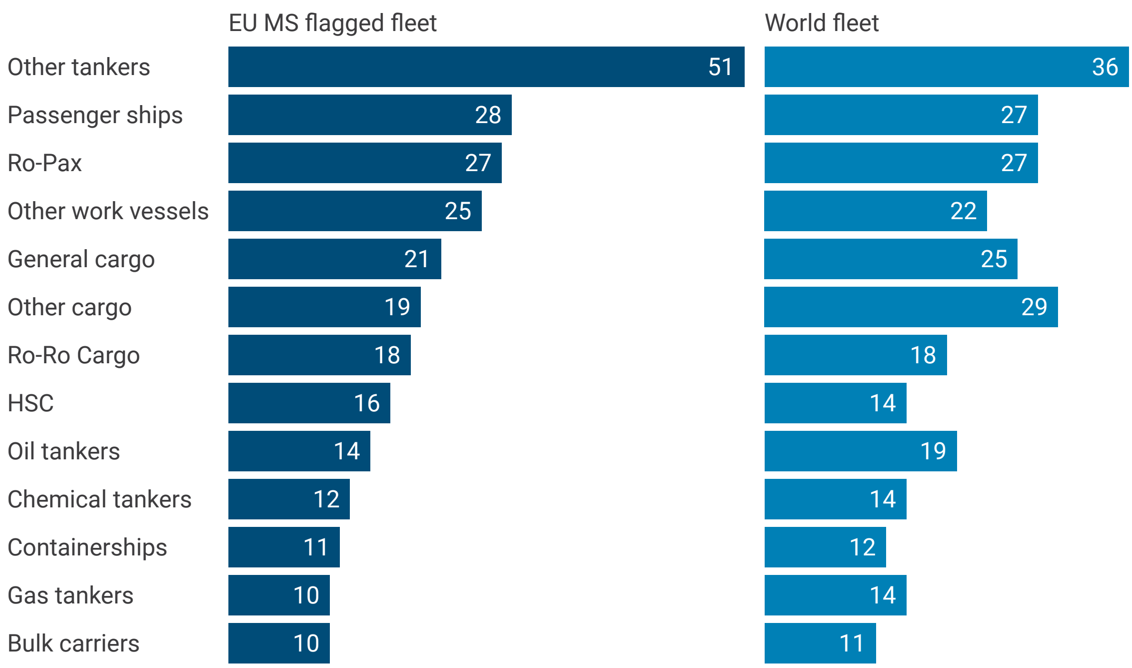
1.4.1.4 Age of the ships

The age of the ships is also an important element to consider when looking at safety. As ships age, they require greater maintenance, and they need parts to be replaced and steel work to be repaired. In general, ships can have a lifespan of 25-30 years, although with adequate maintenance this can be extended.

In addition, the age of the ship defines the applicable safety standards. On many occasions, newly approved safety requirements are not immediately applicable to existing ships, as explained in the ship safety section. Therefore, ships can operate on the same route even though they have different safety levels as a result of their age.

In general, the average age of the ships registered under EU Member State flags is less than or similar to the world average, except for tankers other than gas, oil or chemical tankers, that are simple ships in terms of design and do not tend to carry harmful substances. Apart from those ships, passenger ships, including RoPax, represent the oldest ship groups. There is more a detailed analysis on this in the ship safety section of this report.

Figure 7: Average age per ship type of ships with an EU MS flag compared with that of the worldwide fleet.



Source: EMSA Services

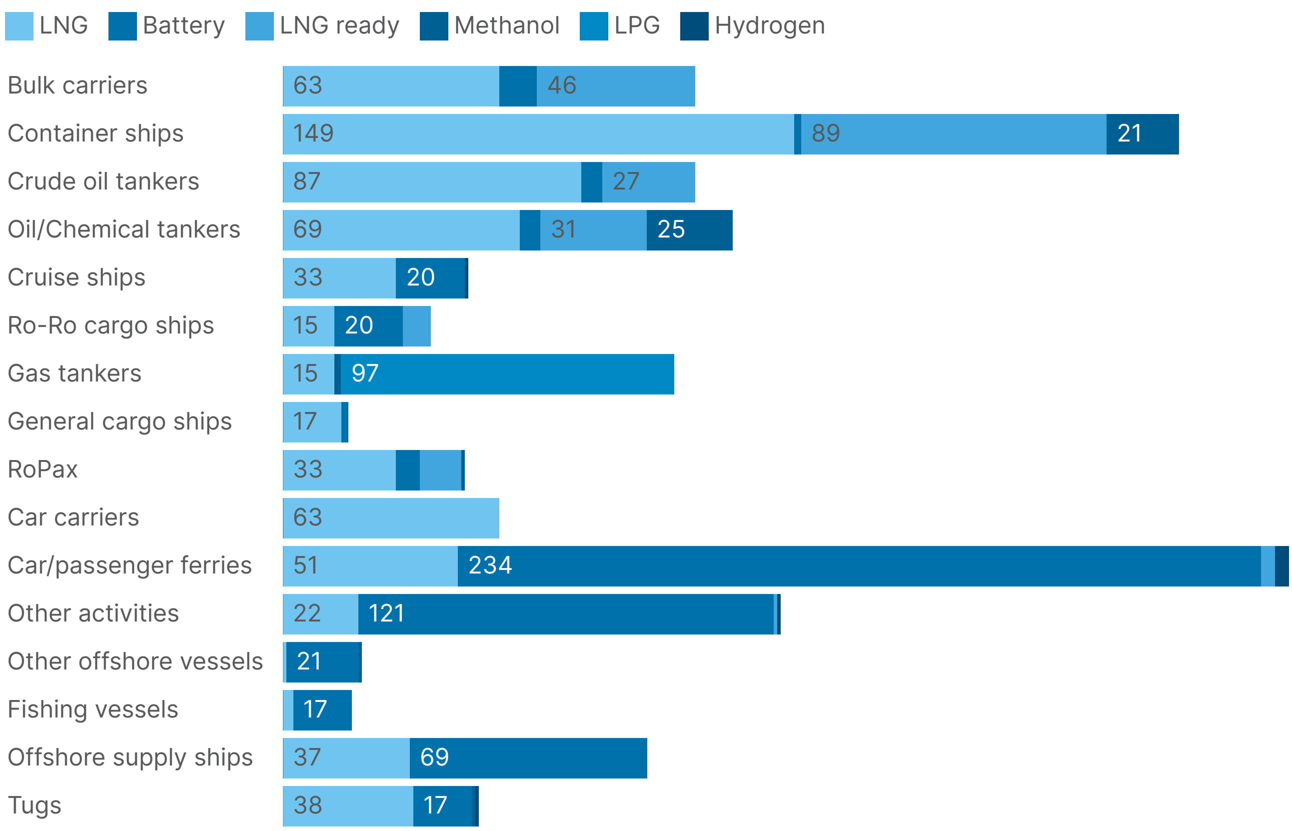
1.4.1.5 Type of powering technology

The type of fuel and powering technology also has important implications on safety and reflects how the fleet is accompanying the most recent developments towards a more sustainable future of shipping.

The current worldwide uptake of alternative fuels and technologies per ship type as collected by DNV[13] is presented below.

In particular, in 2020, more than 60% of the world's battery powered ships (either partly or wholly) were trading in the EU-27, UK and EFTA states.[14]

Figure 8: Current uptake of alternative fuels and technologies per ship type.



Source: DNV Alternative Fuels Insight Platform

13 In the Alternative Fuels Insight platform: https://store.veracity.com/alternative-fuels-insight-platform-afi

14 http://emsa.europa.eu/sustainable-shipping/new-technologies.html

1.4.1.6 Fishing vessels

Databases at EMSA provide reliable data on the cargo/passenger fleet. However, for fishing vessels, the database hosted and managed by the Directorate-General for Maritime Affairs and Fisheries at the European Commission (DG MARE), is the best source with which to characterise the fleet. In total, there are close to 75,000 fishing vessels registered in EU Member States, excluding Norway and Iceland, for which there is no data available in the DG MARE database. For this ship type, the length of each vessel is an important label for the applicability of legislation, as detailed in Section 2 of this report.

According to the data available at the end of 2020, 3% of the EU fishing fleet is above 24 m in length, 6% is between 15 m and 24 m in length and 91% is less than 15 m.

In terms of age, 65% of the EU fishing fleet is over 25 years old and only 2% of the vessels were built in the last five years. The smaller vessels in terms of length are often the older ones.

Figure 9: Distribution of EU MS fishing vessels in terms of length – fleet of 2020.

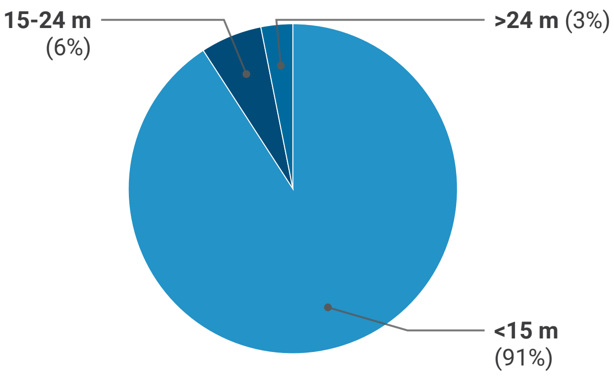
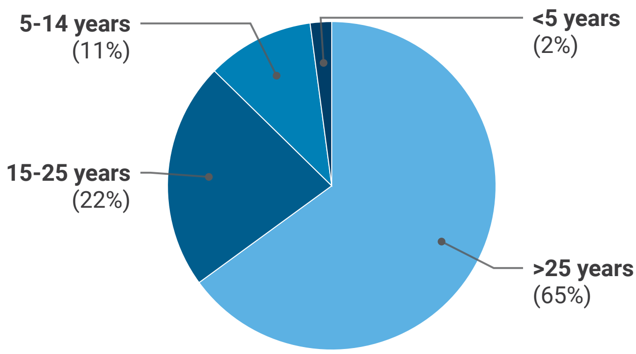
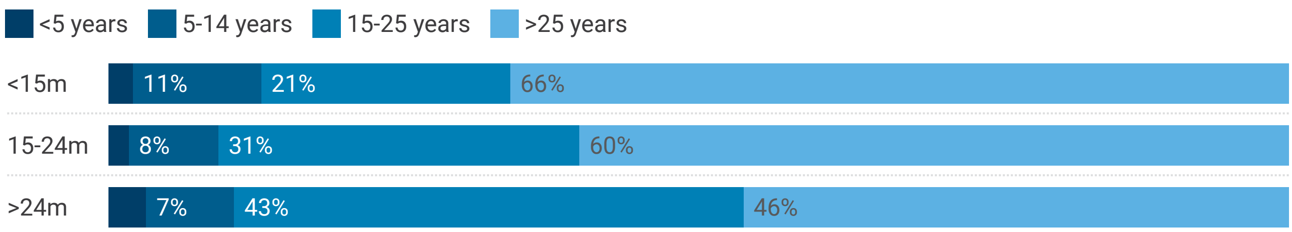


Figure 10: Distribution of EU MS fishing vessels in terms of age – fleet of 2020.



Source: DG MARE Fleet register (https://webgate.ec.europa.eu/fleet-europa/index_en)

Figure 11: Age distribution of EU MS fishing vessels by length.



Source: DG MARE Fleet register (https://webgate.ec.europa.eu/fleet-europa/index_en)

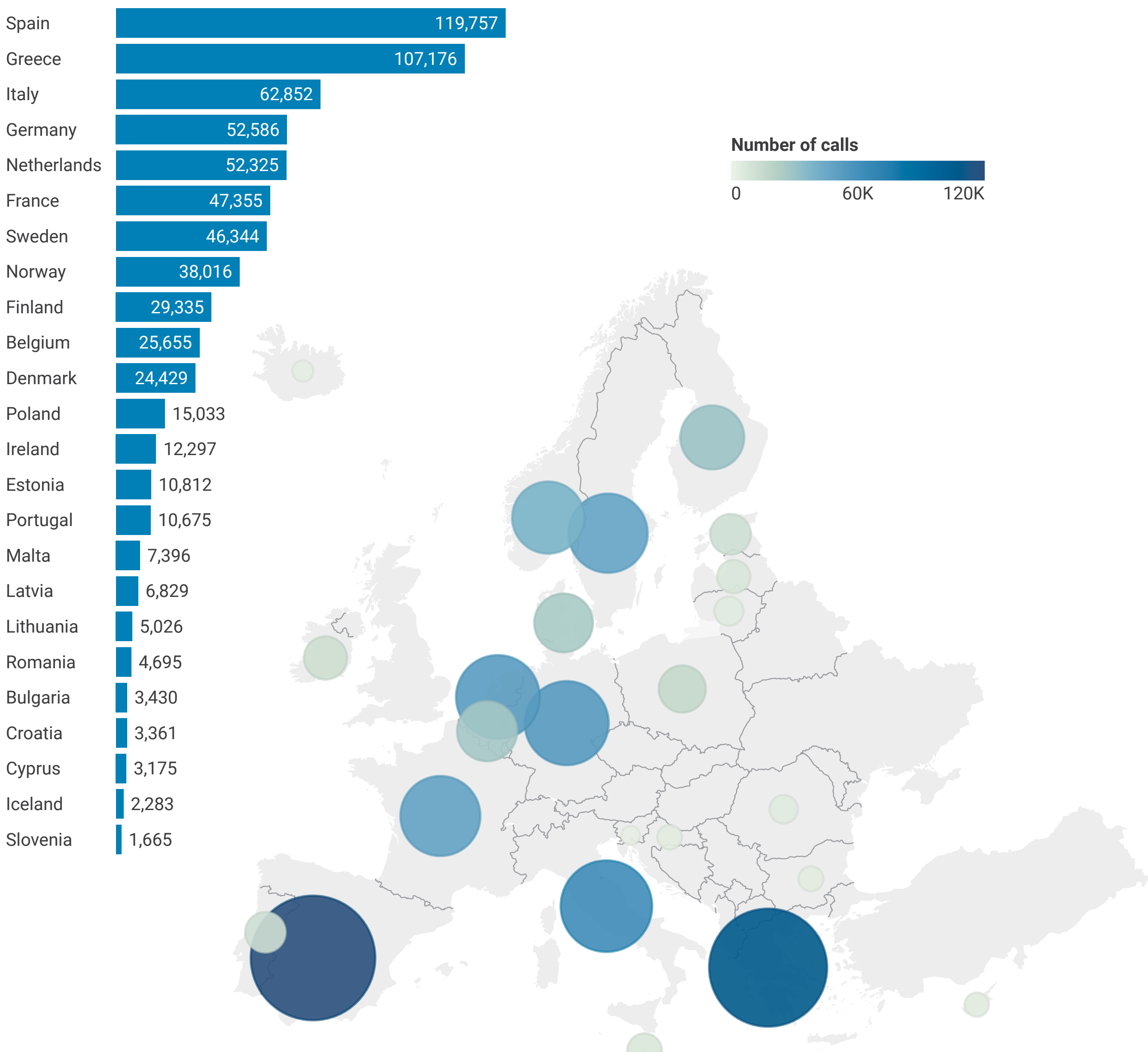
1.4.2 Maritime traffic in the EU

As indicated in the introduction to this section, to address EU maritime safety properly, it is important to consider the number and type of ships calling at EU ports. The main source used in this section is SafeSeaNet (SSN), the European network for maritime data exchange managed by EMSA.

1.4.2.1 Number of port calls

The number of port calls has important implications for the reporting, monitoring, and inspection efforts of EU Member States. The following figure presents the number of port calls per Member State for 2020. Despite the fact that this marked the first year of the COVID-19 pandemic, the data nevertheless provides a clear picture of the Member States managing the most port calls:

Figure 12: Number of ship calls at each EU MS in 2020. Geographical distribution of port calls.



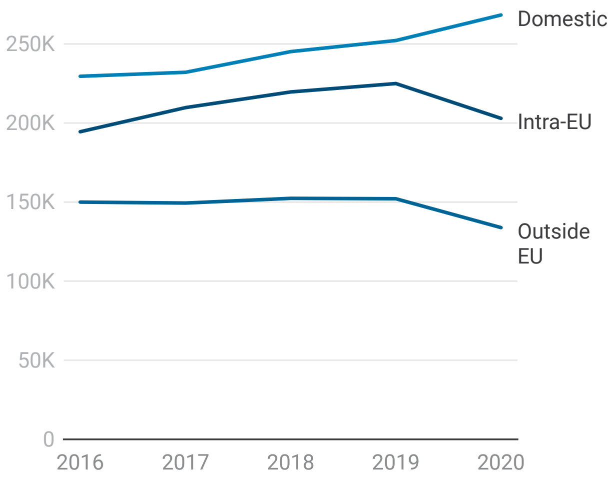
Source: EMSA Services (SafeSeaNet)

Spain and Greece are the Member States with the highest number of port calls, with a significant gap between them and the next Member State in the list (Italy). This difference is mainly due to passenger ship traffic, including RoPax, and the highly developed tourism industry of these Member States, which receive millions of visitors each year. Both Greece, due to the large number of islands offering tourism facilities, and Spain, with the high demand of the Balearic and Canary Islands, as well as connections with Morocco, receive numerous port calls from passenger ships.

1.4.2.2 Number of port calls per type of traffic

The type of traffic determines the legislation that is applicable to a certain ship. In general, international legislation differentiates between international and domestic voyages. The EU, in addition to these categories, has legislation applicable to ships visiting EU ports. In this sub-section, the type of traffic is divided into three categories: outside EU; domestic; and intra-EU.[15] Outside EU includes those voyages departing from a non-EU port and arriving at the EU, while intra-EU refers to those voyages departing from a port in one EU Member State and arriving at a port in another EU Member State. Finally, domestic voyages include voyages departing from an EU Member State and arriving in the same EU Member State. Therefore, the voyages labelled as outside EU and intra-EU are both international voyages.

Figure 13: Evolution of domestic, intra-EU and outside EU traffic based on number of ship calls at EU ports.



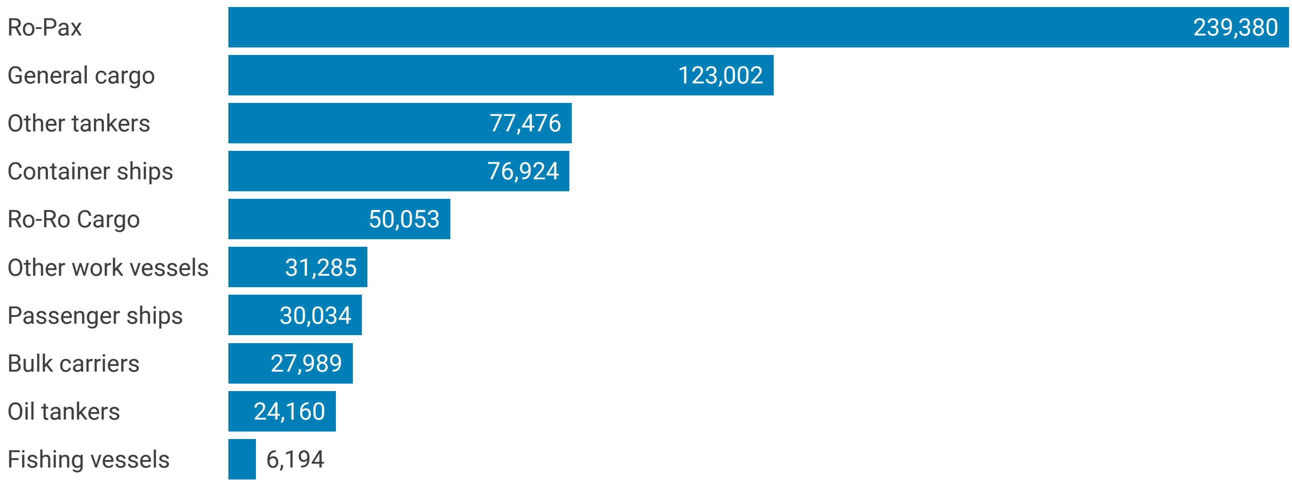
Source: EMSA Services (SafeSeaNet)

The data clearly shows a stabilisation of the traffic coming out of the EU and a steady increase in intra-EU and domestic traffic. Obviously, there was a sharp decrease in intra and outside EU traffic in 2020 due to the COVID-19 pandemic. However, this was compensated by an increase in domestic traffic.

1.4.2.3 Number of port calls per type of ship

The following figure presents the number of ships calling at EU ports by ship type:

Figure 14: Number of calls at EU ports in 2020 by ship type.



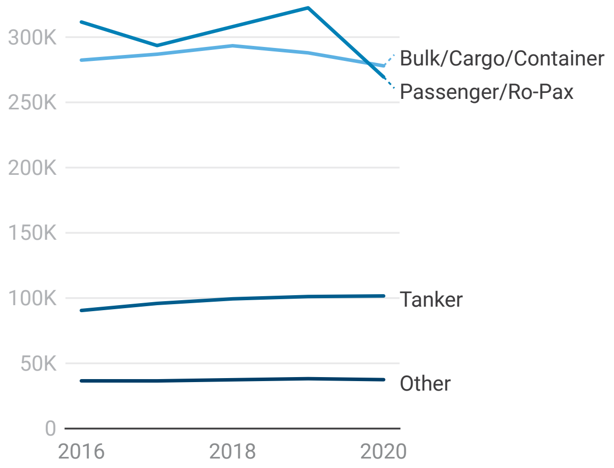
Source: EMSA Services (SafeSeaNet)

15 It is not mandatory for Member States to provide information on the last port of call; and one Member State does not yet provide this data due to technical reasons.

Unsurprisingly, the RoPax is the ship type with the highest number of port calls; these ships usually operate on regular routes with tight timetables and short turnaround times. For that reason, the number of accidents involving passenger ships is higher than those involving cargo ships, as explored further in Section 4. Given the high activity levels of passenger ships, specially RoPax, the EU has implemented specific legislation for these ship types, as detailed further in Section 2.2 of this report.

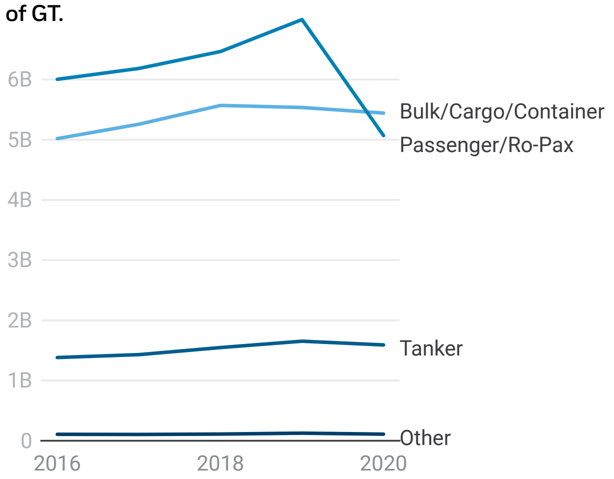
In terms of trends, the following graph shows that the mix of ships calling at EU ports has been relatively stable in the last 5 years, except for passenger ships, which saw a steady increase in 2018 and 2019, especially in terms of GT, meaning that the passenger ships that visit EU ports are growing in size. This is an important point to factor in the contingency plans of EU Member States. Finally, in 2020 there was a sharp decrease in the port calls of passenger ships, due to the COVID-19 situation where the biggest cruise ships all but ceased operations.

Figure 15: Evolution of ship types in number of calls at EU ports.



Source: EMSA Services (SafeSeaNet)

Figure 16: Evolution of ships calling at EU ports in billions of GT.



Source: EMSA Services (SafeSeaNet)

The maps below show traffic density in EU waters in total and per ship type:

Figure 17: Traffic density map – all ships.

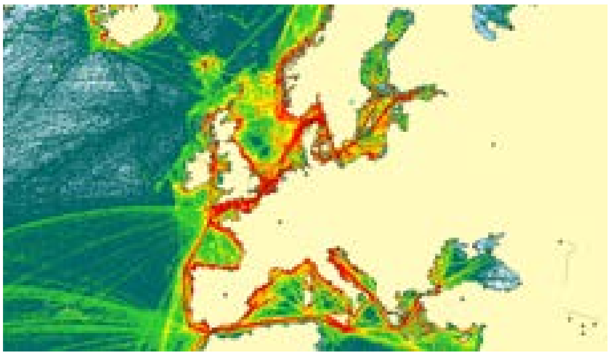


Figure 18: Traffic density map – fishing vessels.

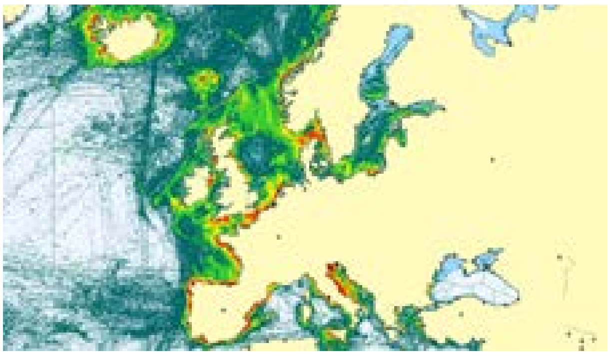


Figure 19: Traffic density map – cargo ships.

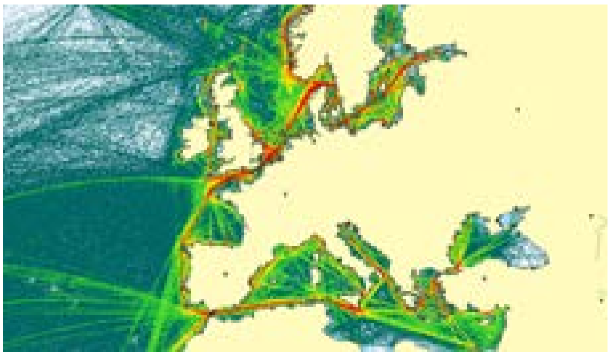


Figure 20: Traffic density map – passenger ships.

Source: EMSA Services

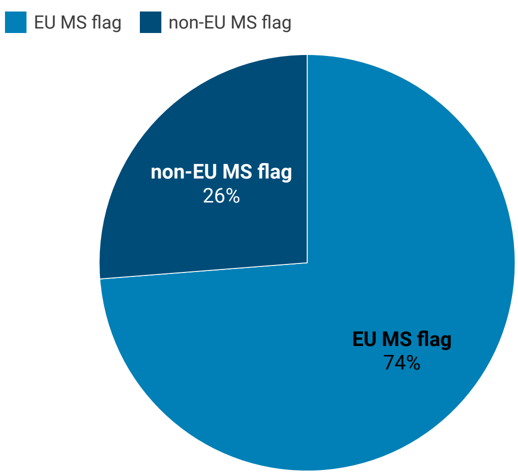
1.4.2.4 Number of port calls per flag

EU Member States, as flag states, are responsible only for those ships flying their flag. But as the EU is an open market, ships flying under many other flags also call at EU ports, which affects Member States in their capacity as port states. Figures 21 and 22 show the proportion of EU Member State versus non-EU Member State-flagged ships visiting EU ports over the past five years:

As shown, approximately 25% of all ships visiting EU ports do not have an EU Member State flag. To ensure the safety of these ships, and that they are not sub-standard (i.e., below the international safety standards), the EU has an efficient second line of defence, Port State Control (PSC) which will be analysed in section 3.2.

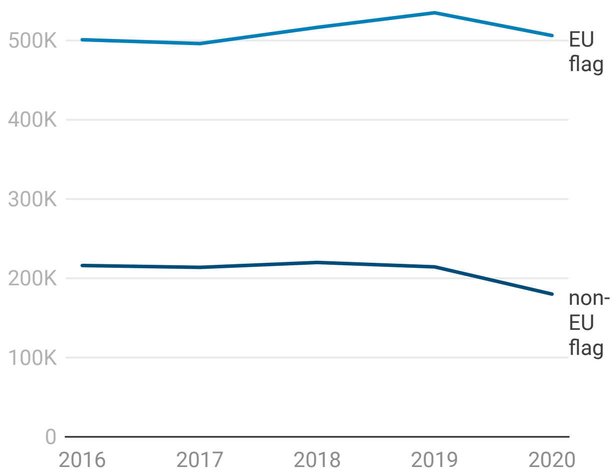
The top-10 non-EU Member State flags calling at EU ports over the past five years are listed in Figure 23.

Figure 21: EU MS/Non-EU MS flag distribution for ships calling at EU ports.



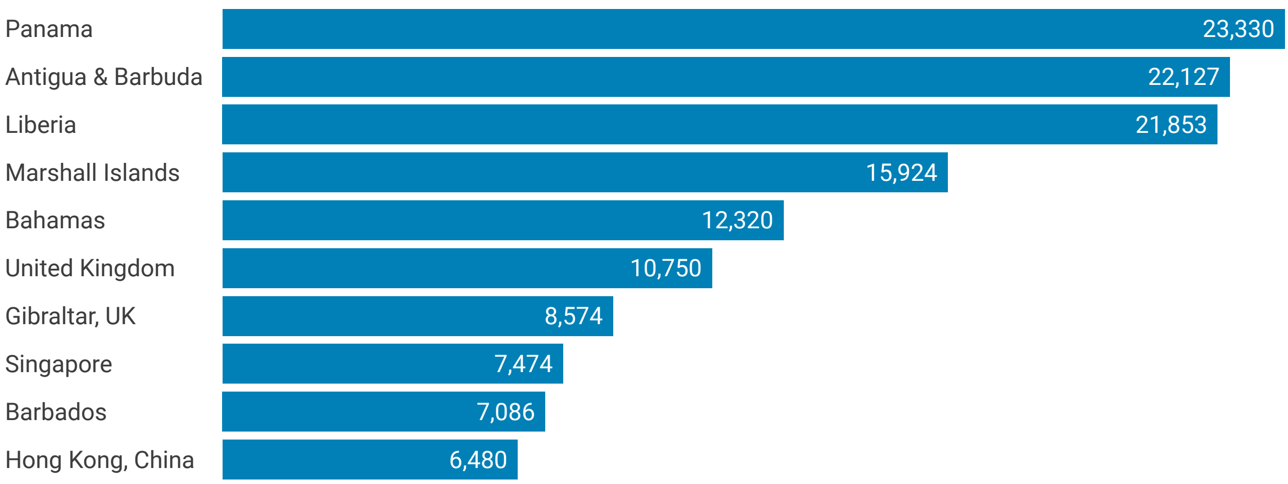
Source: EMSA Services (SafeSeaNet)

Figure 22: Evolution of individual ship arrivals by EU MS/ Non-EU MS flag.



Source: EMSA Services (SafeSeaNet)

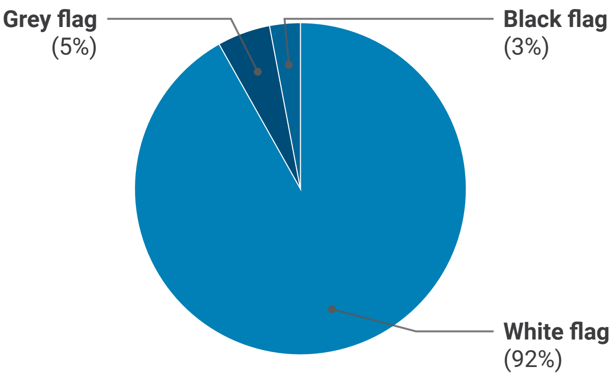
Figure 23: Top 10 non-EU MS flags of ships calling at EU ports.



Source: EMSA Services (SafeSeaNet)

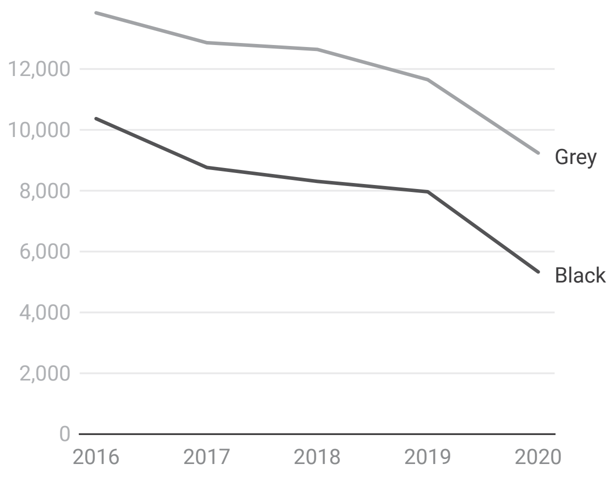
It is worth noting that all of the previously-listed flags are included in the White list of the Paris MoU[16], i.e., those with a better safety performance. The grey and black lists include flags with poorer safety performance, but which are allowed to call at EU ports. The following figures present the percentage of calls from ships flying grey or black listed flags:

Figure 24: Distribution of the non-EU MS flags of the ships calling at EU ports in 2020 according to the most recent Paris MoU 'White, Grey and Black list'.



Source: EMSA Services (SafeSeaNet)

Figure 25: Evolution of port calls in the EU by ships with non-EU MS grey and black flags according to the Paris MoU 'White, Grey and Black list'.



Source: EMSA Services (SafeSeaNet)

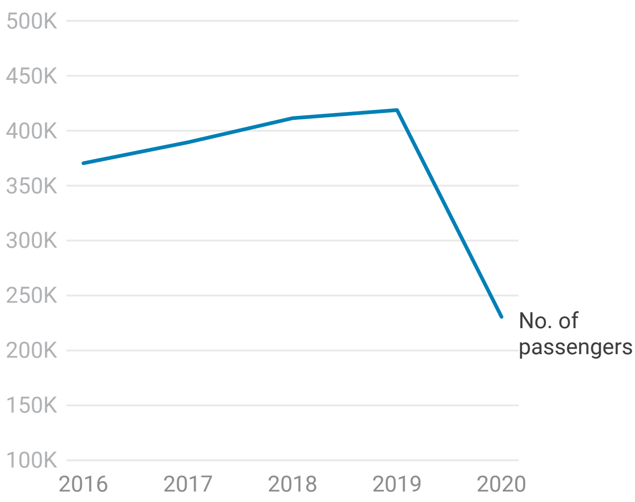
16 Paris Memorandum of Understanding on PSC is an administrative agreement between 27 maritime administrations covering waters of the European coastal States and the North Atlantic basin from North America to Europe aimed to eliminate the operation of sub-standard ships through a harmonized system of port State control. More at https://www.parismou.org/.

As observed, the percentages of ships with grey and black flags are relatively low. In addition, from 2016, a positive trend can be noted, namely a steady decline in the number of port calls from ships flying these flags.

1.4.2.5 Number of passengers transported to/from EU ports

The figure below presents the number of passengers transported to/from EU ports. As can be seen, the numbers have been gradually increasing, reaching more than 400 million passengers in 2019.

Figure 26: Number of passengers embarked and disembarked in EU ports – in thousand passengers per year.



Source: EMSA based on Eurostat data (https://ec.europa.eu/eurostat/databrowser/view/mar_pa_aa/default/table?lang=en)

2. The crew, the ship and its operation

2.1 Human element

2.1.1 Introduction

This section looks at the human element from a holistic perspective. It addresses the relevance of the work of seafarers (officers and ratings) in the world of shipping and puts it into context. As the shipping industry operates different types of vessels, on various routes, carrying high quantities of valuable cargo, some of it composed of dangerous goods, it is important that seafarers are well trained and educated, and able to work under pressure. In addition, when working on board large passenger vessels carrying thousands of passengers, seafarers' responsibilities towards safety increase significantly. Many seafarers, after leaving their seagoing careers, continue to work in the industry ashore in areas where they can contribute to improving maritime safety, be it in maritime administrations, education and training institutions, pilotage, surveying, ports or shipping companies, among others. The human element has also a shore-based component that should also be considered here.

The level of manning, as indicated previously, is defined by the flag state based on IMO Guidelines. Accordingly, there is a lack of harmonisation which in turn paves the way for competition to decrease the manning levels in order to make a particular flag more attractive than its competitors.

It is also important to bear in mind that seafarers' living and working conditions are inherently linked not just to human rights but also to maritime safety. The requirements related to safe management have a direct impact on the work on board performed by seafarers and on the way in which shipping companies are managed ashore, with consequences in terms of maritime safety and pollution prevention. This section will explain why this topic is important for maritime safety and how it is regulated at international, European, and national level. Furthermore, it will include an analysis of the available data on seafarers, highlighting the different education and training systems as well as the challenges and opportunities ahead, including the attractiveness of seagoing careers.

Why is this topic important for maritime safety?

The development of technologies that have facilitated the exploitation of marine resources and maritime transport growth has resulted in increased employment in a wide range of maritime economic activities (fishing, aquaculture, maritime transport, port work, ship building and repair and coastal tourism). In line with this increase, it is essential to ensure that there are sufficiently qualified seafarers capable of responding to the growing regulatory demands associated not only with seafarer training and certification but also with the necessary level of maritime safety that these activities require.

The 2019 EMSA Annual Overview of Marine Casualties and Incidents highlights that 65.8% of all maritime accidents were attributed to human error. It should be noted that the number of accidents avoided by seafarers are not reflected in this overview. Neither are they reflected in any other available publication. This is an area where research would be useful, especially for maritime educators and policy makers.

Besides the risks associated with their work, seafarers have many responsibilities on board ships and play a key role in ensuring the safety of ship operations in a global and multicultural environment. Seafarers work without borders, and as a consequence, seafaring professions must be continuously regulated at international level so that seafarer education, training, professional qualification requirements, working conditions, and safety can be ensured in accordance with international agreements. In this area, the legal basis comes originally from the IMO, sometimes in cooperation with the International Labour Organization (ILO). In their respective areas of responsibility, both organisations have developed over the years a legal framework covering different aspects of the human element, including seafarer qualifications, safe management of ships and prevention of pollution in order to avoid accidents that are likely to threaten either human life, the ship, or the marine environment.

As highlighted before, qualified seafarers are key to ensuring maritime safety and the prevention of pollution by reducing maritime accidents. However, currently, there are two main challenges for the maritime sector: the effort to keep attracting new entrants into seafaring careers, in particular within the EU; and the ageing workforce, particularly where more traditional maritime nations are concerned, including in EU Member States. These circumstances highlight the need to attract young people to seafaring careers and to find maritime experts to work in shore-based maritime activities, such as pilotage, surveying, education, and training, among others. These are the challenges that lie ahead and need to be tackled in the short term by the shipping industry.

Due to the importance of seafarers in keeping the world's vessels operating and the global economy running, the working and living conditions they are offered are important. Although the ILO has under its umbrella the Maritime Labour Convention (MLC 2006), it is not always easy to ensure its implementation.

Of particular relevance to the working and living conditions at sea is social isolation. This is intrinsic to the reality of people working on a ship, especially on cargo ships where the crew number is already reduced. This together with fatigue at sea (which has already been subject to many research studies), difficulty in connecting to the internet, limited shore leave (emphasised by the Pandemic), and the decrease in ship's cruising speed (as a method of fuel-saving that increases travel time), among others, are factors that do not contribute to retaining people in a seafaring career.

Some problems may appear due to the growth of automation in the maritime sector and particularly on board. Increased automation has allowed shipping companies to reduce manning levels. The main goal is to achieve maximum efficiency particularly in economic terms. Nevertheless, reducing manning levels may also have negative effects for the crew by leading to an increased workload in certain specific situations (for instance when the turnarounds in ports are short and all crew have tasks that cannot be postponed, including cargo operations, accompanying surveyors, PSC inspectors, bunkering, among others). This can result in a lack of sleep, and the resulting fatigue can lead to impaired performance and diminished alertness. Fatigue in crew members is a serious problem and plays a significant role in maritime accidents. Addressing fatigue risk management through the establishment of onboard techniques during the scheduling of shipboard work and resting periods is an essential part of safeguarding maritime safety.

Finally, the development of Maritime Autonomous Surface Ships (MASS) will likely imply the transfer of some or, in a few cases, complete human intervention to shore-based control stations. Although the number of accidents at sea caused by seafarers on board ships can be reduced, such a transfer creates potential risks which have not yet been identified given the lack of safety knowledge and experience. Different types of accidents can also occur, but in different roles, such as those carrying out remote supervision, verification, monitoring or even programming. It is important that attention is given to the qualification of the seafarers who will operate these vessels as well as to those who will control them from shore-based stations.

The previous paragraphs highlight the importance of this topic to maritime safety, firstly by the consequences that errors made by seafarers can have but also by the need to ensure that the education and training programmes are updated to include new technologies and that proper working conditions are available to those who chose a seafaring career.

2.1.2 Regulatory framework

The STCW Convention, adopted in 1978 and which entered into force in 1984, is the most relevant instrument dealing with the education, training and certification of seafarers. It was subject to a major amendment in 1995 (including the adoption of the STCW Code). Other major amendments were adopted in 2010 in Manila, the Philippines, hence being known as the 'Manila amendments. The date of the adoption of these amendments, 25 June, was later established by the IMO as the International Day of the Seafarer.

The Maritime Labour Convention, 2006 (MLC, 2006) is another relevant instrument adopted at ILO level in 2006. It establishes minimum working and living standards for all seafarers employed on ships, irrespective of the flag. It is the most important instrument recognising the need for maritime labour regulation to protect seafarers when they sign employment agreements. New amendments in the short term may result from the experience gained throughout the COVID-19 pandemic.

Table 13: Legislation on the human element.

	Level	Instrument	What it regulates
Legislation	International	STCW 78, as amended	Education, training, assessment and certification of seafarers.
		MLC, 2006 as amended	Seafarers' living and working conditions.
		ISM Code, as amended	Following the Herald of Free Enterprise accident, several IMO resolutions were adopted which resulted in an amendment to the SOLAS Convention, introducing a new Chapter IX, making it mandatory to establish a Safety Management System in the companies and on board.
	EU	Directive 2008/106/EC	Transposes the STCW Convention (education, training and certification of seafarers).
		Regulation (EC) No 336/2206	On the implementation of the ISM Code within the EU.
		Directive 2009/13/EC	Implementing the Agreement concluded by the European Community Shipowners' Associations (ECSA) and the European Transport Workers' Federation (ETF) on the Maritime Labour Convention, 2006, and amending Directive 1999/63/EC.

The International Safety Management (ISM) Code was adopted through an amendment to the International Convention for the Safety of Life at Sea (SOLAS Convention), which resulted in the introduction of a new Chapter to the Convention. Its purpose is to provide an international standard for the safe management of ships and for pollution prevention. Its main objectives are to provide safe practices in ship operation and working environments; establish safeguards against all identified risks and continuously improve safety management skills of personnel ashore and onboard ships. Regulation I/14 of the STCW Convention provides a clear link between the STCW Convention and the ISM Code.

These three instruments are the foundation of international regulation dealing with the human element. On this basis, instruments were developed and adopted at EU level, as Table 13 shows.

2.1.3 Relevant data and analysis

2.1.3.1 Number of certified seafarers

It has always been difficult to get accurate data on seafarer numbers. Despite some studies conducted by different organisations, notably ICS/BIMCO, the problem has remained, making it difficult to know the exact number of seafarers available to crew both the world fleet and the EU Member State fleet.

In 2007 EMSA started to develop an STCW Information System which, apart from registering information about the maritime education, training and certification systems at EU level, aims to provide reliable information on the availability of masters and officers to EU Member State-flagged ships. EU Member States can also send data on ratings on a voluntary basis.

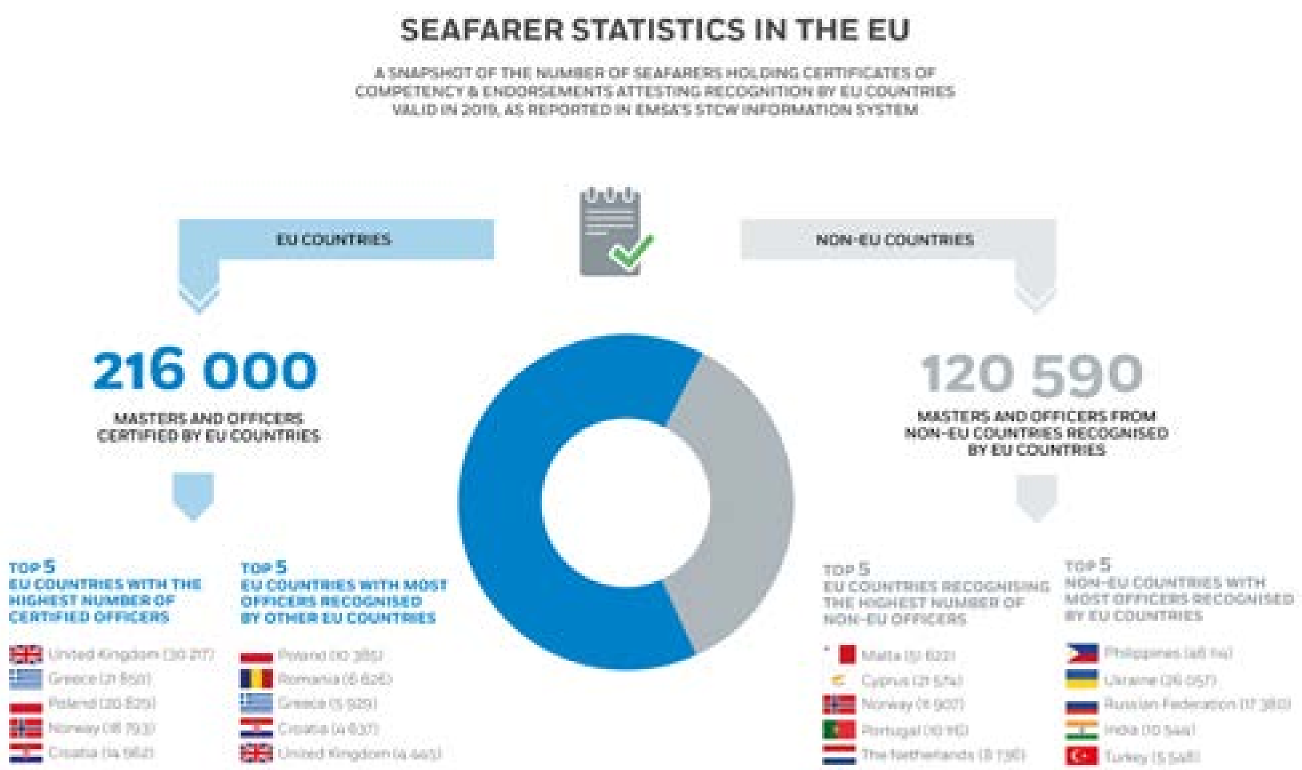
Since 2014, following the 2012 amendment to Directive 2008/106/EC, Member States are required to send to EMSA on an annual basis data on certificates of competency (CoC) issued to masters and officers, and endorsements attesting recognition (EaR) issued to masters and officers from other countries. CoC are necessary for masters and officers to work on board and when these certificates are not issued by the flag state of the ship, EaR of the original CoC have to be issued. The data, received in anonymised form, is processed through the STCW-IS and an annual statistical review is published.

The data included in the latest STCW-IS annual report shows that by the end of 2019, 216,000 masters and officers held valid CoC issued by EU Member States while another 120,590 masters and officers held original CoC issued by non-EU countries with endorsements issued by EU Member States attesting their recognition (EaR). Overall, 2019 ended with a third of a million masters and officers as potential manpower to serve on board EU Member State-flagged ships.

The five EU Member States that had the most masters and officers holding CoC issued by them in 2019[17] were the United Kingdom[18] (30,217), Greece (21,850), Poland (20,829), Norway (18,793), and Croatia (14,962). The five non-EU countries which had the most masters and officers holding CoC recognised by EU Member States were the Philippines (46,114), Ukraine (26,057), the Russian Federation (17,380), India (10,6544) and Turkey (5,548).

EMSA is currently working on a project called the EU Seafarers Certification Platform which aims to assist EU Member States in the process of issuing e-certificates. This is still at an early stage and in the coming years is expected to become one of the Agency's flagship projects. Importantly, it will facilitate the publication of regular data on seafarers.

Figure 27: Seafarer Statistics in the EU (2019).



Source: EMSA/STCW-IS

17 Valid in 2019, not necessarily issued in 2019.

18 The latest available annual statistical review from 2019 uses a pre-Brexit dataset where the United Kingdom is included.

2.1.3.2 Human element deficiencies in Port State Control

Between 2016 and 2020, 4,875 STCW deficiencies were identified during PSC inspections. These deficiencies are related to the STCW Code Part A which contains mandatory provisions that detail the minimum standards required to give full and complete effect to the provisions of the STCW Convention.

From the analysis carried out for the PSC section, most of the deficiencies since 2016 are linked to the STCW Code, Part A, Chapter VIII which sets out standards regarding watchkeeping, such as hours of rest. Next in line is deficiencies linked with Chapter I with 1,418 deficiencies recorded. This chapter regulates standards regarding general provisions, for instance, standards governing the use of simulators. In third place is Chapter II with 340 deficiencies and concerns standards relating to the master and deck department, such as the mandatory minimum requirements for the certification of ratings forming part of a navigational watch.

Moreover, looking at the comparison between the number of deficiencies and the total number of inspections per year, on average there is one deficiency related with working and living conditions found in every other inspection.

Table 14: STCW PSC number of identified deficiencies in the period 2016-2020.

STCW	Part A	Part A Ch.I	Part A Ch.II	Part A Ch.III	Part A Ch.IV	Part A Ch.V	Part A Ch.VI	Part A Ch.VIII	
No. of deficiencies	216	1,418	340	206	30	63	163	2,439	4,875

Source: EMSA/THETIS

Table 15: Number and frequency of deficiencies related with working and living conditions found in the past 3 years under port state control.

	2018		2019		2020	
Category of deficiencies	**No. def**	**No. insp./def.**	**No. def**	**No. insp./def.**	**No. def**	**No. insp./def.**
MLC Title 1	76	186	44	320	19	550
MLC Title 2	359	39	332	42	275	38
MLC Title 3	2006	7	2203	6	1595	7
MLC Title 4	3218	4	3246	4	2770	4
Total	**5659**	**2**	**5825**	**2**	**4659**	**2**

Source: EMSA/THETIS

Minimum requirements for seafarers to work onboard a ship (MLC, Title 1) is the category with the least deficiencies registered throughout the years among the working and living conditions group and this is a decreasing trend. In 2020, on average there was one deficiency found every 550 inspections, a third of the average found in 2018. A minimum requirement set out in this section of the convention is that 16 years old corresponds to the minimum age allowed to work in any capacity on a ship to which the convention applies.

Deficiencies in the conditions of employment (MLC, Title 2) part are found every year with a frequency of around one in every 40 inspections. In addition, according to Table 15, deficiencies concerning the accommodation, recreational facilities, food, and catering (MLC, Title 3) were found once every eight inspections in the past few years.

Health care, safety protection and accident prevention of seafarers (MLC, Title 4) was the category with the most deficiencies found during 2020. However, a decreasing trend was observed between 2018 and 2019. On average, once every four inspections there is one deficiency found related to accident prevention (everything that may create risk onboard is reported under Title 4).

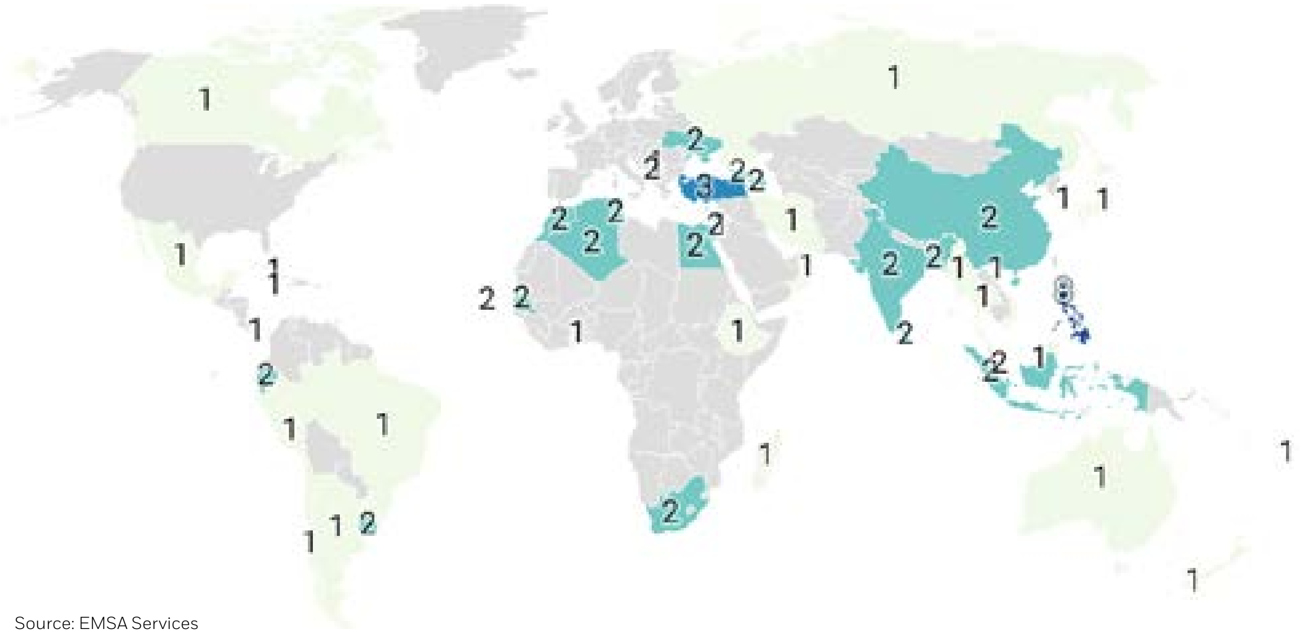
2.1.4 Education and training systems

The education system for maritime careers is not uniform throughout the European Union. Each country determines its own educational and training systems, some may have access to a maritime career during secondary education, others through higher education or polytechnic institutes. Therefore, the academic level reached at different stages constitutes a barrier to the mobility of seafarers within the European Union, such as for example students wishing to participate in an Erasmus programme.

It is also worth mentioning that EU Member State-flagged ships can have on board seafarers educated, trained, and certified both inside and outside the EU; something that should be accounted for when determining the best methods to ensure that crew members on board EU registered ships are appropriately educated and trained. Directive 2008/106/EC introduced a specific procedure based on which the assessment of compliance with the STCW Convention by non-EU countries is centralised in the European Commission, so that their Certificates of Competency can be recognised by Member States and, accordingly, they can be allowed to work on board EU MS flagged ships. The European Commission, assisted by EMSA which carries out the necessary field inspections, assesses the systems implemented in non-EU countries on behalf of EU Member States and in line with the STCW Convention. All assessments take place based on a five-year cycle so that, in addition to the occasional evaluation of proposed new non-EU countries, each country that has already been recognised at EU level will be assessed regularly. The inspections conducted by EMSA, geographically summarised in Figure 28, are the basis for the assessments.

To this end, **more than 70 inspections of maritime administrations, education, and training institutes have been carried out in third countries around the world** to assess the compliance with STCW and, as a consequence of those, 49 non-EU States have been recognised.

Figure 28: Geographical distribution of EMSA's inspections to maritime administrations and education & training institutes in third countries since 2005.



Source: EMSA Services

In addition, the European Commission, assisted by EMSA, has also been given the task of verifying the levels of implementation of EU legislation relating to the education, training, and certification of seafarers in EU Member States. The associated visits to Member States are carried out by EMSA based on a five-year cycle. This allows the existence of mutual recognition of certificates among Member States.

2.1.5 Status

EU countries, together with some other IMO members and observers, put forward a proposal for a comprehensive review of the STCW Convention. The previous comprehensive amendment took place more than 10 years ago (in 2010) and major revisions are anticipated every 10 years. It is expected that if this proposal is adopted in April 2022 during MSC 105, the work will be initiated in 2022 and may last until at least 2026. The amendments will have to take into account the current developments in shipping and need to be a tool to improve maritime safety in the coming years through the education, training, and certification of seafarers.

Finally, it should be noted that the EMSA Annual Overview of Marine Accidents and Incidents reports a decrease in accidents/incidents. However, this needs to be taken with some caution as in 2020 there was a reduced traffic due to the Pandemic. The reports of the following years will be important to confirm or not such trend as well as whether there is any identification of the relevance of the human element.

2.2 Ship safety standards and marine equipment

2.2.1 Introduction

The standardisation of any industry is a key element for its growth at global scale. However, economic factors should always be balanced with a proper safety level, to minimise accidents which can bring fatalities, injuries, loss of property and damage to the environment. As shipping is a global industry, a level playing field is required for all economic actors so that the competition is based on service, specialisation, etc., but not on safety. To achieve this objective, the United Nations (UN) created the IMO, a specialised UN Agency to harmonise the minimum safety standards that ships trading internationally should meet.

Several conventions have been concluded at IMO in different fields. SOLAS (Safety of Life at Sea) is the main convention dealing with maritime safety and has several associated codes. The safety standards have been, until recent times, based exclusively on prescriptive requirements according to the existing technology at the time of drafting the relevant regulation. This approach facilitates a uniform implementation but hampers the introduction of new technologies into the market. To overcome this obstacle, the prescriptive requirements have been complemented, in some limited cases, with goals as well as with functional and performance requirements according to the so-called Goal Based Standard (GBS) framework. Another way to introduce new technologies under the SOLAS Convention is through the Alternative Design framework, which requires an equivalent safety analysis on a case-by-case basis. However, this approach may present some disadvantages, which are further explored in this section.

The IMO cycle to develop safety standards is quite complex, due to the multi-layered approach of committees and sub-committees which must discuss and approve any new proposals. In the case of the EU, the internal mechanisms to submit a proposal to the IMO, which include the technical groups, the European Commission's internal consideration, and the European decision at Council level, must be added to this complex set-up. Finally, the fact that most new standards are not applicable retroactively, through the so-called grandfathering clause, means that a real change in the level of safety when a new safety standard is proposed can take decades.

On certain occasions, the EU, to speed up the implementation process of a certain requirement or to increase/complement the safety level agreed at IMO, has also developed several pieces legislation applicable to EU-flagged ships or ships visiting EU ports engaged on international and domestic voyages. This is the case, for example, in the specific damage stability requirements applicable to ro-ro passenger ships.

In principle, any major new introduction or modification of a safety standard must include a complete risk assessment, balanced with an economic analysis which justifies that the new measure is cost-efficient, i.e., that the risk avoided in economic terms is not achieved at a disproportionate cost for the industry. This means, in practice, assigning a cost not only to property but also to human life. This approach is common to most industries and in the maritime sector is called the 'Formal Safety Assessment', which is the equivalent to the impact assessment at EU level.

Complementing SOLAS and EU legislation are standards established by specialised technical bodies, the Classification Societies, which cover elements like structure, mechanical and electrical elements, etc., which are essential to ensure the seaworthiness and safety of ships. And finally, there are non-specialised standardisation bodies, like the International Organization for Standardization (ISO), the European Electrotechnical Committee for Standardisation (CENELEC), etc., which cover gaps left by the other two regulatory layers in very specific areas like testing. In this regard, the Marine Equipment Directive complements the IMO requirements through the specification of relevant standards for safety equipment to be installed on board EU Member-State flagged ships so that there is harmonisation at the safety level.

Table 16 lists the international and EU legislation on ship safety standards.

2.2.2 Development of Standards

2.2.2.1 Triggering elements

The main factors triggering the introduction/ modification of standards are the following:

- **Lessons learnt coming from accident investigation**

This is the main source of new safety proposals. The investigation reports of serious and very serious accidents, developed by the flag states concerned, include safety recommendations to be implemented by different actors. Some of the recommendations are related to the need to improve certain standards which were considered not to provide a sufficient safety level and are discussed, where appropriate, within the IMO framework. When several accidents point in the same direction, then there is a need to take action. However, such action requires time, determination, resilience, and investment from interested parties to develop comprehensive scientific studies with cost-benefit analysis. In general, flags alone lack the financial and human resources to carry out a project of this nature, especially if it covers a high number of technical elements. The EU's common action in these cases provides efficiency and facilitates cooperation.

This is more easily illustrated via an example. In 2012, the UK submitted a paper to the IMO (FSI 20/5/3) asking the IMO to consider the safety issues arising from several RoPax fire accidents. Unfortunately, this paper passed relatively unnoticed through the IMO and remained dormant for some time. After the very serious accident involving the Norman Atlantic in December 2014, which caused at least 22 deaths, the EU took up the initiative.

Table 16: Legislation on ship safety standards.

	Level	Instrument	What it regulates
Legislation	International	SOLAS	Promoting safety of life at sea by establishing in common agreed uniform principles and rules in the construction, equipment and operation of merchant ships.
		COLREG	Safety of navigation in preventing collisions at sea.
		International Convention of Load Lines	Limiting the draught of the ship by establishing minimum freeboard as a buoyancy reserve.
		Cape Town Agreement (not in force)	Safety of fishing vessels by establishing minimum standards for construction and outfitting of such vessels.
		FAO/ILO/IMO 2005	Voluntary guidelines for the design, construction and equipment of small fishing vessels.
		Convention for Safe Containers (CSC), 1972	Ensuring safety in the handling, stacking and transporting of containers.
	EU	Directive 2009/45/EC	Safety rules and standards for passenger ships.
		Directive 2003/25/EC	Specific stability requirements for ro-ro passenger ships.
		Directive 98/41/EC	Registration of passengers
		REGULATION (EU) No 530/2012	The accelerated phasing-in o double hull or equivalent design requirements for single hull oil tankers.
		Directive 2001/96/EC	Requirements and procedures for the safe loading and unloading of bulk carriers.
		Directive 97/70/EC	Safety regime for fishing vessels of 24 metres in length and over.
		Directive 93/103/EC	Minimum safety and health requirements for work on board fishing vessels.
		Directive 20014/90/EU	Marine Equipment Directive
		Regulation (EU) 2021/1158	Design, construction, performance requirements and testing standards for marine equipment.
		Regulation (EU) 2018/608	Technical criteria for electronic tags for marine equipment.
		Regulation (EU) 2018/414	The identification of specific items of marine equipment which can benefit from electronic tagging.

In 2015, the first workshop to deal with this topic was organised by EMSA and an EU expert group was formed. The result was two studies (FIRESAFE I and II) commissioned by EMSA which ended up in an EU submission to the IMO and subsequent Interim Guidelines being approved at IMO level in 2019. Currently, the corresponding amendments to improve the safety standards are being discussed at IMO and it is expected that the amendments will be in force from 2024.

Ideally, safety standards should be upgraded before accidents happen, but unfortunately this is not always the case. It is not due to a lack of will by industry, but rather because elements that fail that are difficult to predict. As shown in Figure 29, the major IMO conventions came after catastrophic accidents.

- **Updating outdated standards**

The current SOLAS Convention in force dates back to 1974. On several occasions, this convention has been amended for safety concerns. However, there are certain elements of the convention that, due to lack of time or momentum, were never updated in line with new technology and are implemented through common practices established by industry but not supported by the regulations in force. A clear example of this can be found in the current steering and manoeuvrability standards. They were developed with a traditional propeller plus rudder set-up in mind. Since the regulation was drafted, several new technologies have emerged which are commonly used by the industry today, like pods, azimuthal thrusters or Voith-Schneider propellers.

Following an initiative from IACS to update these requirements, EMSA launched a study called STEERSAFE to address this topic and specify the amendments that SOLAS requires in order to be aligned with the latest technologies. Submissions were sent to IMO in this respect; however, due to the heavy workload at IMO, it is likely that the consideration of this proposal will be severely delayed.

- **Clarification of vaguely defined standards thereby making implementation difficult**

On many occasions, the final drafting of a requirement leaves elements open for interpretation. These elements are, in general, addressed by the International Association of Classification Societies (IACS) which proposes Unified Interpretations (UI) to be used when implementing a certain safety requirement. The UI have two sides: on one hand, they provide for a clear basis for approval; but, on the

Figure 29: Shipping conventions and the events that triggered them.

Source: MarineInsight

other hand, they do not ensure that all flags will adopt the IACS UI. Around 60% of the world fleet is classed by IACS members, rising to almost 80% in terms of tonnage. This means that the UI have a substantial global impact but are nevertheless not always adopted by flags and/or classification societies other than IACS members. Although an IACS UI often becomes an IMO UI, the ideal situation would be to integrate, where possible, the contents of the UI within the relevant conventions.

- **Environmental challenges**

The European Maritime Transport Environmental Report (EMTER[19])report indicates in detail the environmental challenges that maritime transport is facing. These challenges may imply, in many instances, changes to the ship design that have an impact on safety standards. For instance, the adoption of cleaner fuels will require a number of safety standards to be developed to address the associated emerging risks of the use of ammonia and hydrogen, for instance. This topic is dealt with in more detail in Section 4 where alternative fuels are analysed from a safety point of view.

- **New technologies**

In terms of technology, the maritime industry is at a crossroads, with substantial change on the horizon. On the one hand, the environmental challenges bring a need to replace current fossil fuels by cleaner alternatives which include hydrogen, ammonia and, in some cases, especially short-sea shipping, large batteries. These alternative fuels imply profound changes in business logistics and ship design, but also new safety risks that must be appropriately handled. And on the other hand, the increase in autonomy on board ship systems will gradually entail new business models with a potential transfer of persons from ships to onshore stations. These new developments will have associated implications for maritime safety, which are difficult to anticipate but which will include topics like responsibility and accountability, the increasing role of communications, remote control systems, maintenance, etc. The change will be gradual and, therefore, there could be a long period, perhaps decades, where more automated ships will co-exist with 'analogic' ships, so creating a dual system of standardisation and operation.

19 European Maritime Transport Environmental Report (EMTER) jointly produced by EMSA and the EEA in 2021 (http://emsa.europa.eu/publications/reports/item/4513-european-maritime-transport-environmental-report-2021.html)

2.2.2.2 Methodologies

Irrespective of the motivating factor behind introducing a new safety standard, there are several existing methodologies to address their development depending on the circumstances. The main ones are listed below:

- **Goal-based standards**

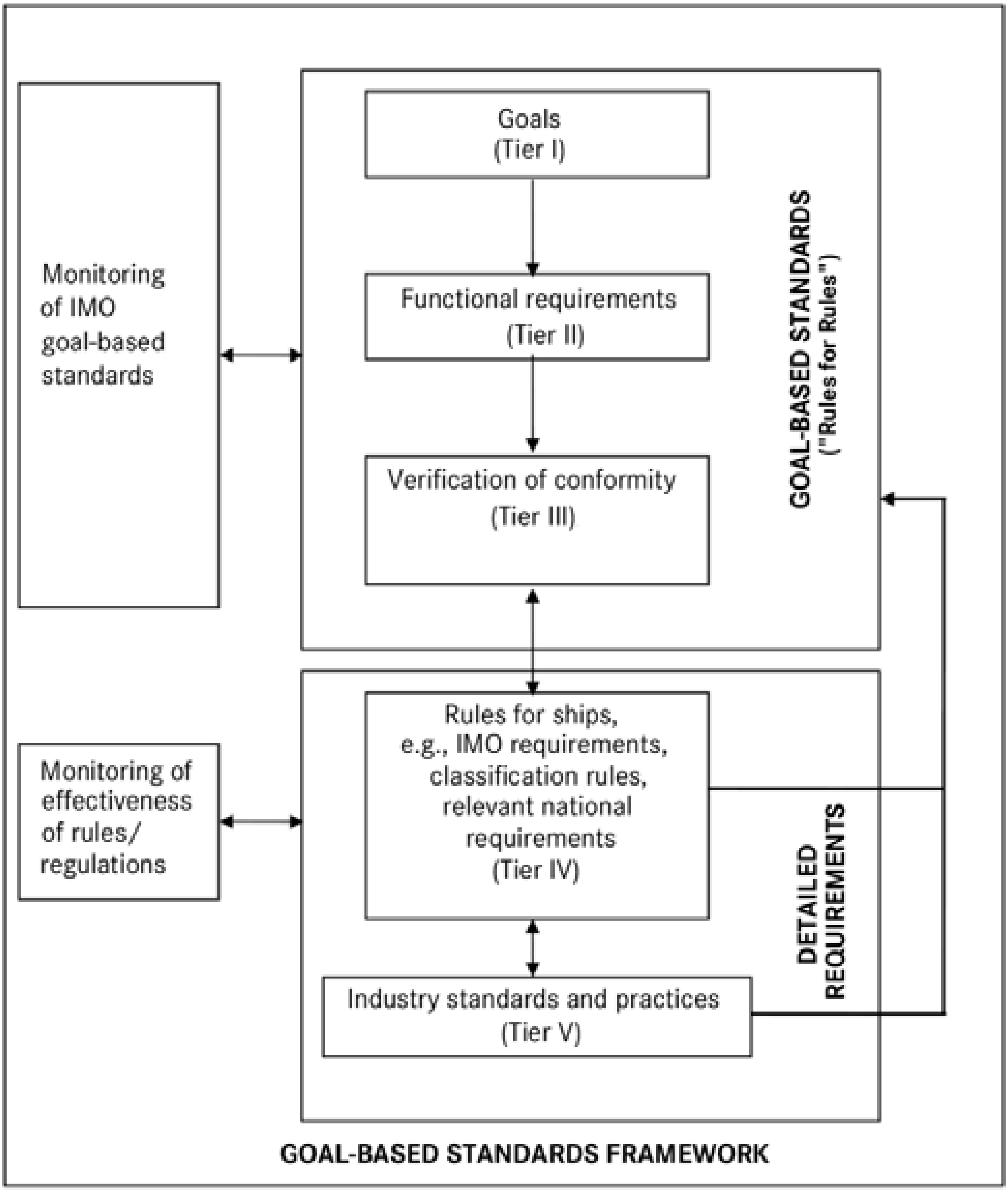
The goal-based approach is a regulatory approach which establishes a methodology to develop regulations, i.e., they are rules for rules. The methodology has a hierarchical structure of principles (tiers), starting with the more general principles (goals and functional requirements) and finishing with detailed rules and industry standards. Between the general principles and the detailed rules is a verification procedure through which it should be possible to assess whether the detailed rules fulfil the general principles.

Within the maritime safety sector, the benchmark for a goal-based approach is the IMO model known as Goal Based Standards (GBS).[20] Although it is considered a robust model from a theoretical point of view, in practice it has not always been easy to achieve practical results. Figure 30 shows the main steps in the GBS methodology.

Each tier increases the level of detail. A common misunderstanding of this methodology is to assume that the GBS finishes with the definition of Tier II, i.e., the functional requirements which are providing general principles. This leads some industry stakeholders to claim that GBS methodology is not effective for practical implementation as, when designing, building, or modifying a ship, detailed safety requirements are needed. It is clear that a standard ship cannot be built based on the general principles of Tiers I and II, however, it is usually overlooked that the GBS exercise is only finalised when detailed prescriptive requirements (Tiers IV and V) are established, and those can be indeed used in shipbuilding.

20 MSC.1/Circ.1394/Rev.2 GENERIC GUIDELINES FOR DEVELOPING IMO GOAL-BASED STANDARDS

Figure 30: The Goal Based Standards framework.



Source: IMO (MSC.1-Circ.1394)

What is then the point of developing goals and functions if only the detailed requirements are needed? Are Tiers I and II purely academic? There are several advantages of developing Tiers I and II:

- Tiers I and II require a hazard identification exercise and based on them, functions are established. Accordingly, when carrying out the verification exercise, i.e., checking that the detailed requirements match the functional ones (Tier III), it is confirmed that all the relevant hazards are properly addressed by the detailed regulations.
- Tiers I and II are drafted in a technology-neutral way. This means that new technologies, which do not match the existing detailed regulations, can be introduced as long as Tiers I and II are respected. On the one hand, this implies that the technological development is not hampered by regulatory barriers and, on the other hand, that they provide a valuable reference for the flag administration when assessing the safety level of the new technologies.
- A similar reasoning to the previous paragraph can be made in the case of non-standard ships to address a very specific need.
- Usually, the development of regulations following the GBS model can take years of work and involve the participation of many specialists in the field. Such a model has been used until now for a specific part of certain ship types, e.g., Common Structural Rules (CSR) for tankers and bulk carriers. The Polar Code has also been developed following GBS standards, although the functional requirements lack performance requirements and hazards. Chapter II-2 of SOLAS was also framed taking into account the GBS philosophy, although in a more generic way. Finally, at EU level, Tiers I and II were developed for passenger ships of less than 24 m operating domestically[21].

Formal Safety Assessment (FSA)

In general, a Formal Safety Assessment (FSA) is used in the IMO to modify/upgrade relevant regulations ensuring that the risks are appropriately addressed and, at the same time, that the cost of implementing risk control options is proportionate to the risk reduction.

The FSA and GBS methodologies can be combined, however, this is not usually the case. The common step of both methodologies is the hazard identification, but GBS is used for more transversal topics or when there is a need to develop a new instrument, e.g., the Polar Code, whereas the FSA is more efficient (with a real impact on regulation) when upgrading specific existing standards, e.g., damage stability of passenger ships. The FSA methodology is quantitative by nature, as risks have to be characterised and calculated, as well as the impact of the correction measures, the so-called Risk Control Options (RCO), to establish a safety level. A key part of the FSA is the cost-benefit analysis, where the costs of RCO are balanced with their risk reduction in terms of potential loss of life, property, and environmental damage. If the RCO proves to be cost-effective, then, it must be proposed to be implemented through regulatory amendments. The cost-effectiveness of RCO can be verified both for new-buildings and existing ships. An advantage of the FSA methodology is the transparency and verification. The IMO has an ad-hoc group, the FSA expert group, which analyses and assesses each FSA submitted to the IMO to ensure that the methodology is complied with. An example of this FSA can be found in the EMSA studies FIRESAFE I and II, which addressed the fire safety of ro-ro decks on passenger ships. Figure 31 shows the areas covered by this studies.

Many RCO were assessed, resulting in a number of them proving cost-effective, and subsequently proposed to the IMO as amendments to the regulatory framework. The result was the development of interim guidelines[22] and several amendments which are being discussed in the SSE Sub-Committee.[23]

21 COUNCIL RECOMMENDATION of 9 April 2019 on safety goals and non-binding functional requirements for passenger ships below 24 meters in length (2019/C 142/01).

22 Interim Guidelines for minimizing the incidence and consequences of fires in ro-ro spaces and special category spaces of new and existing ro-ro passenger ships (MSC.1/Circ.1615).

23 More information can be found on the EMSA website: http://emsa.europa.eu/firesafe.html

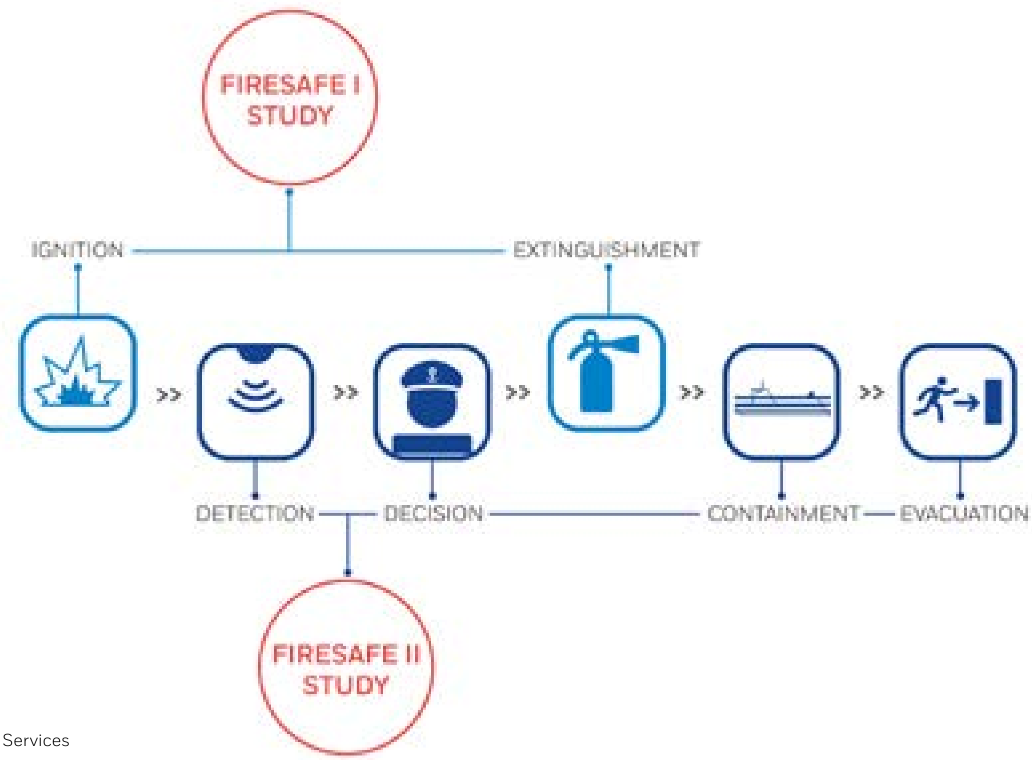
Alternative Design

The Alternative Design is a methodology used at IMO when a specific ship needs to deviate from the prescriptive requirements of SOLAS, and the IMO has developed relevant guidelines for its use. The Alternative Design approach, contrary to GBS and FSA, is in general applied to a specific ship and is approved by the relevant flag on a case-by-case basis (although, on many occasions, the analysis made for one ship is used for other cases). Once an Alternative Design is approved, the IMO should be informed.

The main disadvantage of this methodology, with respect to the other two, is transparency. Firstly, not all the cases are reported to the IMO and, secondly, there is no need to submit the engineering analysis to the IMO; only a notification is required. Accordingly, there is no expert group or sub-committee that reviews the Alternative Design. If the system is abused by a flag state, there is no control element that can be used to avoid it.

The Alternative Design was developed not to allow the safety level to decrease, but to ensure that innovative elements introduced on a particular ship provide a level of safety equivalent to that of the applicable regulations. A well-known case of Alternative Design has to do with maximum lifeboat capacity. According to the Life-Saving Appliances Code, included in SOLAS, “No lifeboat shall be approved to accommodate more than 150 persons.” This limitation mainly centres on the time needed to enter lifeboats in the event of an accident. However, on large passenger ships, this implied the installation of many lifeboats thereby restricting the space dedicated to cabins. To avoid this problem, some lifeboat manufacturers carried out an engineering analysis to establish that there would be no decrease in the safety level if the lifeboat capacity were to be increased. The analysis was accepted by a number of flags, to the effect that today it is considered normal practice to install such lifeboats, which can reach a capacity of almost 400 people, on board large passenger ships. An Alternative Design, in this case, became a standard design.

Figure 31: The EMSA studies FIRESAFE I and II - fire safety areas covered.



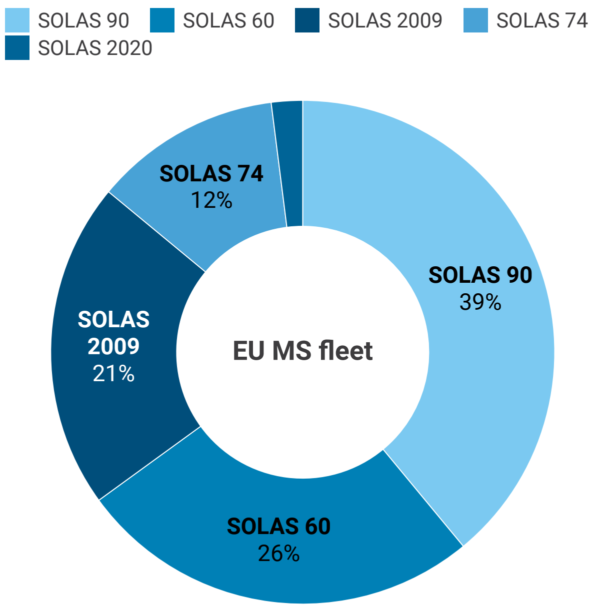
Source: EMSA Services

2.2.2.3 Cycle to develop safety standards and consequences

As indicated above, the cycle of proposing, discussing, and approving new safety requirements, and their subsequent entry into force, is a complex and lengthy process. However, developing a new requirement will not produce any real effect in safety unless it is implemented in practice. Taking into account that, in most cases, new safety requirements are not applied retroactively, but only on ships yet to be constructed (due to the grandfathering clause), the real effect of a new requirement in the fleet can take decades. This can mean that certain safety improvements become outdated and need to be replaced before they have a global effect on safety. Another consequence of the grandfathering clause is that there can be ships with different safety levels operating in the same routes and areas of maritime traffic for long periods of time, something that maritime users, like passengers, are often not aware of.

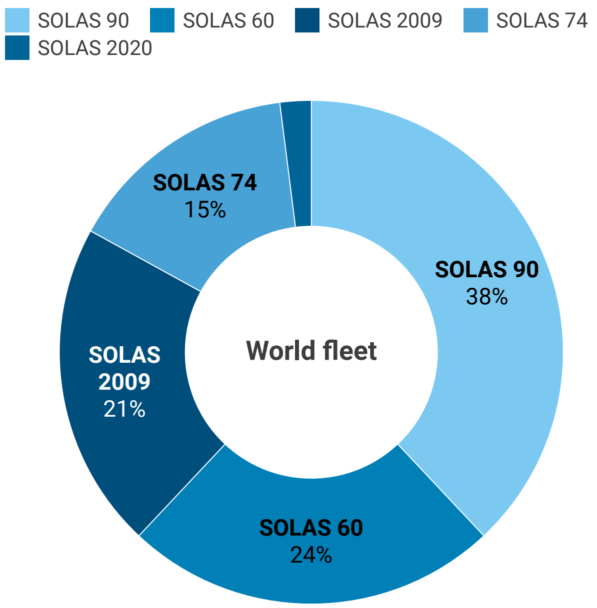
A good example of this can be seen in the damage stability requirements for passenger ships. The previous SOLAS Convention, known as SOLAS 60, had certain damage stability requirements which were upgraded in subsequent versions (SOLAS 74, SOLAS 90, SOLAS 2009 and finally SOLAS 2020). Each update brought a safer standard due to lessons learnt from accidents, but in general, none of these upgrades were retroactively applied, meaning that ships built before certain dates could continue sailing without any modification. The consequence is the picture that can be seen in the following graphs, where the world and EU Member States passenger fleet is classified according to the damage stability standards applicable at the date of construction:

Figure 32: Passenger ships under different SOLAS damage stability requirements based on date of build – EU MS fleet.



Source: EMSA Services

Figure 33: Passenger ships under different SOLAS damage stability requirements based on date of build – World fleet.



Source: EMSA Services

As shown, there is hardly any difference between the EU Member State fleet and the world fleet from an age profile perspective. It can also be seen that less than 25% of the fleet was built following the mandatory introduction of the probabilistic method to calculate damage stability (SOLAS 2009), and around 40% was constructed before SOLAS 90 became mandatory, which was a standard developed following the Herald of Free Enterprise accident, where 193 persons lost their lives. SOLAS 90 introduced important upgrades in terms of residual stability and factors to be considered like passengers crowding on one side, wind, etc.[24] This means that the fleet has a very heterogenous safety level as far as damage stability is concerned.

It is also interesting to note the time it takes for a new requirement to have an impact and the quantification of such impacts. SOLAS 2009 was mandatory for 11 years, a period in which around 20% of the current fleet was built. This period can be added to all the years that it took for the new standard to be developed and approved. Therefore, in this case, it took around 20 years from the standard's development until the new improved safety level had a positive effect on a limited part (20%) of the world fleet before being replaced by another standard, the so-called SOLAS 2020.

This can be seen as controversial, but it has to be balanced with the huge economic investment of building a ship in general and a passenger ship in particular. These investments have a long-term perspective, around 25 years. Retrofitting a passenger ship to upgrade it to fulfil new damage stability requirements might imply, in some cases, heavy modifications in the ship's configuration which can be very costly and lengthy. It is in many cases not proportional to ask for such an upgrade on ships that have been recently built or are in the middle of their lifecycle.

But a mid-way approach was found when introducing other standards. One of the few cases where new standards were retroactively applied relates to the fire safety elements on passenger ships. In 1992, the IMO decided to require all passenger ships built according to SOLAS 60 standards to be retrofitted according to SOLAS 74 with a phased-in approach. The additional elements required, which included sprinklers, structural fire protection and ventilation improvements among many others, had to be upgraded, following a sequential timeline, until 2010 at the latest. This implied, in practice, that passenger ships which were 30 years old had to be either upgraded in terms of their safety level or phased-out. At this stage, all SOLAS 60 passenger ships, i.e., around 25% of the fleet, should have been upgraded.[25]

A conclusion that could be taken from this brief analysis is that, on many occasions, the increase in the safety level, if not accompanied by appropriate phase-out measures and financial support for fleet renewal in cases of passenger routes essential for public transport, can provoke an effect that is opposite to the one intended. This is particularly true in those cases in which the new requirements imply a significant investment. In this analysis, the damage stability example has been used. However, a similar issue is likely to arise with respect to Safe Return to Port requirements, where the operational life of the ship is extended to avoid the associated financial investments of the new requirements. It can be noted in the fleet data that the average age of passenger ships is almost double than that of tankers.

The grandfathering clause is a necessary practice when used for its original purpose: allow that existing ships complying with previous applicable rules within a certain market continue operating without the obligation of adapting to new costly requirements. However, this purpose can be distorted in certain instances. For example, the EU domestic passenger ship legislation was drafted in a way that domestic ships built before 1998 could continue operating without major adaptations to the new rules to avoid making them economically unviable. However, it was found during the EMSA RO inspections that some passenger ships built before 1998 were transferred from international to EU domestic traffic at a moment where a costly retrofitting according to the international legislation was due, e.g., upgrade of the fire safety standards of SOLAS 60 ships. This is absolutely legal but the grandfathering clause acted as a refuge for old ships which could not trade internationally due to their safety standards instead of being used for its original purpose, a recognition of the rights of existing ships operating in the domestic market before 1998. Recent proposals from the European Commission in the review of Directive 2003/25/EC go in the direction of avoiding an abuse of the grandfathering clause.

24 Vavourakis, Georgios, Deterministic framework for damage stability, presentation, Motorways of the Sea, https://www.onthemosway.eu/wp-content/uploads/2015/06/Deterministic-Damage-Stability.pdf

25 EMSA has been carrying out inspections to verify that these retroactive requirements were implemented. The results showed that on many occasions this is not the case. For more information, see the section on Flag State/RO.

2.2.3 Current safety agenda

This topic can be quite broad, so the scope of this report is restricted to those ships engaged on international and domestic voyages for which there are implications for the EU. It does not claim to be an exhaustive list, so only the most relevant topics will be introduced.

2.2.3.1 Passenger Ships

At international level, the main discussion topics are the following:

- **Amendments to fire safety requirements of ro-ro passenger ships:**

- As indicated above, these amendments are based on the FSA EMSA study FIRESAFE. The modifications will significantly increase the safety level of these ships. The additional elements built on the experience gathered in recent accidents like that of the Norman Atlantic or the Sorrento.

- One of the many lessons learnt from the Sorrento accident was that there was a need to further define the distance between side openings in the ro-ro spaces and life-saving appliances. The current legislation only indicates the following:

  "Permanent openings in the side plating, the ends or deckhead of the space shall be so situated that a fire in the cargo space does not endanger stowage areas and embarkation stations for survival craft and accommodation spaces, service spaces and control stations in superstructures and deckhouses above the cargo spaces."

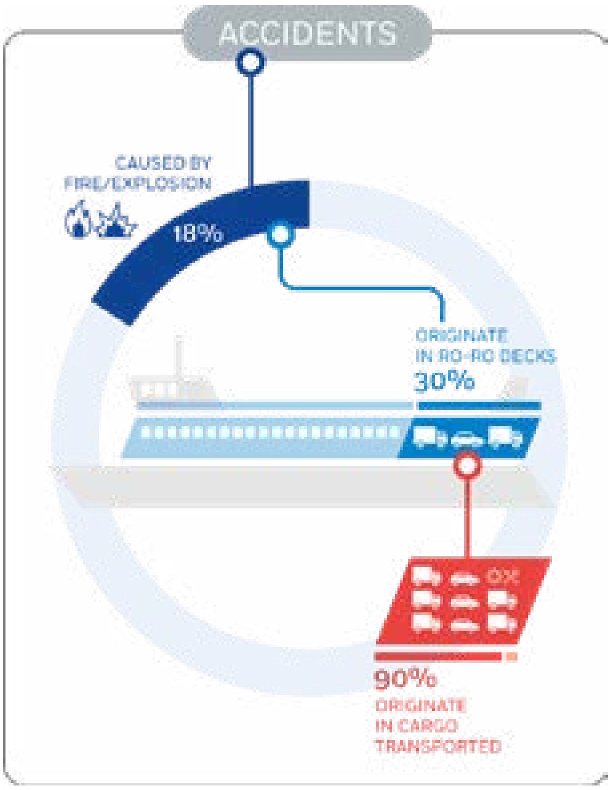
- The flames coming out of the permanent side openings burned the life-saving appliances, making evacuation difficult and only possible via aerial means. FIRESAFE, among other topics, proposed a minimum distance to avoid this situation from happening again in new ships.

Image 2: Fire onboard the Sorrento.

Source: Sociedad de Salvamento y Seguridad Marítima

- Other elements included in FIRESAFE and currently under discussion at IMO include improvements in fire detection, through additional detectors and CCTV systems, additional fire-fighting elements in weather decks, and the banning of permanent openings, as they contribute to decreased efficiency for detection and fire-fighting measures. As can be seen in the graph below, the vast majority of fires (90%) on ro-ro decks originate in the cargo transported, generally cars and trucks, the safety of which is difficult for ship operators to control:

Figure 34: Percentage of accidents caused by fire onboard Ro-Ro decks and the location of origin onboard.



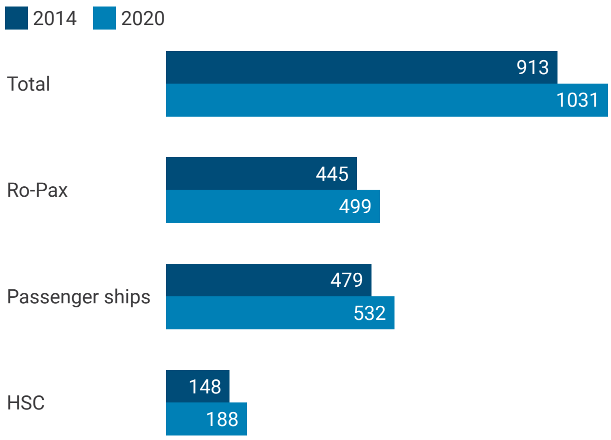
Source: EMSA Services

Status of EU passenger ship safety legislation:

At EU level, there are four pieces of specific legislation dealing with passenger ship safety which are further specified below. These directives were subject to a regulatory fitness and performance (REFIT) process that began in 2015 and which is still ongoing for one of the directives in question:

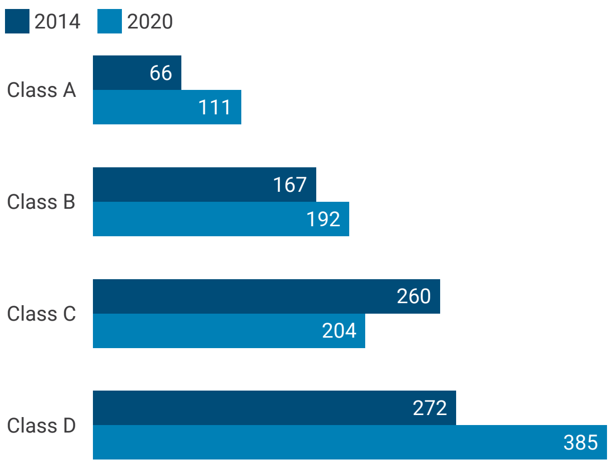
- Directive 2009/45/EC establishes the standards for passenger ships engaged on domestic voyages, as SOLAS only covers those ships engaged on international voyages. There are more than 1,000 ships covered under this directive. The fleet profile is summarised in the following graphs:

Figure 35: Evolution of EU domestic fleet of passenger ships. Comparison between 2014 and 2020.



Source: EMSA Services

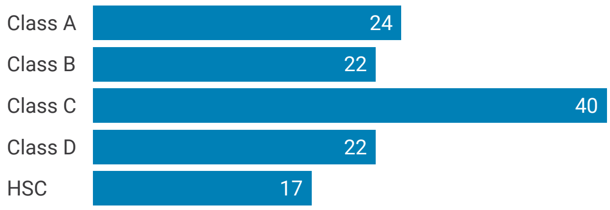
Figure 36: Evolution of the EU domestic fleet of passenger ships per class according with Directive 2009/45/EC. Comparison between 2014 and 2020.



Source: EMSA Services based on questionnaire to MS

As can be seen below, the average age of some of these ships is quite high.

Figure 37: Average age of passenger ships per class according with Directive 2009/45/EC in 2020.



Source: EMSA Services based on questionnaire to MS

Domestic passenger ships below 24 m in length were excluded from the scope of this Directive in 2019. To harmonise the safety standards of these ships, the European Commission, supported technically by EMSA, prepared a GBS guidance covering only Tiers I and II which was published in the form of a Council Recommendation[26], indicating that Member States should "support further analytical work with a view to identify and further assess the goals and requirements referred to in point (a) within the performance-based framework, and to identify and assess possible alternative forms for their verification and implementation. This analysis should include assessment of the wide variety of passenger ship types and sizes, materials of construction and operating conditions". To address this request, the European Commission launched a study, which is currently ongoing, to assess potential policy options. One of the key topics to address is related to the fire safety aspects of materials other than steel. Most of these ships are built with aluminium, fibre, or wood, for which there is no harmonised safety framework.

- Directive 2017/2110, establishing a special regime for the survey of RoPax is dealt with in a dedicated section.
- Directive 2003/25/EC establishes specific damage stability requirements for RoPax. A group of Baltic countries decided to sign an agreement in 1995, following the accident of the RoPax Estonia which led to more than 850 deaths.

  The so-called Stockholm Agreement established additional damage stability requirements for ro-ro passenger ships to take into account the effect of water accumulation on the vehicle deck. Some years later, the EU decided to apply such requirement to all ro-ro passenger ships operating to/from EU ports regardless of the flag and type of traffic (international/domestic) through Directive 2003/25/EC. This higher EU stability standard for ro-ro passenger ships in damaged condition is considered to address the higher vulnerability of these vessels in a proportionate and necessary manner. Currently, Directive 2003/25/EC is under revision following the adoption of new damage stability standards for passenger ships at IMO, the so-called SOLAS 2020 standards resulting from an EU submission.
- Directive 98/41/EC deals with passenger registration to facilitate search and rescue in the aftermath of an accident. The number and the identification of persons onboard must be recorded and transferred to a passenger register onshore. From 2023, the passenger details will be communicated using the National Single Window.

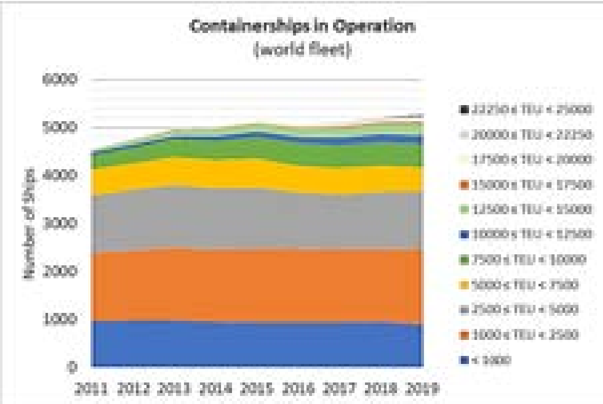
2.2.3.2 Containerships

Following recent high-profile accidents, like that of MSC Zoe with the loss of almost 350 containers at sea, or the fire on the X-Press Pearl, containerships moved up the safety agenda, especially with regard to two topics: loss of containers at sea and fires in cargo.

The continuous growth in size of this type of ship in the past decade, driven by economies of scale in the global trade of containerised goods, brings additional design and operational factors into consideration when analysing these safety challenges. As can be seen in the following graphs, whereas the overall container fleet has increased from 2011 to 2019 by around 15%, the container fleet above 10,000 TEU has increased by 500%. When looking at the fleet above 15,000 TEU the growth is even higher as presented in Figures 38 to 41.

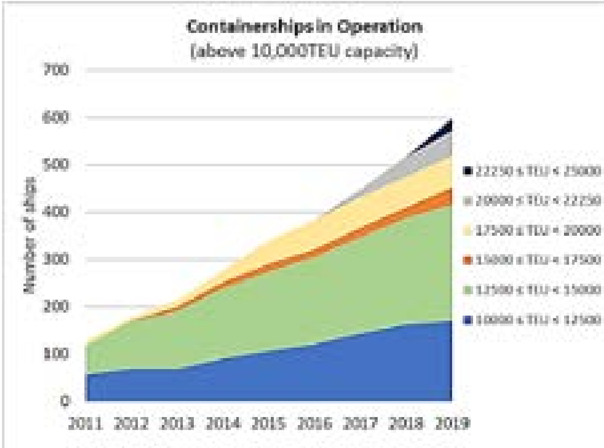
26 Council Recommendation of 9 April 2019 on safety goals and non-binding functional requirements for passenger ships below 24 meters in length (2019/C 142/01)

Figure 38: Evolution in number of containerships in the world between 2011 and 2019.



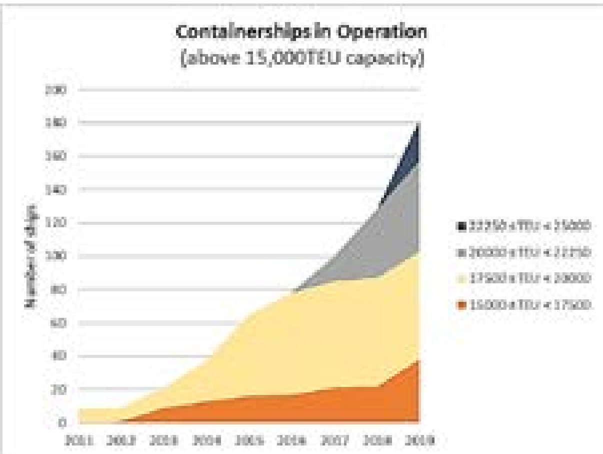
Source: EMSA Services

Figure 39: Evolution in number of containerships above 10 000 TEU capacity in the world between 2011 and 2019.



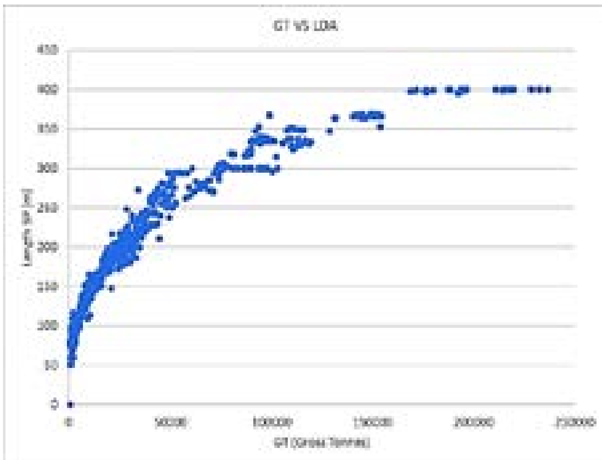
Source: EMSA Services

Figure 40: Evolution in number of containerships above 15,000 TEU capacity in the world between 2011 and 2019.



Source: EMSA Services

Figure 41: Gross tonnage and length of containerships.



Source: EMSA Services

We can also see in the graph that, despite the growth in size (GTs), the maximum length has been kept at an upper limit of around 400m, conditioned by berthing limitations and structural issues. However, the breadth has experienced an important growth, from approximately 50m to 60m, leading to increasingly stable ships.[27]

The main safety issues of containerships are analysed as follows:

- **Cargo fires:**

The increasingly high numbers and density of containers on and below deck, the very limited space between stacks and the configuration of the ship, which despite the significant increase in size has remained unaltered, means that any fire or explosion in the innermost containers is very difficult to detect at an early stage, control and/or extinguish.

In general, dangerous goods transported and cargo which potentially can ignite, should be located in areas where fire can be easily detected and extinguished. However, it is well known that on many occasions such goods are not declared or mis-declared in the documentation accompanying the containers. This means the master and crew are not aware of the associated risks and cannot take appropriate preventive measures according to the cargo manual

27 A direct relation exists between the breath of the ship and its transverse intact stability characteristics. Higher transverse stability may be associated to high roll accelerations, especially for intermediate loading conditions. Excessive roll accelerations may play an important role on the failure of cargo securing systems leading to loss of containers.

onboard. This non-declaration or misdeclaration of cargo is a key contributing factor to the cargo fires.

There are some recent examples of serious fires: YANTIAN EXPRESS (7,510 TEU, fire on 3 January 2019 – Image 3) and MAERSK HONAM (15,262 TEU, fire on 6 March 2018, five fatalities – Image 4).

Image 3: YANTIAN EXPRESS (7,510 TEU, fire on 3 January 2019).

Source: Hapag Lloyd

Image 4: MAERSK HONAM (15,226 TEU, fire on 6 March 2018).

Source: Indian Coast Guard

View of the damaged consumed forward cargo bay.

Both the EU and the IMO are taking steps to address this issue. The IMO has added this topic to its safety agenda following two requests from several parties, including the Bahamas, BIMCO Germany, IACS, the IUMI, the Marshall Islands, Singapore and WSC, "to amend regulations in SOLAS chapter II-2 and the FSS Code to enhance provisions for early fire detection and effective control of fires in containerised cargoes stowed on and under deck of containerships". In this regard, EMSA launched a study called CARGOSAFE to support the efforts made to tackle this problem and will follow the FSA methodology.

- **Loss of containers:**

The loss of containers at sea has an important impact, both on maritime safety and the environment. A ship's movement at sea, especially in bad weather conditions, cause accelerations and forces, particularly in the higher tiers, which can cause containers to fall if not properly secured.

SOLAS requires containerships, through the Code of Safe Practice for Cargo Stowage and Securing (CSS Code), to develop a Cargo Securing Manual tailor-made to the ship's design and the forces it is expected to encounter. The manual must be approved by the flag state. The master and crew must distribute the containers on board according to their weight and to the manual, although in this task they depend on the terminal operators following their instructions, which might not be always the case.

It is already mandatory that every container is weighed before being loaded on board, unless all the different cargo packages loaded into the container has been weighted in advance. The latter procedure increases the possibilities of false weight declarations, as the container is not actually weighted, so challenging the safety onboard.

In addition, the distribution of weight and the cargo stowage inside the container is out of the control of the crew. Furthermore, it has to be noted in this context, that very often planned stowage positions are not adhered to by the terminals. To address this problem, which can have serious consequences if not properly carried out, the IMO, together with the ILO and the United Nations Economic Commission for Europe (UNECE) developed the Code of Practice for the Packing of Cargo Transport Units (CTU Code), to advise those responsible on the safe packing of cargo transport units (CTU), including containers.

The strength of the container is also essential. Whereas most of the containers nowadays are built to a stacking strength of 213,000 kg, the IMO standards within the Convention of Safe Containers for testing is limited to 192,000 kg. Although all the containers should be marked with the maximum allowable load, this figure should be updated to avoid confusion.

With regard to accidents, a distinction can be made between cases where the origin comes from a ship accident (e.g., grounding) and those coming from a failure of the cargo system, as can be seen in the following images.

Image 5: MSC ZOE (2018) – loss of 342 containers in the North Sea.

Source: BSU / Netherlands Coastguard

Image 6: Close up view of wrecked container stacks onboard MSC ZOE (2018).

Source: NL/DSB

Note: In addition to lost containers, those that remain onboard can be seen as severely damaged.

Image 7: Svendborg Maersk, aft deck after arrival (517 lost containers, 2014).

Source: Maersk Line A/S via DMAIB

Image 8: MV RENA – Loss of 900 containers following grounding and consequential ship loss.

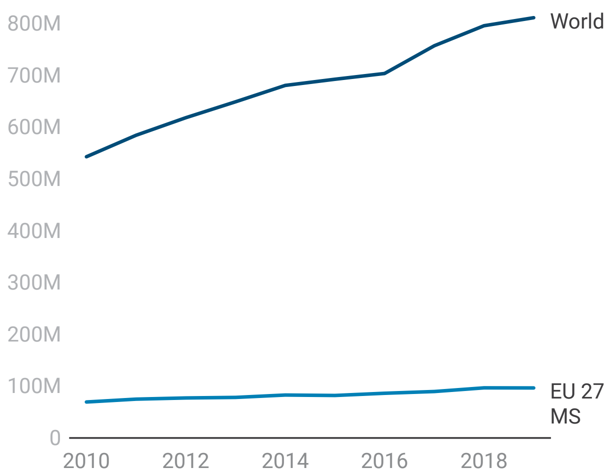
Source: New Zealand Defence Force, CC BY 2.0

The number of containers transported by sea in the world is indicated in Figure 42.

Several analyses have already been carried out on the number of containers lost at sea. The Surfrider Foundation Europe estimates that 16,635 containers were lost between 1994 and March 2019, i.e., around 665 per year. The World Shipping Council, in the IMO submission CCC 7-14-2 estimates the average number of containers lost at sea at 1,382 units per year over the period 2008-2019, and 612 excluding catastrophic events, as indicated in Figure 43.

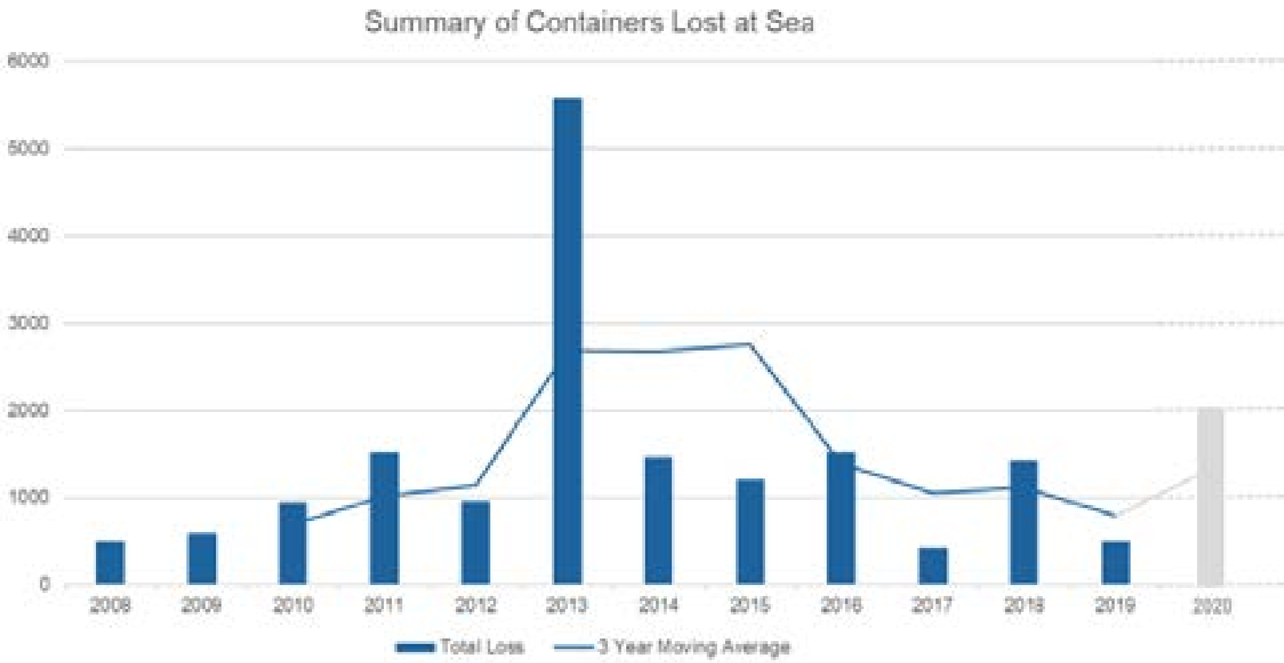
Data reported to the The European Casualty Information Platform (EMCIP), an EU-wide database managed by EMSA, is also an important reference that provides a good proxy estimate of the containers lost in EU waters as shown in Figure 44.

Figure 42: Number of containers transported in the world and in EU ports.



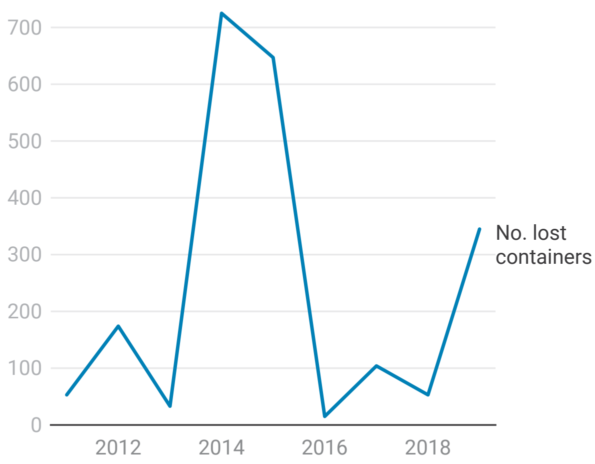
Source: UNCTAD (https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=13321)

Figure 43: Updated statistics on lost containers at sea.



Source: World Shipping Council, edited by EMSA with addition of the rightmost column presenting data from 2020.

Figure 44: Annual loss of containers at sea [9].



Source: EMSA/EMCIP

Overall, it can be estimated that, on average, between 550 and 2,000 containers are lost at sea each year around the world, depending on the different sources available. Considering that the number of containers transported in the world in 2019 was around 800 million per year and around 100 million in EU ports, it can be concluded that the containers lost at sea represent, at a maximum, 0.0006% of the all the containers transported by sea in the EU. The percentage at global level is similar. Despite this figure, lost containers have an impact in society which the competent authorities must address. A recent example was the accident involving the MSC Zoe in the North Sea, which resulted in the loss of 342 containers. As a consequence, the Netherlands initiated an investigation of the causes, a qualitative risk analysis and a targeted inspection campaign. The main conclusions from the study were that there were four main topics:

- design specifications of ships, container capacity or the lashing system limits were exceeded;
- weight in the container pile was too high or improperly distributed;
- the container or the cargo in the container was not properly secured; and
- there were excessive movements of the ship.

The inspection campaign covered 64 containerships inspected over 2 months in 2019. Deficiencies were found in 67% of the ships in relation to the loading and securing of containers and lashing materials used. The main conclusions include:

- containers found not to be secured according to the cargo securing manual in 36% of the inspected vessels;

- different lashing materials were used interchangeably, in many occasions deviating from the cargo securing manual and confusing crew and lashers;
- on 86% of the inspected ships, less lashing material was used than what the cargo securing manual required;
- 11 ships (close to 20% of the total ships inspected) used damaged lashing material;
- incorrect use of lashing equipment (by crews or lashing companies). Turnbuckles and twist locks often placed in an incorrect position;
- due to the size of the ships, it was confirmed the crew cannot check all lashings before departure.

The WSC, together with ICS and BIMCO, made a statement at MSC 103 (see Annex 16 of the MSC 103 report) which includes several factors to be addressed to avoid the loss of containers. In addition, in the submission MSC 104/17/4, several parties, including France, Germany, France and the Netherlands, advocated the requirement for a holistic approach to deal with the loss of containers at sea, and highlighted the joint industry project Top Tier JIP, a joint industry project which aims to lower the probability of lost containers at sea.

Regardless of the measures taken, accidents do happen, and a coordinated response to the containers lost at sea should be taken, as they can constitute a navigation hazard. The IMO, at the request of several parties, including the European Commission and EU Member States, agreed to include a new agenda item: "Development of measures regarding the detection and mandatory reporting of containers lost at sea that may enhance the positioning, tracking and recovery of such containers" to address this issue.

Structural strength:

With regard to structural strength, following the accident reports of the MOL Comfort (2013) and the subsequent paper to the IMO by Japan and the Bahamas (MSC 95/16, dated 1 April 2015), which included recommendations with regard to the structure of large container ships, IACS established a project team to tackle the topic. The result of this work was the publication of two IACS Unified Requirements (UR S11A and UR S34). Ongoing work relevant for containerships is triggered by improved insight in wave environments and hull girder whipping. Progress of this development was reported to MSC 103 (MSC 103/20/3). Updates of longitudinal strength requirements of all ships, including containerships can be expected, according to the current plans, during 2025.

Image 9 (a) and (b): MOL Comfort (8,100 TEU, 2013, total ship loss in the Arabian Sea), broken in two following primary hull girder failure.

(a)

(b)

Source: MRCC Mumbai

Still afloat in these pictures, the forward part of the MOL Comfort caught fire in containers containing dangerous goods and subsequently sank. The aft part was subject to a complex towing operation which culminated in the loss of the whole section following a dramatic loss of stability and water ingress. The MOL Comfort was the largest containership ever to declare a total loss.

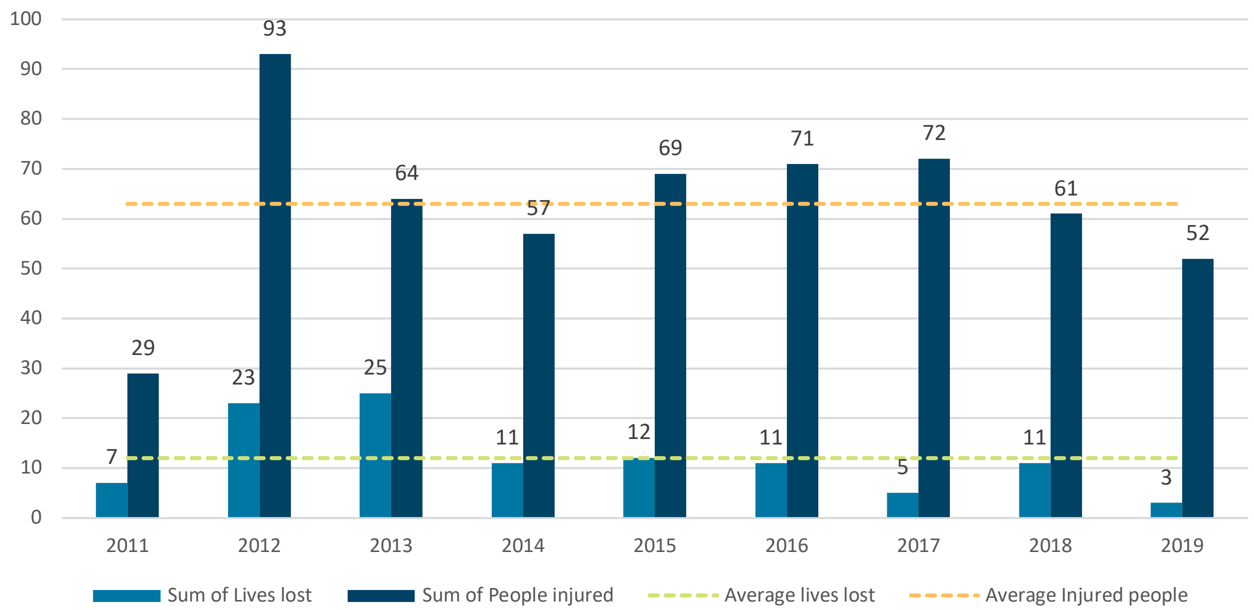
The MV MOL Comfort was a post-Panamax containership, built in 2008 at Mitsubishi Heavy Industries in Japan. After the incident, sister ships were withdrawn from service and their hull structures upgraded to increase the longitudinal strength. The ship's young age – only five years old at the time of the accident – is an important fact driving attention on design and construction, rather than on structural maintenance.

- **Cargo handling:**

Cargo handling can be understood as the moving, preparing, verifying, lashing, and unlashing of containers onboard and across the ship-shore interface, while engaged in load-on/load-off operations alongside it. This is a labour-intensive process which requires significant coordination under the pressure of tight turnaround times.

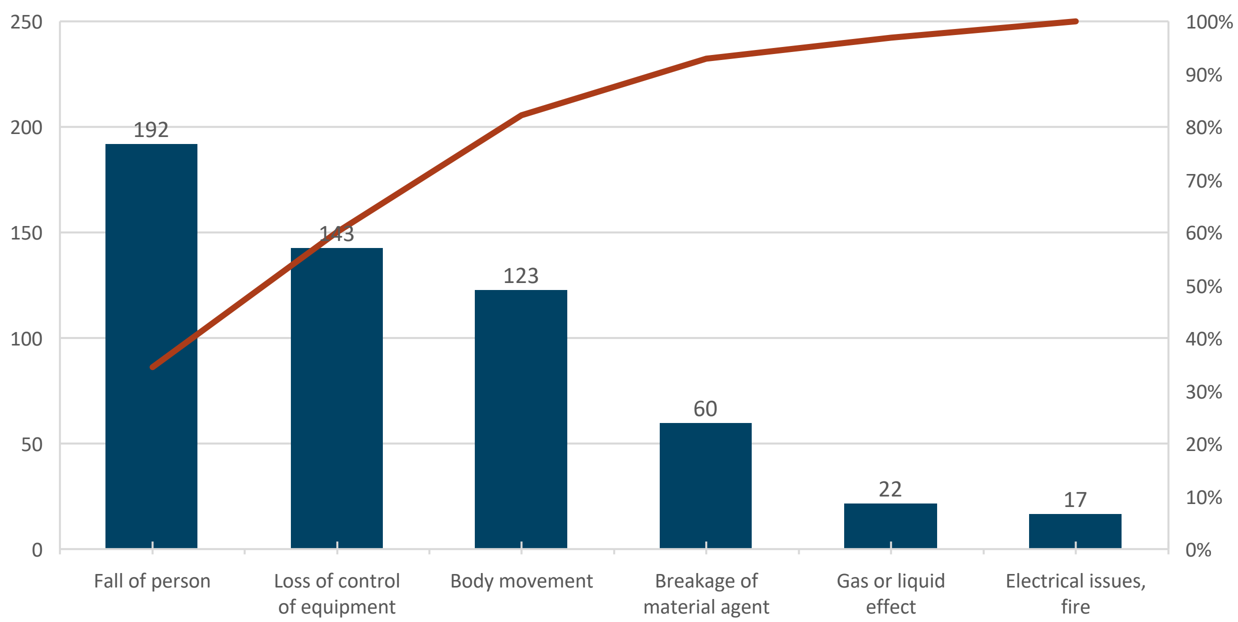
Cargo handling is an occupational safety element, but one which has strong links to maritime safety. The EMSA analysis of the EMCIP data in relation to container ship safety [9] shows that the cargo handling of container ships is in fact the factor with that leads to the highest death toll related to these ships.

Figure 45: Consequences to persons (fatalities/injuries) from casualties onboard containerships between 2011 and 2019.



Source: EMSA/EMCIP [9]

Figure 46: Occurrences with persons (frequency) onboard containerships reported in a period between 2011 and 2019.



Source: EMSA/EMCIP [9]

The following main points should be noted:

- There were 108 fatalities and 568 people injured in the study period (2011-2019), with a percentage variation between 2019 and 2018 showing a decrease for both fatalities (-73%) and a much less pronounced decrease in injuries (-15%).

- Around 80% of the marine casualties and incidents concerned a “fall of persons”, “loss of control of equipment” and “body movement”.

It can be surmised that cargo handling and securing is an area directly linked to three safety areas which should be looked at in conjunction: 1) occupational safety; 2) cargo safety; and 3) the safety of cargo handling equipment.

2.2.3.3 Fishing vessels

- **Safety standards:**

Fishing vessel safety is sometimes considered the ‘elephant in the room’ of maritime safety, as the specific nature of fishing operations, working conditions, and vessel design are factors that have prevented fishing vessels from being fully included within the scope of the various international safety regulatory instruments implemented for conventional vessels. In the last 50 years, there have been several attempts to agree on minimum safety standards for these ships, without success. In 1977 the Torremolinos International Convention for the Safety of Fishing Vessels was presented as the first attempt to provide standards on the design, construction, and equipment of fishing vessels of more than 24 m in length, but it never entered into force. The second opportunity arose when the 1993 Torremolinos Protocol was developed, but with a similar result. At that stage, the EU acted, and adopted Directive 97/70/EC which makes the Torremolinos instruments mandatory for EU Member State-flagged ships of more than 24 metres in length. Finally, in 2012, the IMO prepared the Cape Town Agreement on the Implementation of the Provisions of the Torremolinos Protocol, but it is still not in force today. Only eight EU Member States plus Norway and Iceland have already deposited the accession act.

The institutional partners behind the regulations are diverse (IMO, ILO, the Food and Agriculture Organization (FAO), the European Commission, the European Fisheries Control Agency (EFCA), EU Member States, etc.), and as a result, the regulatory framework, whether mandatory or voluntary, is complex and multidisciplinary. In collaboration with the FAO and ILO, the IMO has developed some non-mandatory instruments related to the safety of smaller vessels:

- Code of Safety for Fishermen and Fishing Vessels, 2005, parts A and B;

- Voluntary Guidelines for the Design, Construction and Equipment of Small Fishing Vessels of 12 m in length and over but less than 24 m in length, 2005;

- Safety recommendations for decked fishing vessels of less than 12 metres in length and undecked fishing vessels;

- Implementation Guidelines on Part B of the Code, the Voluntary Guidelines and the Safety Recommendations (Implementation Guidelines).

The EU has also developed codes, guidance, and related publications in this regard:

- EMSA: “Safety analysis of data reported in EMCIP – analysis on marine casualties and incidents involving fishing vessels”;

- EU-OSHA[28]: “European Guide for risk prevention in small fishing vessels”;

- European Parliament:

  - Information note 501 FISH: “Safety and the causes of accidents in the fishing sector”; and

  - Report on Fishers for the Future: Attracting a new generation of workers to the fishing industry and generating employment in coastal communities (2019/2161(INI)).

The European Commission is currently in the process of reviewing several directives in which fishing vessels are considered. One of them is the Accident Investigation Directive (2009/18/EC) which limits the obligation to report accidents to fishing vessels above 15 m in length. The revision of the PSC Directive is also considering the inclusion of fishing vessels into its scope.

Another open process is the ex-post evaluation of Directive 97/70/EC for which a roadmap has been published which indicates the following:

28 European Agency for Safety and Health at Work

"The original intention of Directive 97/70/EC was to be a first step in fishing vessel safety and in the light of the implementation of Council Directive 93/103/EC[29], the Commission and Member States would consider the appropriateness of developing relevant safety rules for new fishing vessels of a length less than 24 m."

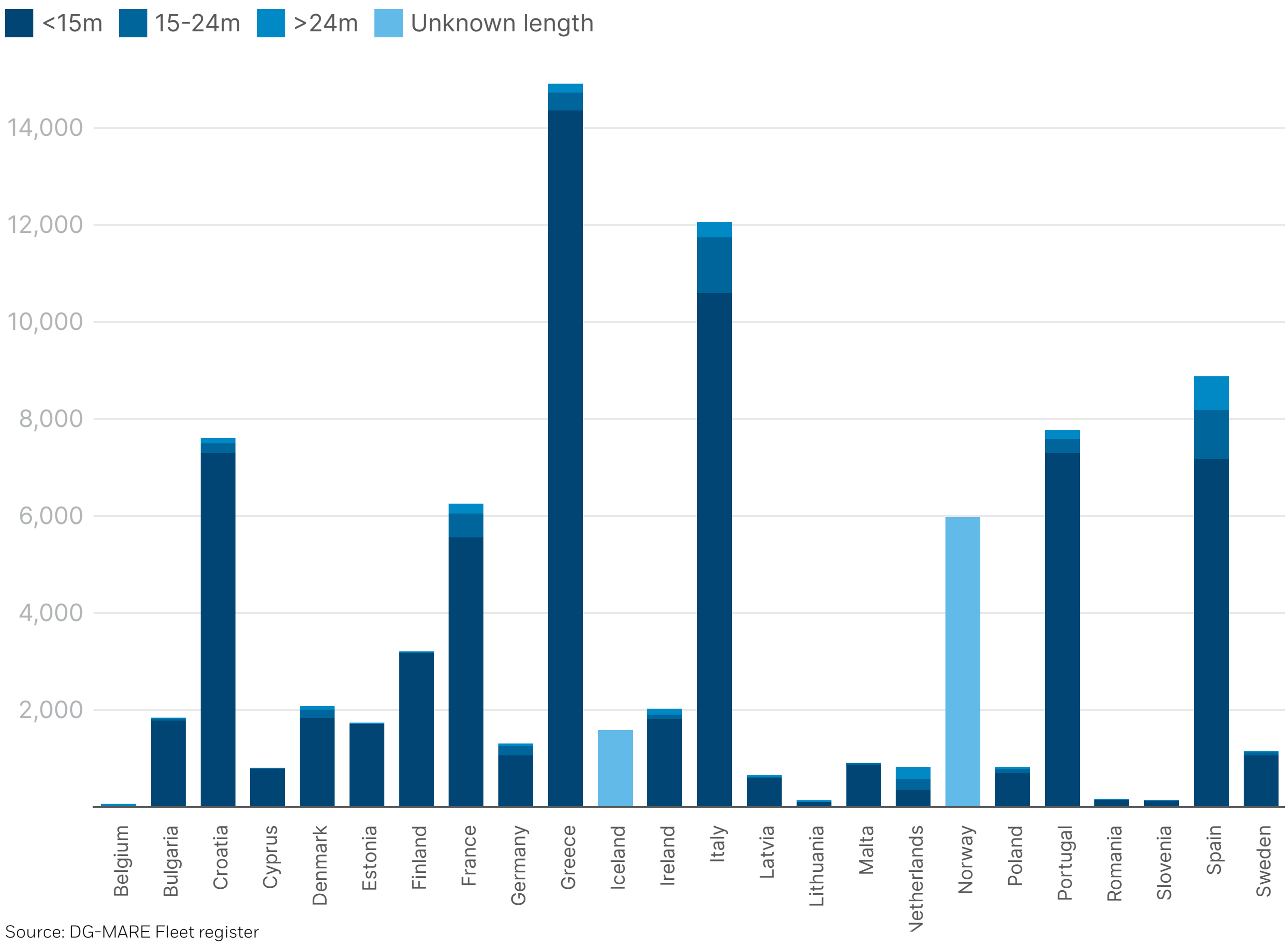
Therefore, the results of these evaluations will be important steps for the future of fishing vessel safety at EU level.

- **Fleet:**

As can be noticed in the previous paragraphs, length is the key parameter used as a threshold in the scope of fishing vessel safety legislation. In this regard, the fleet can be characterised as follows:

- the EU Member State fleet is composed of around 75,000 fishing vessels, which makes this category of ship the most numerous in the EU;
- 3% measure 24 metres in length or more (under the scope of the Directives 97/70/EC and 2009/18/EC);
- 6% measure between 15 m and 24 m in length (under the scope of Directive 2009/18/EC);
- 91% measure below 15 m in length.

Figure 47: Fishing vessels fleet per Member State and length.



Source: DG-MARE Fleet register

29 Directive 93/103/EC lays down minimum safety and health requirements applicable to work on board fishing vessels above 15 m. The requirements are of a very general nature.

A more detailed analysis of the typology of vessels by length shows that, for those Member States with a significant fishing fleet (over 6,000 vessels), most of their fleet is composed of vessels below 15 metres (Croatia 96%, France 89%, Greece 96%, and Portugal 94%).[30]

The Spanish fleet is quite different: even if the most representative vessels measure less than 15 metres (80%), the Spanish fleet is also composed of a significant number of vessels between 15 and 24 metres (1005) and the percentage of vessels above 24 metres is higher than the European average (8%).

The EU fishing fleet tends to have an older age profile. In 2019, 48,910 vessels were more than 25 years old, 15,088 were between 15 and 25 years old, 9,565 between 5 and 14 years old and just 1,600 were less than 5 years old.

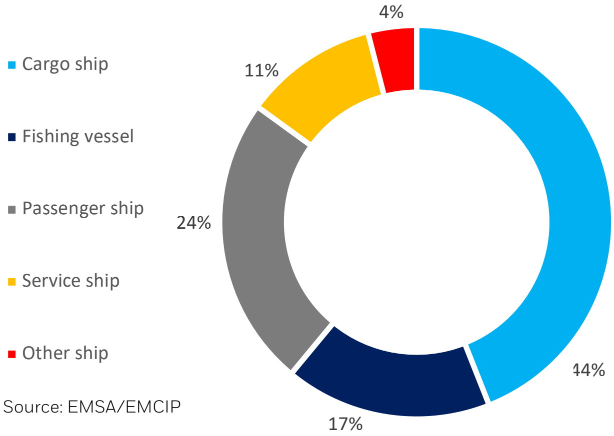
Vessels measuring less than 24 metres and more than 25 years of age represent most of the fleet (65%). This trend is different for the range of vessels above 24 metres, where older vessels represent less than half of the total fleet (see Figure 11).

This means the fleet covered under the relevant EU Directives is relatively small in terms of the number of vessels, but it covers the largest 10%. The smaller ships, typically owned by self-employed people using traditional techniques, are out of the scope of the legislation Given that many fishing boats are essentially family businesses, and that their owners are entirely economically dependent on the income they generate, there can sometimes be a need to fish overlooking possible safety implications.

- **Accidents:**

From an accident perspective[31], the following figure shows that 17% of all ships involved the occurrences registered in EMCIP correspond to fishing vessels[32]:

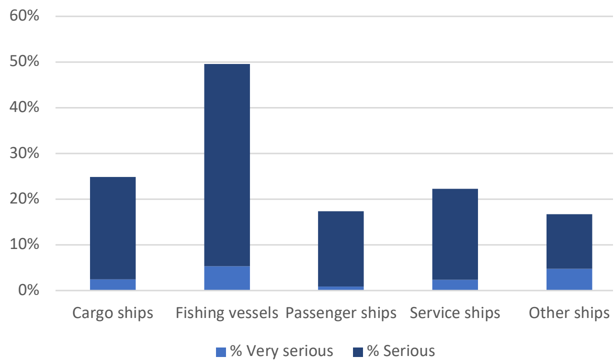
Figure 48: Distribution of ships involved in occurrences per ship type - Annual overview of marine casualties and incidents 2021.



Source: EMSA/EMCIP

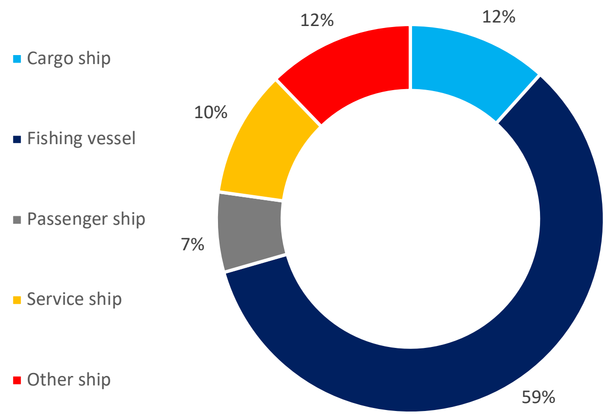
But the following figures are more relevant to analyse fishing vessel safety:

Figure 49: Rate of very serious and serious occurrences per ship type - Annual overview of marine casualties and incidents 2021.



Source: EMSA/EMCIP

Figure 50: Ships lost per category - Annual overview of marine casualties and incidents 2021.



Source: EMSA/EMCIP

30 The fishing fleet of Norway is composed of 5,980 vessels and that of Iceland is composed of 1,582 vessels. The detail of their fleet by size is not available on Eurostat.

31 For more information on fishing vessels accidents, see the "Analysis on marine casualties and incidents involving fishing vessels" published on EMSA website: http://emsa.europa.eu/newsroom/latest-news/item/3253-safety-analysis-of-data-reported-in-emcip.html

32 As can be seen in section 4.3, the number of accidents of ships above 24 m and those between 15 and 24 m in length are practically the same despite the fleet of the second group being double than the first. This leads to the conclusion that there is probably some under reporting associated to these figures, as the national resources needed to investigate accidents are limited

The most important conclusion that can be extracted from the previous figures is that fishing vessels are more vulnerable to accidents, not so much in terms of frequency, but in terms of the seriousness of the consequences when they do occur. The rate of very serious casualties and serious casualties for fishing vessels is much higher compared to the overall fleet. In addition, even though fishing vessels represent 17% of the total number of accidents, the number of fishing vessels lost represents more than 55% of total number of lost vessels, a trend observed in recent years. It can then be concluded that when an accident occurs with a fishing ship, the probabilities of total loss or serious consequences are higher than for any other ship type, thus confirming their vulnerability.

- **Enforcement and reporting:**

Even though some Member States have comparatively large fleets, often the resources available for enforcement and reporting (on the fleets themselves, on accidents, etc.) are not available.

- **Qualifications:**

The International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel, 1995 (STCW-F) was adopted on 7 July 1995 to promote safety of life and property at sea, and the protection of the marine environment. It entered into force on 29 September 2012. The Convention establishes common international standards of training, certification and watchkeeping for personnel employed on board fishing vessels. The EU Member State parties to the STCW-F Convention are:

- Belgium
- Denmark
- France
- Latvia
- Lithuania
- Netherlands
- Poland
- Portugal
- Romania
- Spain.

Iceland and Norway have also ratified the convention.

The 1995 STCW-F Convention is currently being comprehensively reviewed by the IMO's Sub-Committee on Human Element, Training and Watchkeeping to align it with the current state of the fishing industry.

Since fishing at sea is one of the most hazardous professions, and fishing vessels and their crew face the same hazards and risks in the open seas as commercial seagoing vessels, appropriate training and qualifications are an essential method to reduce the number of accidents, and to contribute to the safety of the crew on board.

Furthermore, the STCW-F Convention may also facilitate the free movement of workers. Fishers could become more mobile through having the possibility of working on board the fishing vessels of all Member State Parties to the STCW-F Convention. Therefore, the harmonisation of their qualifications through the introduction of a common minimum level of training for fishing vessel personnel would not only improve safety at sea but could also further facilitate the free movement of workers. Moreover, it could establish a level playing field both within the EU and in relation to non-EU countries.

- **Living conditions:**

The MLC Convention does not apply to fishing vessels, so the ILO developed a convention to address this gap. The Work in Fishing Convention, 2007 (C188) entered into force on 16 November 2017, after being ratified by ten ILO Member States, and is applicable to all types of commercial fishing vessels. It establishes provisions to protect those who work on fishing vessels in different aspects of their work, safety on board fishing vessels, food, accommodation, and medical care at sea, employment practices and insurance and liability. It is important to note that C188 requires the implementation of specific port state inspection to ensure that its provisions are applied on fishing vessels operating in areas under the jurisdiction of the states which ratified the C188.

The ILO Convention 188 represents a significant step forward in terms of working conditions on board fishing vessels. This convention contains provisions regarding habitability, respect for hours of rest, etc., which also contribute to safety on board. So far 7 Member States have ratified C188. However, several Member States with significant fishing fleets have not yet ratified the convention.

The application of C188 by all Member States would make it possible to create a complete common regulatory framework for fishing safety based on ship safety (Directive 97/70/EC), qualification of seafarers (STCW-F), environmental protection (relevant MARPOL regulations) and health and safety at work (C188).

2.2.3.4 Ships carrying industrial personnel

With the EU emphasis on climate change, offshore renewable energy production is a rapidly growing sector. The development of offshore windfarms in EU waters means that there is a need to transport personnel offshore to construct and maintain these set-ups. As these workers do not fit into any of the traditional categories in maritime legislation, the IMO is developing a new Code for the carriage of "Industrial Personnel" at sea such as offshore technicians. It takes account of the risk scenarios for transporting such personnel having common knowledge of ships' layout and possible emergency scenarios and thereby recognised to be a category between passengers and ship's crew. It is expected that the new Code enters into force on 1 July 2024. In the meantime, the IMO issued Resolution MSC.418(97) of the interim guidance for these ships engaged on international voyages, indicating that industrial personnel should not be regarded as passengers.

However, many of these ships are operating domestically and Member States are developing national standards to regulate these vessels for domestic voyages. The lack of harmonisation, especially for smaller ships, creates difficulties when these vessels change flag to operate in a different Member State.

2.2.3.5 EU R&D Projects

The EU has a permanent research and development (R&D) programme the name of which is updated every seven years, to coincide with the EU budgetary cycle. It covers all types of activities and sectors, including maritime safety. Although most of these projects have a more academic or technology development perspective, there are some with a more pragmatic approach in terms of proposals to amend maritime safety legislation. They are usually formed by several partners, including industry, academia, and even maritime authorities in some cases. Within this group, the list below includes those which could potentially impact some key areas of ship safety standards:

LASH FIRE
This is aimed at significantly reducing the risk of fires on board RoPax, and so complements FIRESAFE. It includes an extensive section on the risks of carrying alternative fuelled vehicles (AFV) onboard ships. The project is running from September 2019 to August 2023.

SAFEPASS
This project deals with life-saving appliances and systems for safe and swift evacuation operations on high-capacity passenger ships in extreme scenarios and conditions. It is developing a risk model which could be used to support the IMO work in the revision of Chapter III.

PALAEMON
This is similar to SAFEPASS but focused on developing equipment rather than models, by designing an innovative and adaptive Mass Evacuation Vessel (MEV).

FLARE
The FLARE project targets the flooding risks (damage stability) of passenger ships by developing a generic and holistic risk model with a potential application for newbuilds and existing ships.

2.2.3.6 Cyber risks

The increased use of systems on board ships that rely on digitalisation, integration and automation have an associated cyber risk that may impact the safety of the ship and those onboard. Cyber safety is concerned with the risks from the loss of availability or integrity of safety critical data and operational technology. In general, cyber security addresses the protection of digital services from intentional attacks. However, there are threats to the digital services on board a ship which can affect its safety as a result of unintentional, benign actions. Examples of this could include a failure occurring during software maintenance and patching, the wrong software operation, etc.

According to the IMO Interim Guidelines on Maritime Cyber Risk Management of 2016 (MSC.1/Circ.1526), vulnerable systems to cyber risks could include, but are not limited to:

- Bridge systems
- Cargo handling and management systems
- Propulsion and machinery management and power control systems
- Access control systems
- Passenger servicing and management systems
- Passenger facing public networks
- Administrative and crew welfare systems and
- Communication systems.

In 2017, the IMO adopted resolution MSC.427(98) on Maritime Cyber Risk Management in Safety Management System (SMS) that requires the SMS to take cyber risk management into account in accordance with the ISM code; notably, these guidelines were introduced in the safety -related code and not in the security-related code. Following this, the IMO guidelines on maritime cyber risk management were developed providing high-level recommendations on the topic to safeguard shipping from current and emerging cyber threats and vulnerabilities.[33]

In 2016, a consortium of shipping industry organisations developed Guidelines on Cyber Security Onboard Ships (Industry Cyber Guidelines[34]) with the aim of developing understanding and raising awareness on cyber security onboard ships. At the time, existing international standards and guidelines covered cyber security for shoreside operations only. The latest versions are aligned with the IMO's views and provide practical recommendations on maritime cyber risk management, by identifying typical vulnerable systems and listing the different types of cyber threats that may affect companies and ships, for example.

33 IMO Guidelines on Maritime Cyber Risk Management MSC-FAL.1/Circ.3

34 The Guidelines on Cyber Security Onboard Ships by BIMCO, CLIA, ICS, INTERCARGO, INTERMANAGER, INTERTANKO, IUMI, OCIMF and WSC

Other industry associations have developed guidelines for specific ship types such as the Digital Container Shipping Association for container vessels. In consultation with industry partners, IACS has also developed Recommendations on Cyber Security, and is working further towards the development of mandatory IACS Unified Requirement, with the aim of enabling the delivery of cyber resilient ships whose resilience can be maintained throughout their working lives.[35]

2.2.4 Marine Equipment

International legislation lists several pieces of equipment which must be carried on board ships, either to ensure the safety of operations or to protect the marine environment. Detailed performance and testing standards for this marine equipment have been developed by the International Maritime Organization (IMO) and by international and European standardisation bodies.

However, the agreed international regulatory framework leaves a significant margin of discretion to the flag administrations in terms of how to implement the rules. This can lead to different interpretations and, consequently, different levels of safety for the certified marine equipment on the market. In addition, the international framework does not envisage quality standards, neither for the final product verification nor for the manufacturing process. Ensuring that this equipment is high quality is indispensable for the safe operation of a ship, life-saving capabilities, and the protection of the marine environment.

Directive 2014/90/EU on marine equipment (MED) of the European Parliament and of the Council lays down common rules for the certification of marine equipment and intends to eliminate differences in the interpretation and implementation of international standards by means of a clearly identified set of requirements and uniform certification procedures. In addition, it adds quality certification mechanisms. The main aim of the Directive is to ensure, as far as possible, that marine equipment on EU Member State-flagged ships is designed and constructed to appropriate standards. This Directive is based on the EU new legislative framework[36] which defines set of measures for use in product legislation that aim to improve marked surveillance and boost the quality of conformity assessment for majority of products.

35 https://www.iacs.org.uk/news/iacs-launches-single-standalone-recommendation-on-cyber-resilience/

36 https://ec.europa.eu/growth/single-market/goods/new-legislative-framework_en

Following that, MED outlines the conformity assessment procedures (known as Modules) to be carried out for a specific item of marine equipment by the manufacturer or its authorised representative in the EU, such as:

Table 17: Conformity assessment modules under the MED.

Module B	Type examination, verification and testing of the technical design of the equipment including its technical documentation.
Module D	Type conformity based on the quality assurance of the production process (verification during manufacturing and verification of final product). Ensures that the final products are the same as the reference product (a product that meets the standards and essential requirements). Applicable mainly when in high volume production. The notified body assess the quality system as provided by the manufacturer.
Module E	Type conformity based on the quality assurance of the product (verification of final product) The notified body assess the quality system as provided by the manufacturer.
Module F	Type conformity based on product verification. Applicable mainly for small production batches. The notified body carries out product examinations (testing of every product or statistical checks).
Module G	Conformity based on unit verification. Applicable mainly for n production of small quantities or individual products, and not in series or in mass. The notified body verifies every individual product.

The conformity for the marine equipment products can be achieved by application of a combination of type examination (module B) and one of the quality assurance procedures (modules D, E or F) or by application of Module G only for The manufacturer can choose the quality assurance inspection model and order the verification (tests, type examination, periodic post-verification) from any notified body, an organisation designated by one of the EU competent national administration to carry out conformity assessment tasks, which issues a certificate for each successfully tested module.

After accomplishment of the conformity assessment procedure, the manufacturer shall draft the declaration of conformity that states the fulfilment of the requirements determined by the directive and affix the conformity mark (wheel mark symbol or the e-tag). A copy of the declaration of conformity shall be provided to the ship which installs the equipment and must be kept on board.

The directive also requires Member States to undertake market surveillance of marine equipment, which is a demanding task given that the equipment is placed on board ships at the time of their construction or repair all over the world. Member States are required to ensure that only compliant equipment is installed on board ships flying their flags and that this obligation is fulfilled through issuance, endorsement, and renewal of the certificates of such ships. In this way, the national Market Surveillance Authorities (MSA) are responsible for drawing up market surveillance programmes that include checks on pieces of equipment (documentary, on board and sample checks), the identification of specific equipment posing a potential hazard and all the related actions to communicate the outcome of these activities to interested parties.

The Commission provides support to the MSA of all Member States by facilitating the exchange of their experience within adequate Administrative Cooperation Groups.[37]

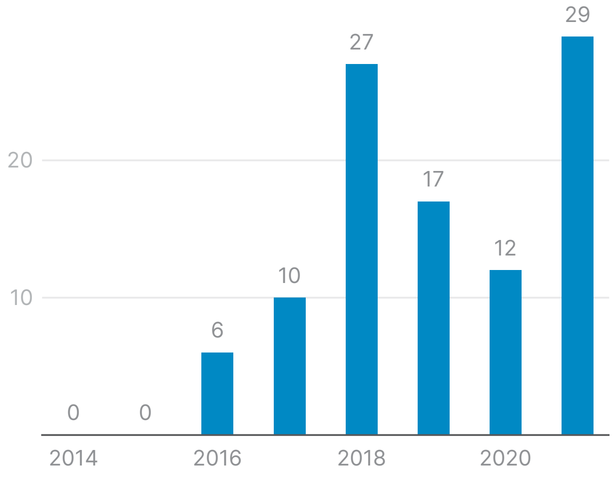
Based on the number of records available in the information system made available by the Commission for the market surveillance purpose ICSMS[38], from 2016 to December 2021 the EU MSA reported 101 potential cases of marine equipment in noncompliance. The final date for adoption and publication of the MED by the MS was in September 2016. The establishment of market surveillance activities yielded results in growing number of suspected cases of noncompliant equipment since then.

To facilitate bilateral trade and promote cooperation on international marine equipment regulations, there is an agreement between the European Union and the United States of America on the mutual recognition of certificates of conformity. This type of agreement allows for the extension of the European market of marine equipment based on the same regulatory requirements. Accordingly, US-flagged ships can directly install onboard those pieces of equipment included in the agreement.

37 https://ec.europa.eu/growth/single-market/goods/building-blocks/market-surveillance/organisation/adcos_en

38 https://webgate.ec.europa.eu/icsms/

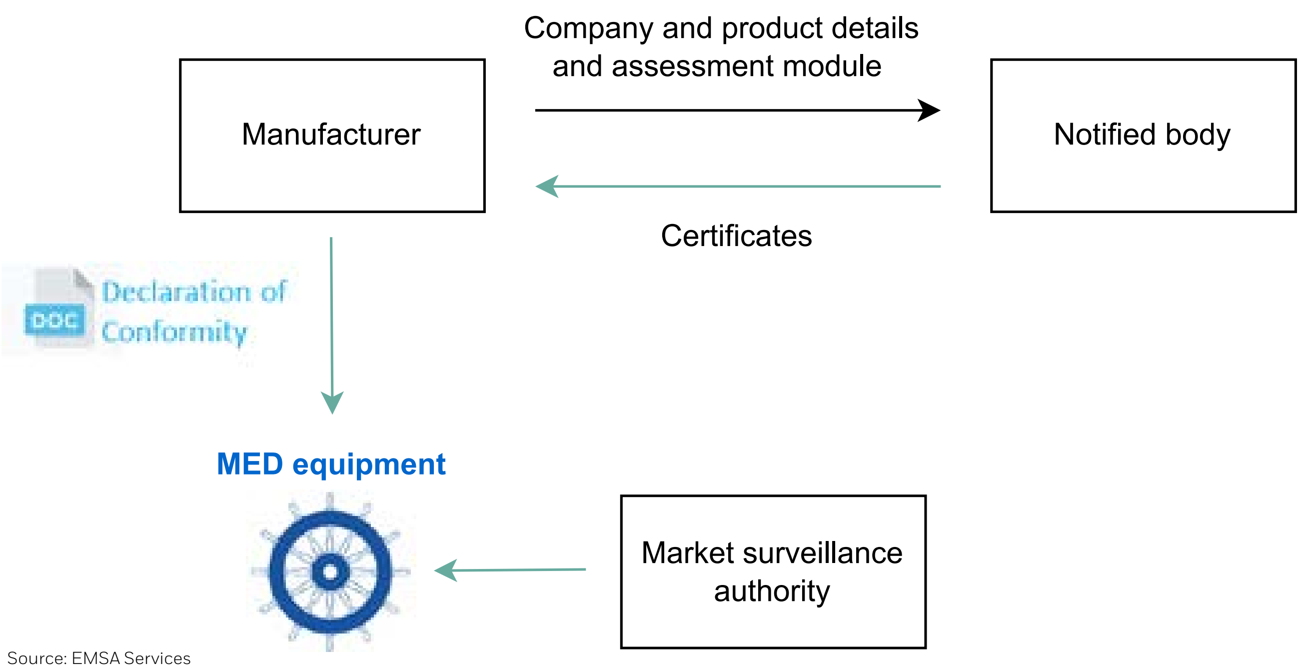
Figure 51: Yearly number of reported suspected cases of MED non-compliant equipment by the EU MSA since 2014.



Source: ICSMS

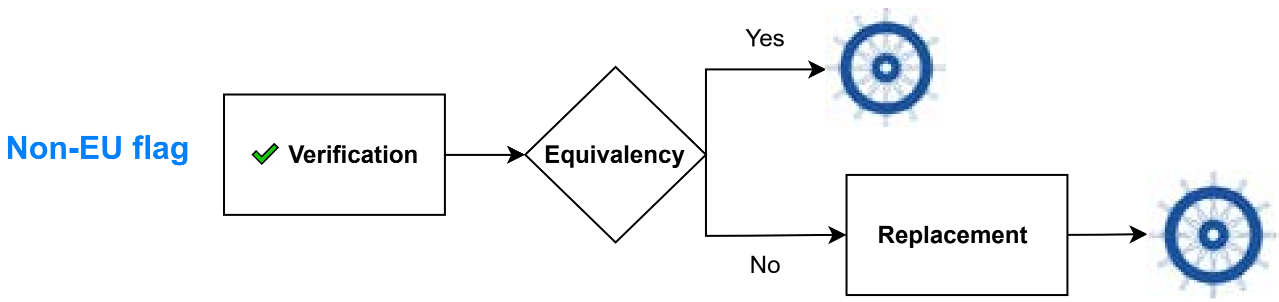
The Marine Equipment Directive is only applicable to EU Member State-flagged ships, meaning that competing ships trading in EU ports do not need to comply with the Directive. When a non-EU ship is transferred to the EU, the ship must be inspected by the receiving flag state to verify that the safety certificates are valid and correspond to the actual condition of the equipment. The receiving flag can either state that the equipment is compliant with the MED, and therefore bears the wheel mark, or that it is equivalent in terms of safety level, to the satisfaction of the administration in question in which case a certificate of equivalence is issued. Otherwise, the equipment needs to be replaced. There are no consolidated statistics on this topic apart from the samples taken during EMSA visits, which appear to suggest that equivalency can be achieved for pieces of marine equipment on which the safety requirements originated at IMO are properly applied.

Figure 52: Summary of MED procedures.



Source: EMSA Services

Figure 53: Transfer of flag under the MED directive.



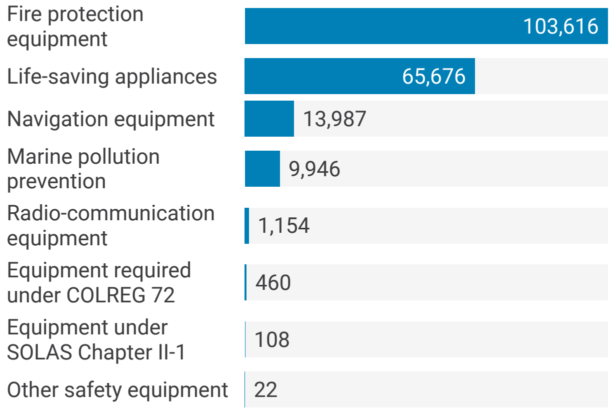
Source: EMSA Services

Member States are supported in fulfilling their obligations under the MED by the information systems made available by the European Commission for the assessment, notification and monitoring of bodies authorised to carry out conformity assessment tasks[39], the sharing of information in relation to approved marine equipment, applications withdrawn or refused and non-compliance. In this regard, since 2020, EMSA has hosted a database known as the MED portal[40], a repository of this information. In addition, the MED portal contains all documentation of the MarED group, the cooperation group for the notified bodies assigned by the Member States, which meets twice a year to discuss technical issues related to difficulties in the interpretations of certain requirements. The MarED group develops interpretations in the form of draft recommendations which are subsequently approved (or rejected) by Member States at the Committee on Safe Seas and the Prevention of Pollution from Ships (COSS). EMSA acts as the technical secretariat of this group which facilitates a harmonisation of the procedures and the internal market.

In addition, EMSA coordinates every year, from a technical perspective, the Annex that includes all the standards and requirements for all the items included in the Directive, which currently number more than 300, including life-saving appliances, fire-safety, pollution prevention, radiocommunication and navigation elements.

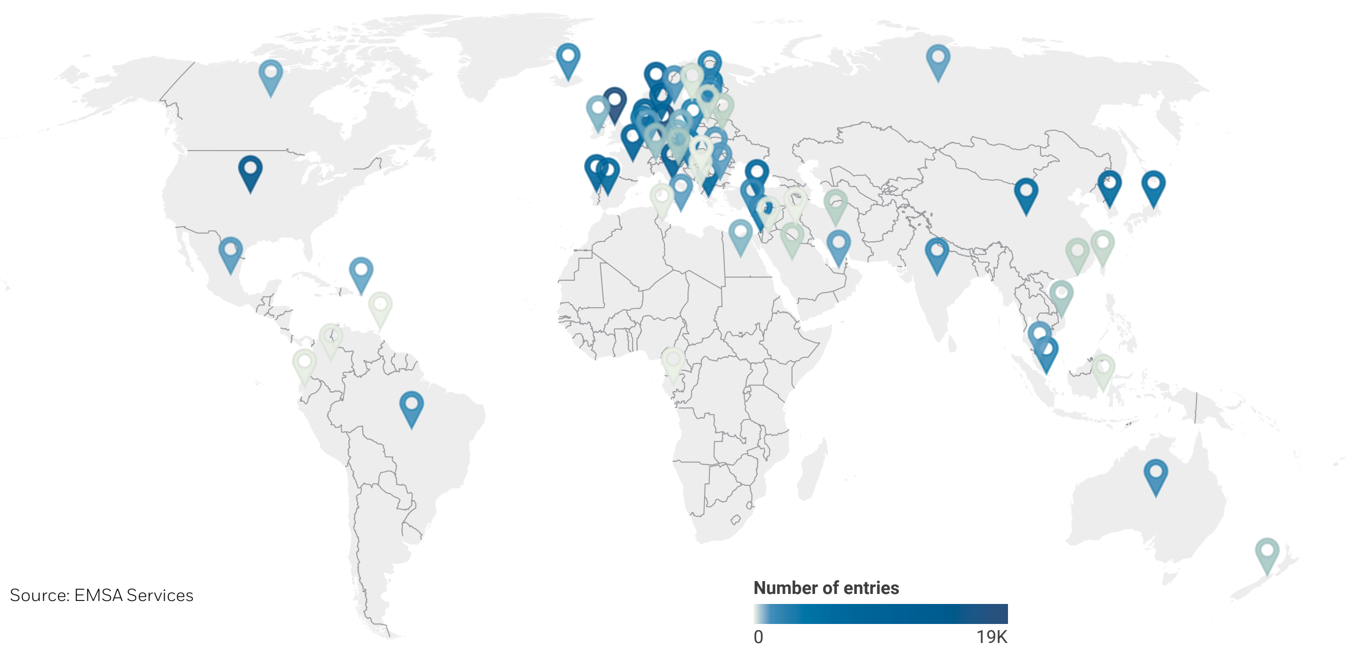
As indicated before, the MED portal is the reference database for products certified under the Directive. They are uploaded directly by the notified bodies through a dedicated interface. Currently there are nearly 200 000 products registered:

Figure 54: Number of products registered in the MED portal per category.



Source: MED Portal

Figure 55: Number and location of users of the MED portal – statistics for the month of September 2021.



Source: EMSA Services

39 https://ec.europa.eu/growth/tools-databases/nando/index.cfm

40 The MED portal can be accessed at: https://portal.med.emsa.europa.eu/

According to the products register, 45% of the marine equipment allowed to be installed onboard EU MS flagged ships is manufactured by companies based in the EU.

The MED portal receives approximately 190,000 monthly entries by 5,412 worldwide registered users representing industry stakeholders, including manufacturers and authorised representatives, administrations, market surveillance authorities, notified bodies, notifying authorities and public users. As an example, the distribution of the database entries for September 2021 is depicted in Figure 55.

The future steps of the MED portal are focused on improving accessibility to product information, particularly with the facilitation of the declaration of conformity, the digitalisation and online publication of documents (manuals, certificates, etc.).

Also notable is the electronic tagging (e-tag) of marine equipment, which was introduced as a supplement to the wheel mark. This aims at facilitating market surveillance with direct and easy access to the relevant databases, preventing the counterfeiting of specific items and making it easier for shipowners and operators to carry out equipment traceability and stock control. Based on the MED portal and on the principle of electronic tagging of marine equipment, EMSA is developing a new MED Mobile application for scanning of the MED e-tags in Data Matrix and RFID format. However, this idea is still on the initial phase of implementation and has not been fully embraced by the industry yet. Its implementation would require a wider awareness among the manufacturers of marine equipment.

Figure 56: E-tag scheme.

Source: EMSA Services

Figure 57: MED Mobile application.

Source: EMSA Services

2.3 Traffic monitoring and information systems

2.3.1 Introduction

As indicated in previous sections, a ship must be safely crewed and built. However, it must be kept in mind that it is operating in a dynamic environment where it interacts with other ships and ports. For this reason, traffic monitoring, reporting and exchange of information is fundamental to ensure proper maritime safety, especially regarding the transportation of dangerous and polluting goods by sea.

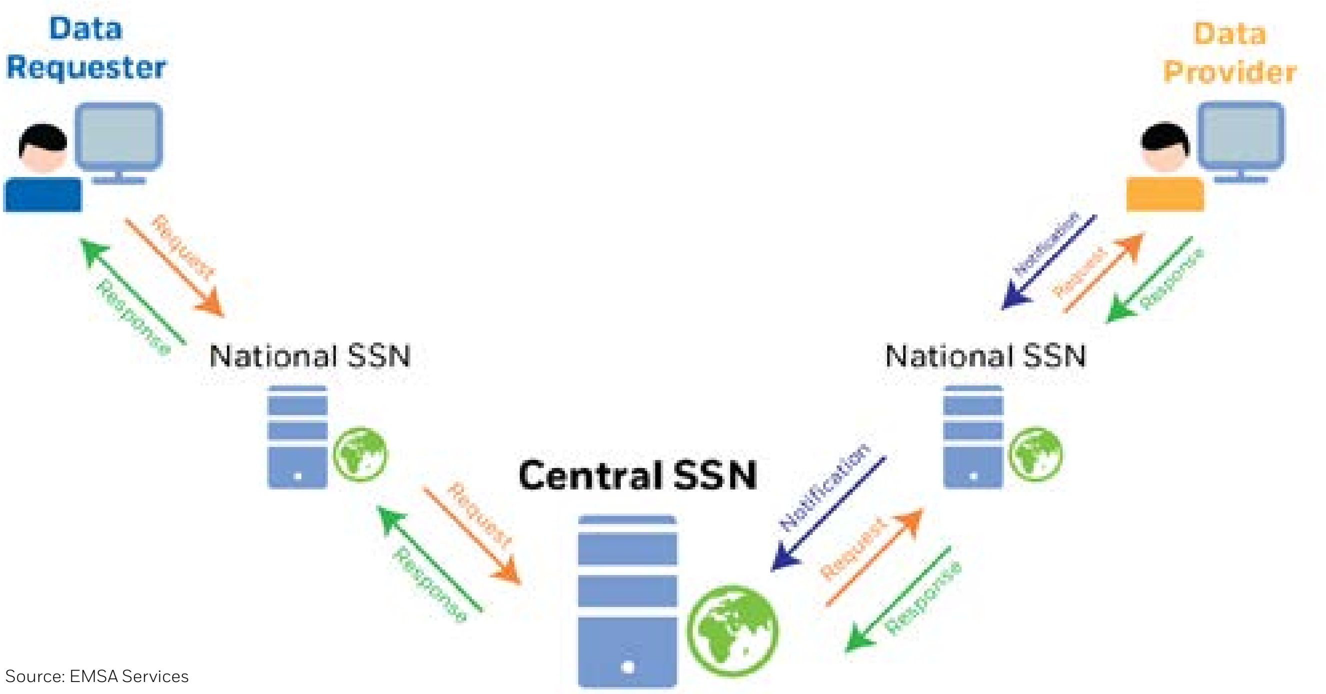
One of the key safety elements to be reported is the transportation of dangerous goods, so that coastal states can take appropriate prevention measures and can also be prepared to respond in case of accident. The IMO, via its codes and conventions, regulates the substances that are considered dangerous and polluting goods (DPG) when transported by sea.

From the perspective of EU vessel traffic monitoring, the maritime community is supported by three key EU legal instruments: the VTMIS Directive (Directive 2002/59/EC); the Reporting Formalities Directive (Directive 2010/65/EU, which will be repealed in 2025); and the EMSWe Regulation (Regulation (EU) 2019/1239). This legislation regulates the information that needs to be reported and exchanged, simplifies the procedures, promotes the reuse of data, and harmonises data submissions.

Under the VTMIS Directive, SafeSeaNet (SSN) was setup as a network for maritime data exchange, linking maritime authorities from across Europe. It enables EU Member States, Norway, and Iceland to provide and receive information on ships, ship movements, and hazardous cargoes.

The scope of the information exchanged is diverse, ranging as it does from times of arrival/departure to and from EU ports, to details of DPG carried by the vessels and their location on board, as well as information on safety and pollution-related incidents.

Figure 58: SafeSeaNet system network for data exchange.



Source: EMSA Services

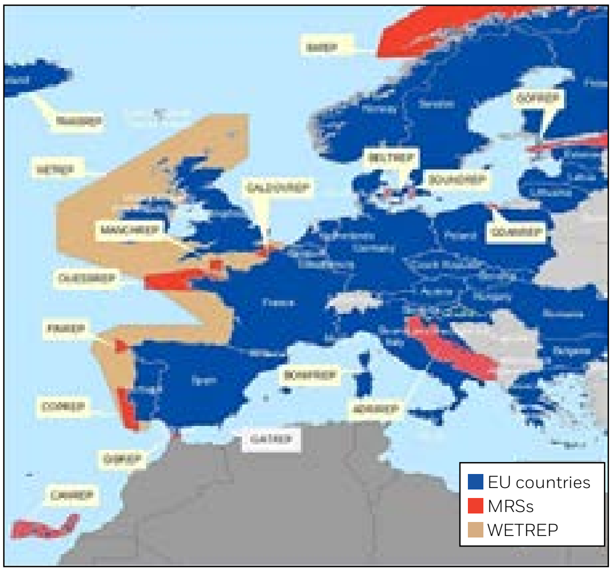
From a technical point of view, SSN started as an index system within a 'hub and spoke' network (including authentication, validation, data transformation and logging). Currently, it is a hybrid system where the information is partially stored centrally and the detailed part is stored at national level, with SSN functioning as an index. Users in Member States can provide and/or request data using national systems or EMSA's Maritime Application Portal.

Another type of information exchanged through SSN are ship position reports in near real-time using ship's Automatic Identification System (AIS) or MRS (Mandatory ship reporting system) messages provided by ship masters to coastal stations.

AIS was developed originally as an anti-collision instrument, used to transmit vessel position and identification. By collecting AIS information through a chain of coastal stations covering the entire EU coastline and combining these position reports with more recent sources such as Satellite-AIS, Long-Range Identification and Tracking (LRIT) and Vessel Monitoring System (VMS) reports, EU authorities can have a better picture of the maritime situation.

MRS areas play a different role because they are established by governments, with approval from the International Maritime Organization (IMO), for certain types of vessel transiting through defined areas,

Figure 59: Mandatory ship reporting areas in Europe.

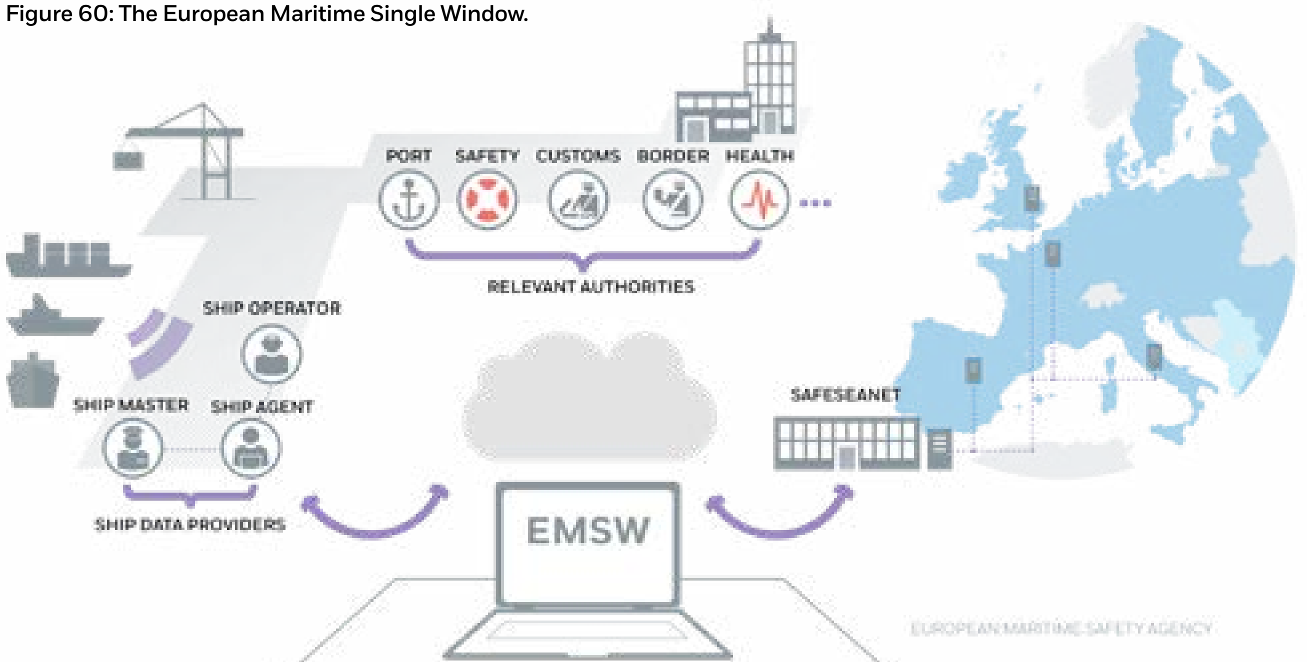


Source: EMSA Services

Note: Pre-Brexit map of EU countries.

usually for safety reasons and for the protection of environmentally sensitive areas. For example, after the Prestige spill off the coast of Spain, the WETREP (Western European Tanker Reporting System) MRS was established, requiring all tankers above 600 deadweight tonnes carrying heavy grade oils to report their entry into the area. This information is then shared via SSN to interested parties at national level.

Figure 60: The European Maritime Single Window.



Source: EMSA Services

Another important characteristic of the shipping industry is the constant search for efficiency and simplification. International and EU legislation impose several reporting obligations on ships. To centralise and facilitate this reporting, National Single Windows (NSW) were created. At an initial stage, Member States set up NSW through which shipping companies could submit information electronically and make this information available as necessary to multiple national authorities in an automated manner, thus reducing the burden on industry. However, as each NSW was developed differently, the purpose of reducing the administrative burden was not achieved.

To tackle this problem, the EU recently adopted the European Maritime Single Window Environment (EMSWe) Regulation to harmonise and simplify the reporting formalities faced by the shipping industry (see Figure 60).

Once the EMSWe Regulation is fully in force, from 15 August 2025, the EU-wide system will simplify and further harmonise the information procedures behind the various reporting obligations imposed on shipping companies through national, EU and international law. A common set of information will be shared on ships arriving, staying, and departing from EU ports. This will be communicated electronically with the different national administrations, and the information will be transferred as necessary between Member States, by making use of existing systems like SSN, common databases (ship, LOCODE[42] and hazmat), etc.

Table 18: Legislation on traffic monitoring and information systems.

	Level	Instrument	What it regulates
Legislation	International	FAL Convention	Facilitate maritime traffic by simplifying and reducing to a minimum the formalities, documentary requirements and procedures on the arrival, stay and departure of ships engaged in international voyages.
		SOLAS	Especially Chapter V: LRIT, notification systems, traffic monitoring, routing systems etc.
	EU	VTMIS Directive (Directive 2002/59/EC[41])	Establishes a vessel traffic monitoring and information system (VTMIS) with a view to enhancing the safety and efficiency of maritime traffic, improving the response of authorities to incidents, accidents or potentially dangerous situations at sea, including search and rescue operations, and contributing to a better prevention and detection of pollution by ships.
		Reporting Formalities Directive (Directive 2010/65/EU)	To simplify and harmonise the administrative procedures applied to maritime transport by making the electronic transmission of information standard and by rationalising reporting formalities, for ships arriving in and ships departing from ports situated in Member States.
		European Maritime Single Window environment (EMSWe) Regulation (Regulation 2019/1239), repealing Directive 2010/65/EU from 15 August 2025	It introduces an interoperable environment with harmonised interfaces, to simplify reporting obligations for ships arriving at, staying in and departing from EU ports. It also aims to improve the European maritime transport sector's competitiveness and efficiency by reducing administrative burden, introducing a simplified digital information system to harmonise the existing national systems and reduce the need for paperwork.

41 https://eur-lex.europa.eu/eli/dir/2002/59/oj

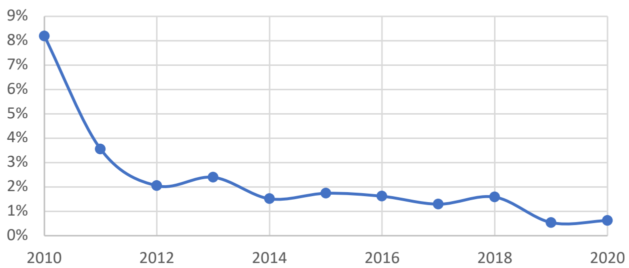
42 The United Nations Code for Trade and Transport Locations, commonly known as UN/LOCODE is a geographic representation of over 100,000 locations across all countries and territories that is used to univocally identify a location and is used by the shipping industry and applied by major international organisations.

2.3.2 Data quality and correctness

The systems implemented by Member States to record the ship arrivals, departures and stays are mostly automated, but the human element is still present, since the notifications are sent by ship masters, agents and/or ship operators. There is a continuous effort by the national administrations in collaboration with EMSA, to ensure the correctness of the information received in SSN.

This effort may be observed by the evolution in the number of missed ship calls recorded in SSN, which has substantially decreased over the last 10 years, as shown by the figure below, reaching less than 1% of all ship calls in 2019.

Figure 61: Evolution of missed ship calls reported over the last 10 years in percentage of total ship calls.



Source: EMSA Services (SafeSeaNet)[43]

2.3.3 Transportation of dangerous and polluting goods by sea

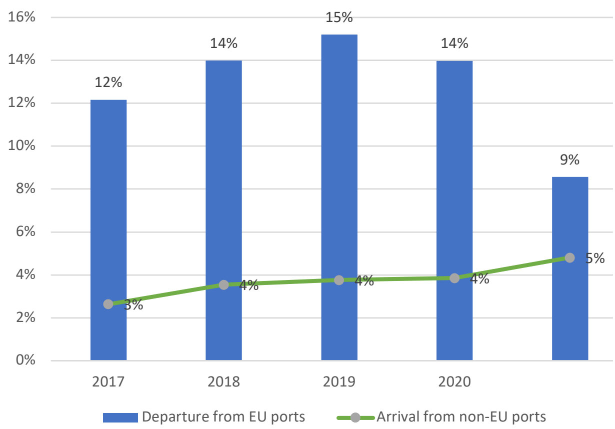
Part of the cargo transported by sea falls under the generic category of dangerous and polluting goods (DPG) and is commonly referred to as hazmat. Vessels carrying hazmat are required to inform the destination port – prior to the ship's arrival – about the specifics of the cargo, amount, and location on board so that in case of an accident, response services can have a better picture of the problem ahead, the risk assessment in ports, etc.

In accordance with the VTMIS Directive, the ship master, agent, or operator of a ship carrying hazmat shall report it upon departure from an EU port, or if arriving from a port located outside the EU, the hazmat must be declared before the arrival to the EU port.

The following figure presents the evolution of the percentage of ship calls reporting hazmat in SSN when departing from EU ports or arriving from outside the EU. The decrease of hazmat in 2020 declared upon departure may be related to the effect the COVID-19 pandemic had on the transportation of goods by sea. As shown in the years before the pandemic more than 10% of the calls departing from EU ports reported hazmat.

The reception of hazmat in European ports arriving from non-EU ports entails a higher risk because the conditions under which the cargo was shipped and packed may not always meet EU standards. For this reason, it is important to understand which non-EU countries normally ship to EU ports and which vessel flags are used to carry those goods.

Figure 62: Percentage and evolution of ship calls with declared hazmat upon departure from EU ports and arrival from non-EU ports.



Source: EMSA Services (SafeSeaNet)

43 Cross checked with other external sources.

The tables below show the non-EU MS flags that called most at EU ports in 2020, arriving from outside the EU and carrying hazmat, and the countries from which these vessels departed.

Table 19: Top-5 flags of ships carrying hazmat from outside the EU.

Vessel Flag	Nr. ship calls
Liberia	3612
Marshall Islands	2587
Panama	2509
Singapore	1186
Turkey	1046

Source: EMSA Services (SafeSeaNet)

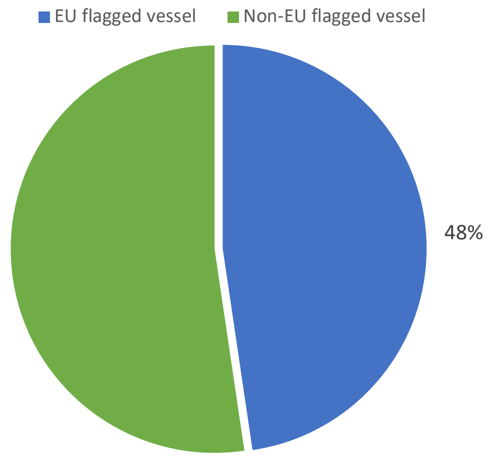
Table 20: Countries of departure of most ships carrying hazmat from outside the EU.

Previous country	Nr. ship calls
United Kingdom	9915
Russia	4914
Turkey	3183
Egypt	2309
USA	2000

Source: EMSA Services (SafeSeaNet)

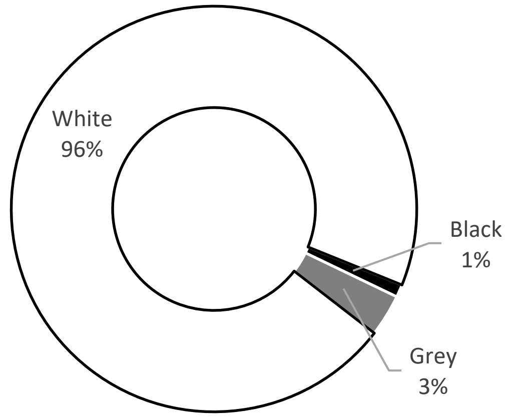
Figure 63 and Figure 64 present the distribution of non-EU MS flagged ships carrying hazmat and coming from non-EU ports in 2020, and the distribution of those flags according with the Paris MoU 'White, Grey and Black List'.

Figure 63: Distribution of flag for calls from outside the EU carrying hazmat in 2020.



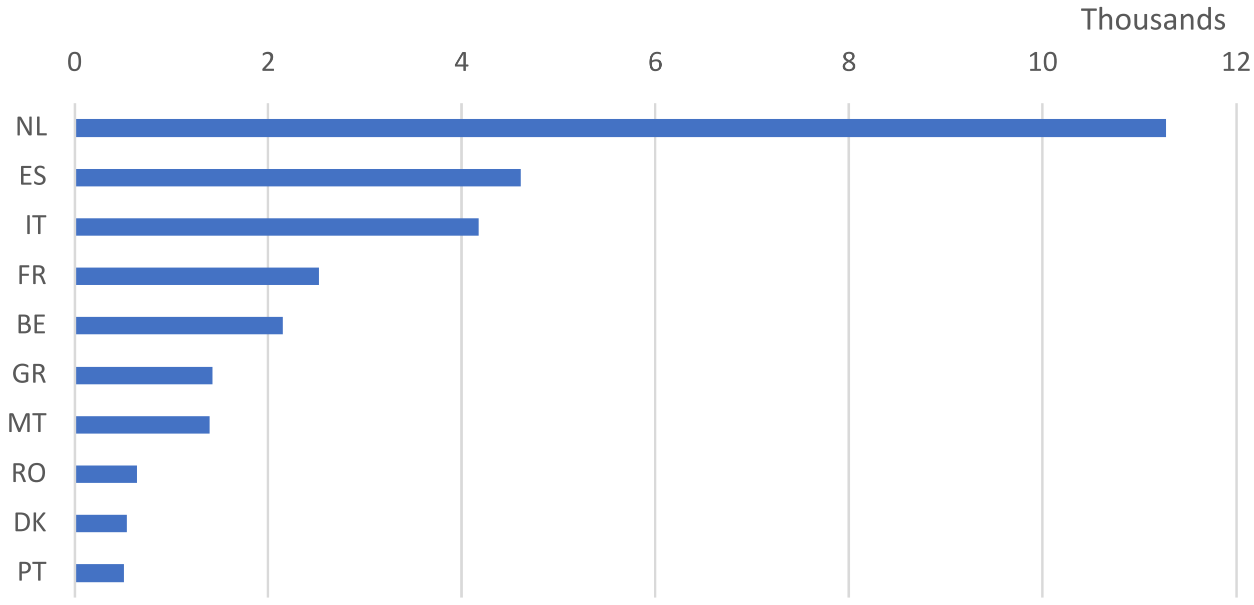
Source: EMSA Services (SafeSeaNet)

Figure 64: Distribution of flags according with the Paris MoU 'White, Grey and Black List' for non-EU MS. vessels arriving from locations outside the EU.



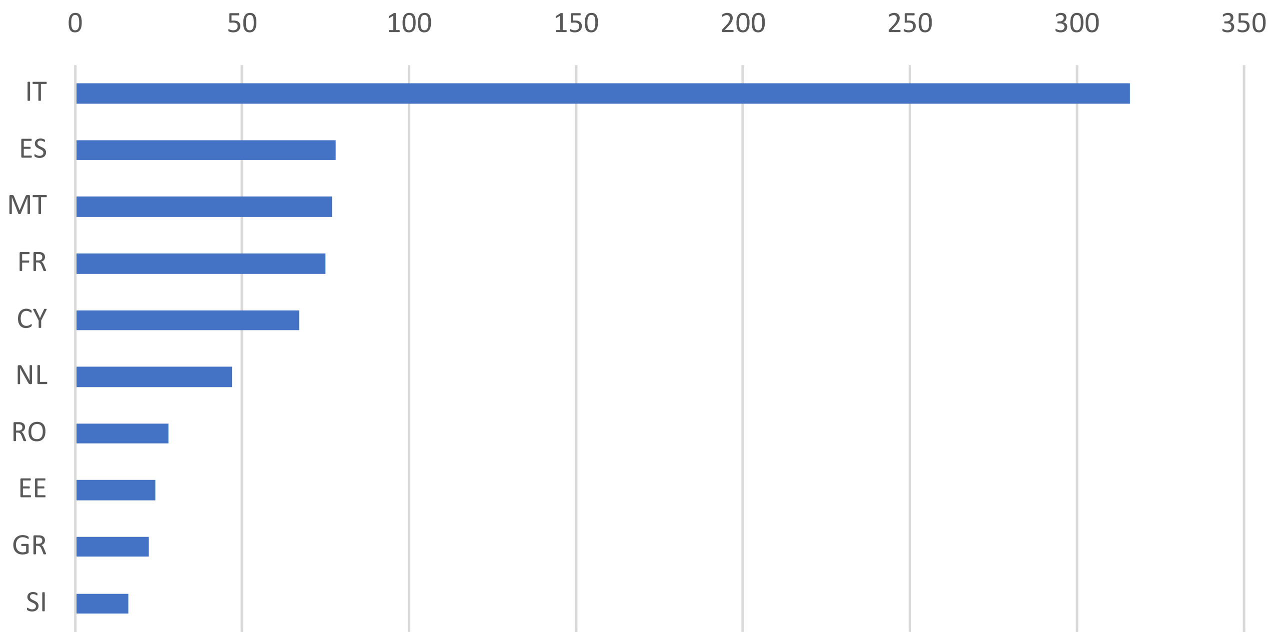
Source: EMSA Services (SafeSeaNet)

Figure 65: Number of ships calling EU MS in 2020, carrying hazmat and arriving from outside the EU.



Source: EMSA Services (SafeSeaNet)

Figure 66: Number of grey and black-flagged vessels calling EU MS in 2020, carrying hazmat and arriving from outside the EU.

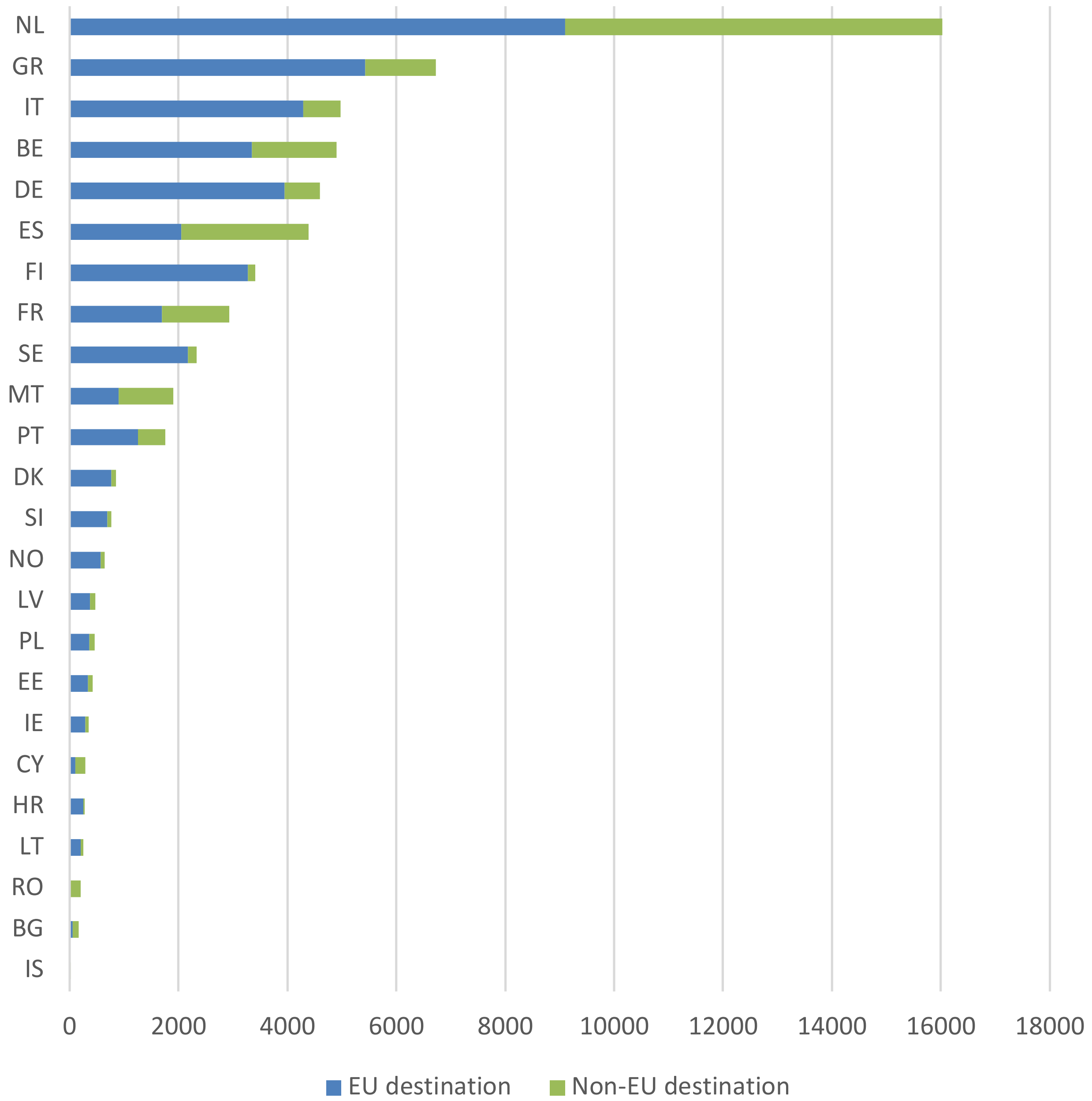


Source: EMSA Services (SafeSeaNet)

Figures 65 and 66 show the EU Member States that receive most ship calls with hazmat from outside the EU, and the Member States that have the most calls of vessels flying Grey and Black flags as per the Paris MoU list.

Figure 67 shows the next call destination of ships departing EU ports containing hazmat in 2020.

Figure 67: Number and distribution per Member State of the declared destination records of hazmat departing from the EU.



Source: EMSA Services (SafeSeaNet)

The misdeclaration of dangerous and polluting goods poses as a severe risk to crew, cargo and reception ports because potentially dangerous cargos may go unnoticed. For this reason, national administrations place a special focus on verifying if hazmat is properly declared and at the right moment. EMSA, in close collaboration with national administrations and industry, performs regular audits in SSN by cross-checking data from different sources.

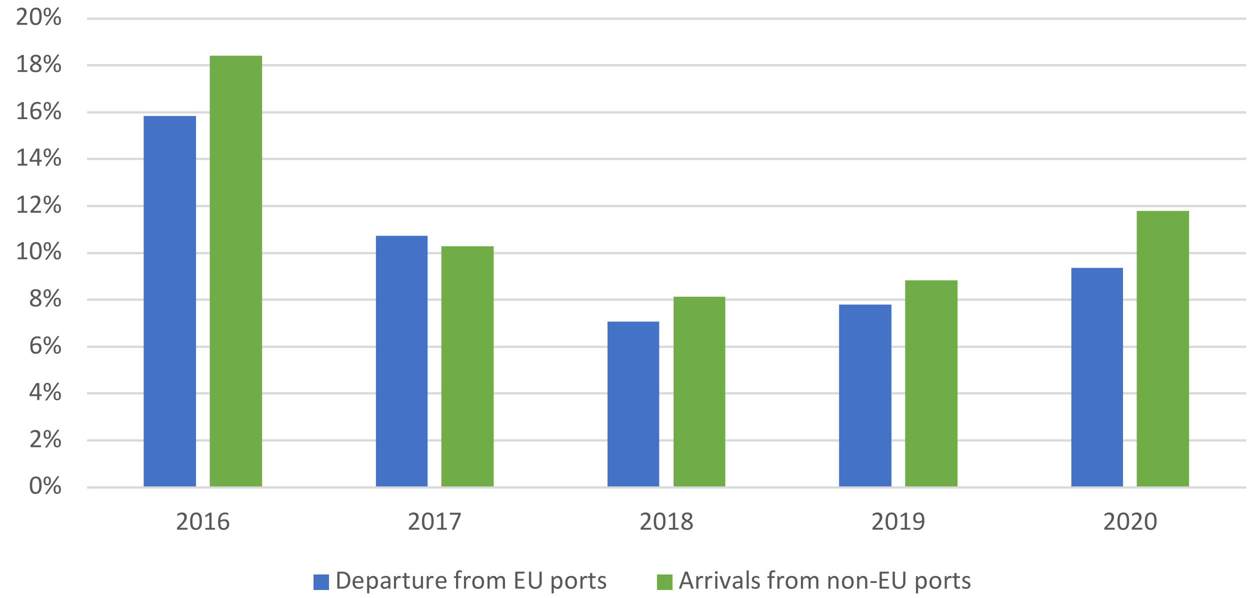
Figure 68 shows the figures of undeclared hazmat, which have generally improved over time but are still considered far from optimal.

2.3.4 Accidents and incidents

Incident report notifications are sent to SSN to inform about incidents related to ship safety and seaworthiness (SITREP), pollution events (POLREP), waste, lost and found containers, etc. These reports may be shared with other Member States that are in the vicinity or along the route of the vessel.

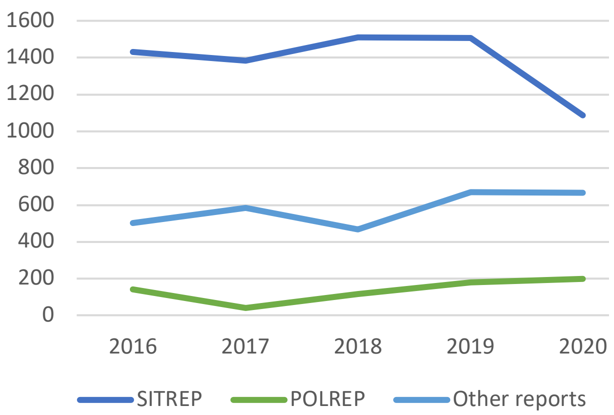
Figure 69 show the evolution over time of reports of incidents affecting the safety of navigation, pollution and grouping the remaining incident reports as one global category 'Other reports'. For 2020, Figure 70 presents the breakdown of the other types of incident reports.

Figure 68: Percentage of missing hazmat declarations upon arrival from ports outside the EU and departure from EU ports.



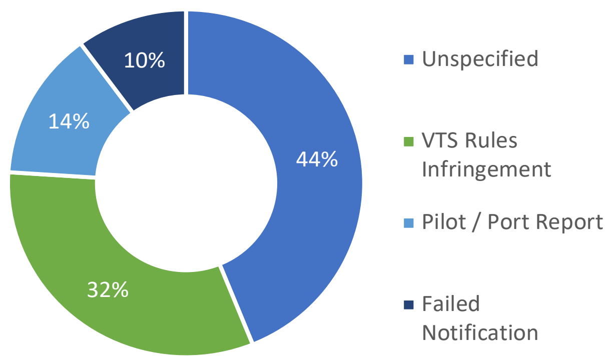
Source: EMSA Services (SafeSeaNet)

Figure 69: Number of incident reports to SSN and evolution over the past 5 years.



Source: EMSA Services (SafeSeaNet)

Figure 70: Distribution of other types of incident reports to SSN apart from SITREP and POLREP.



Source: EMSA Services (SafeSeaNet)

3. Enforcement/ Compliance Checks

3.1 Flag State and Recognised Organisations

3.1.1 Introduction

Even when the standards are well defined and are proportional to the associated risks, if the enforcement of such standards and measures is weak, then the safety level drops. The main responsibility for the implementation of safety standards, including seafarers' certification, training, and working conditions, lies with the flag state. At international level, its obligations are summarised in the IMO Instruments Implementation (III) Code. These obligations were slightly expanded at EU level by Directive 2009/21/EC, which requires the implementation of a quality system based on ISO 9001:2015 to ensure the enforcement of relevant safety legislation, an electronic ship register, and an audit every seven years through the dedicated IMO Member State Audit Scheme (IMSAS) which aims at monitoring the performance of flag states.

Flag state obligations include the survey of ships and the issuance and renewal of certificates. However, flag states can authorise classification societies to act on their behalf to carry out statutory surveys[44] and the certification work of their flagged fleet. The classification society, when performing this role, is known as a Recognised Organisation (RO) and should meet the minimum requirements established in the IMO RO Code. It is the responsibility of each flag state to verify that a classification society fulfils the conditions of the RO Code before recognising it.

But the work of flag states is not over with this recognition. The process must be complemented with a regular oversight programme for the activities of the RO. The oversight programme is supported, but not replaced, by quality systems that RO must implement subject to independent, third party verification.

44 Statutory surveys refer to those surveys activities which are mandatory according to the International Conventions and which might imply the issuance or renewals of international navigation certificates.

Table 21 shows the regulatory framework at international and EU level on Flag States and Recognised Organisations.

3.1.2 Flag State

3.1.2.1 General

As indicated in the introduction, the responsibilities of flag states at international level are quite heterogenous and are listed in the III Code. They include the implementation of international legislation through national law, the delegation of authority to RO, enforcement, qualification of flag state surveyors and accident investigation. This section of the report will deal with enforcement.

Flag states are audited at international level through IMSAS, an IMO-managed programme. The audit output usually includes findings and a corrective action plan. However, there is no harmonised safety performance of flags at international level and no associated penalties in case of non-fulfilment of the corrective programme. To partially tackle this issue at EU level, Directive 2009/21/EC makes reference to the Paris MoU flag scheme ('White, Grey and Black list') as the main indicator in terms of performance and establishes obligations for flags in case of low performance. However, PSC inspections do not cover all the elements under flag state responsibility and accordingly, this indicator is only a partial measurement. It is worth noting that Directive 2009/21/EC is currently in the process of being reviewed.

The main enforcement work of flags has to do with regular mandatory surveys and audits, including those related to the ISM Code, international and EU legislation and the issuance of certificates. In addition, there can be flag surveys for other reasons like a detention of a ship by the port state system or an accident.

However, in view of the size of the fleet of many Member States and their distribution around the globe, on many occasions flag administrations have to delegate their surveying and/or certification authority to classification societies working as recognised organisations.

At EU level, the approach differs, depending on the Member State. While some administrations keep a high number of flag state surveyors and an approval office for drawings, others have effectively delegated all their approval and survey tasks to ROs and simply keep an RO oversight programme. Equally, other EU Member States have chosen to retain the approval and survey responsibility for certain types of ships, for example passenger ships in view of the number of persons onboard, or on new ships build. Accordingly, the delegation of authority from the flag States state to the RO can be either:

- Full delegation of authority to a RO;
- Partial delegation, i.e., certain tasks are not delegated and remain the exclusive competence of the flag administration. These particularities are defined on a case-by-case basis in the agreement between the RO and the flag state;
- No delegation, i.e., the flag state has not delegated any competence to the RO.

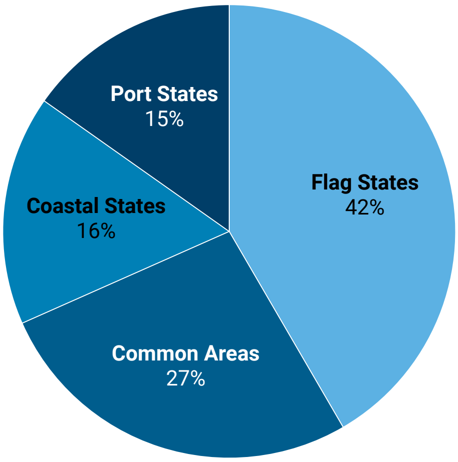
Table 21: Legislation on Flag States and Recognised Organisations.

<table>
<tr><th rowspan="12">Legislation</th><th>Level</th><th>Instrument</th><th>What it regulates</th></tr>
<tr><td rowspan="4">International</td><td>UNCLOS Article 94</td><td>Definition of Flag State.</td></tr>
<tr><td>IMO Instruments Implementation Code (III Code) Part 2

Res.A.1070(28)</td><td>Implementation
Delegation of authority
Enforcement
Flag State surveyors
Flag State investigations
Evaluation and review</td></tr>
<tr><td>Code for Recognized Organizations (RO Code)</td><td>Minimum criteria against which organizations are assessed towards recognition and authorisation and the guidelines for the oversight by flag states.</td></tr>
<tr><td>International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code)</td><td>Safety management systems on board ships, including identification of risks, establish appropriate safeguards and continuous improvement of safety to ensure compliance with mandatory rules and regulations.</td></tr>
<tr><td rowspan="7">EU</td><td>Directive 2009/21/EC</td><td>Flag State Directive.</td></tr>
<tr><td>Directive 2009/15/EC</td><td>Common rules and standards for ship inspection and survey organisations and for the relevant activities of maritime administrations.</td></tr>
<tr><td>Regulation (EC) 391/2009</td><td>Common rules and standards for ship inspection and survey organisations.</td></tr>
<tr><td>Regulation (EU) 2019/492</td><td>Amending Regulation (EC) No 391/2009 with regard to the withdrawal of the United Kingdom from the Union.</td></tr>
<tr><td>Regulation (EC) 788/2014</td><td>Laying down detailed rules for the imposition of fines and periodic penalty payments and the withdrawal of recognition of ship inspection and survey organisations pursuant to Articles 6 and 7 of Regulation (EC) No 391/2009 of the European Parliament and of the Council.</td></tr>
<tr><td>Regulation (EC) 336/2006</td><td>Implementation of the International Safety Management Code within the Community.</td></tr>
</table>

Unlike port state inspections, there is no public reporting system of the flag surveys in terms of numbers and/or deficiencies found, so it is not possible to provide an analysis in this regard. However, some data comes from the IMSAS audits. The IMO Secretariat note III /INF.27 includes an analysis of the four consolidated audit reports from 68 audits conducted between 2016 and 2019. The IMSAS audits are divided into four main areas to assess the performance of a state in its different capacities: Common Areas, Coastal State, Flag State and Port State. The category with the highest number of findings (42%) is that related to flag state obligations, as shown in the following graph:

Figure 71: Distribution of findings and observations by parts of the III Code.



Source: IMSAS Audits (https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/III-7th-Session.aspx)

Within the flag state category, the recorded findings are classified by area of responsibility according to Figure 72.

In the area of implementation, the findings include the lack of issuing national legislation and guidelines to implement international rules and those requirements left to the discretion of the Administration, type approval processes, lack of resources and determination of minimum safe manning.

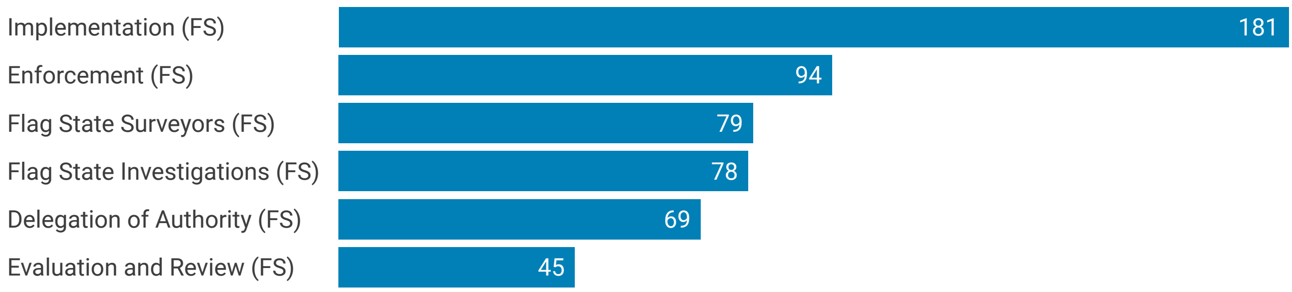
As for enforcement, the findings include the absence of national legislation, guidance and human resources and the lack of penalties to discourage violation of international rules.

Concerning flag state surveyors, the findings refer to training programmes, qualification, authority, and continuous updating of their knowledge.

With respect to the delegation of authority, the findings are related to the administration's oversight programme of ROs, agreement between the administration and the RO, as well as compliance with other relevant provisions of both the RO Code and the III Code.

Finally, with respect to evaluation and review, the most recurrent findings are related to the absence of a system to evaluate, on a periodic basis, the performance of the state when in the conducting of flag state activities.

Figure 72: Number of findings and observations under part 2 of the III Code – Flag States.



Source: IMSAS Audits (https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/III-7th-Session.aspx)

3.1.2.2 ISM Code

The International Safety Management (ISM) Code is a very particular instrument within the sphere of responsibility of the flag state. The goal of the ISM Code is to provide an international standard for the International Management for the Safe Operation of Ships and for Pollution Prevention. The Code was made mandatory through Chapter IX of SOLAS and can be seen as the framework through which IMO Conventions can be effectively implemented. Under this Code, each ship must have an internal safety management system (SMS) which should include all the relevant safety procedures. Each ship must be certified by the flag, according to the ISM Code through the Safety Management Certificate (SMC) and its SMS must be audited internally by the company responsible for the safety management of the ship. This company must also hold the Document of Compliance with the ISM Code (DoC), issued by the flag. In addition, both the ship and the company holding the DoC must be subject to regular audits by the flag or RO acting on its behalf.

Table 22: Number of ISM managers per country and number of ships for which they hold a DoC.

Country	No. Companies (ISM Managers) ▼	No. Ships
Norway	256	1,826
Germany	216	2,476
Netherlands	198	1,283
Greece	150	461
Italy	125	801
Denmark	59	829
Cyprus	52	670
Sweden	46	219
Spain	43	165
France	32	253
Finland	28	127
Poland	27	196
Malta	26	71
Croatia	25	157
Bulgaria	22	74
Estonia	20	98
Belgium	15	140
Latvia	15	109
Portugal	14	42
Lithuania	9	62
Irish Republic	8	54
Luxembourg	5	79
Slovenia	4	12
Iceland	3	10

Source: EMSA Services based on IHS Markit Sea-web™

The companies holding the DoC are responsible for the safety management of the ship, but they need not necessarily be either the ship's commercial operator or the company owning the ship. Moreover, they do not need to be located or registered in the flag state, unless otherwise stated in the national law. Table 22 lists the location of the companies having a DoC registered in the EU Member States, and the number of ships for which they manage safety from an ISM perspective.

This Code is an overarching safety framework; therefore, if the DoC of a company is withdrawn then all the associated Safety Management Certificates become invalid.

EU Member States and the European Commission have recognised the essential contribution that the ISM Code brings to maritime safety and the protection of the marine environment by incorporating it into EU legislation through Regulation (EC) 336/2006. This Regulation extends the scope of the ISM Code to cover cargo and passenger ships engaged on domestic voyages (although with some exemptions), as well as to mobile offshore drilling units (MODU). In addition, Member States have an obligation to report every two years to the European Commission on the implementation of this Regulation.

The importance given to this Code can also be seen in the delegation rate, which is considerably lower than that of the major safety conventions, as shown in the following table, and in Table 27.

Table 23: Degree of EU MS delegations of authority to RO in the issuing process of the ISM certificates.

Certificate		Full delegation	Partial delegation	No delegation
DoC (ISM company)	Audit	63%	7%	15%
	Certificate	44%	7%	33%
Safety Management Certificate (ISM ship)	Audit	67%	11%	7%
	Certificate	48%	7%	30%

Source: GISIS (https://gisis.imo.org/)

Data is left blank for 15% of the certificates due to under-reporting.

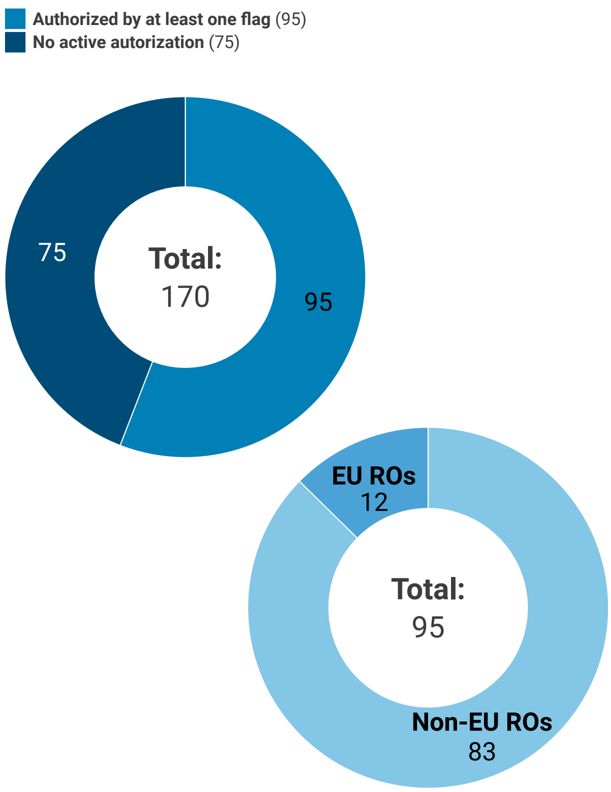
3.1.3 Recognised Organisations

3.1.3.1 Recognition

As indicated before, it is common practice in the maritime industry that flags delegate authority to classification societies which, when acting on behalf of the flag state, are called Recognised Organisations. Delegation can only be granted to organisations that fulfil the minimum requirements stipulated in the IMO RO Code, which serves as the international standard for the minimum criteria against which organisations are assessed for recognition and authorisation. However, on many occasions, flags authorise ROs with a poor safety performance.

Flag states must report to IMO the specific responsibilities and conditions of authorities delegated to ROs through the Global Integrated Shipping Information System (GISIS), which currently lists 170 recognised organisations, 95 of them being at least authorised by one flag and only 12 recognised by the European Commission.

Figure 73: Number of Recognised Organisations listed in GISIS with active authorisation by at least one flag. Number of authorised RO that are EU RO.



Source: GISIS (https://gisis.imo.org/)

The 12 EU recognised organisations belong to and are the only members of IACS[45], the International Association of Classification Societies. EU Member States can only authorise a classification society recognised by the European Commission to act on their behalf, but there is no restriction on accepting a ship in EU ports which is surveyed and certified by a non-EU RO.

For the system to work properly at international level, flags should only recognise classification societies which ensure an appropriate safety level. However, the information available indicates that certain combinations of flags and ROs result in ships not fulfilling the safety and pollution prevention requirements of the conventions. The Paris and the Tokyo MoU prepared a joint submission to the IMO (III/5/5/5) indicating those combinations consistently presenting the worst safety performance. This paper quotes the Declaration of the second Joint Ministerial Conference of the Paris and Tokyo Memoranda of Understanding on Port State:

"To invite the Port State Control Committees to develop criteria for the identification of the flag states and their recognised organizations that jointly have poor performance and to investigate options, including the possibility of changing the relevant international conventions so that certificates issued by these recognised organisations on behalf of these flag states are not recognised as valid."

At EU level it was decided to harmonise the process by centralising the recognition of such entities at the European Commission with support from EMSA. This makes a significant difference with respect to the international recognition system which can be, on some occasions, subject to abuse as indicated in the previous paragraph. Member States can participate in the assessment of the RO they have authorised and join in the EMSA inspections as observers. In Table 24 and Table 25 the 12 ROs are listed with the number of EU Member State flagged ships under Class and divided per type of ship.

45 At the time of finalising this report, IACS had taken the decision to withdraw the membership of the RMRS: https://iacs.org.uk/news/iacs-council-withdraws-russian-register-s-membership-of-iacs/

Table 24: Number of classed ships with an EU MS flag per EU RO.

	No. of ships	GT
DNV	3235	71M
BV	2767	35M
RINA	1757	23M
LR	1562	48M
ABS	846	50M
CRS	3...	704K
ClassNK	326	11...
PRS	187	640K
RS	132	971K
CCS	97	7M
KR	61	2M
IRCLASS	7	346K

Source: EMSA Services

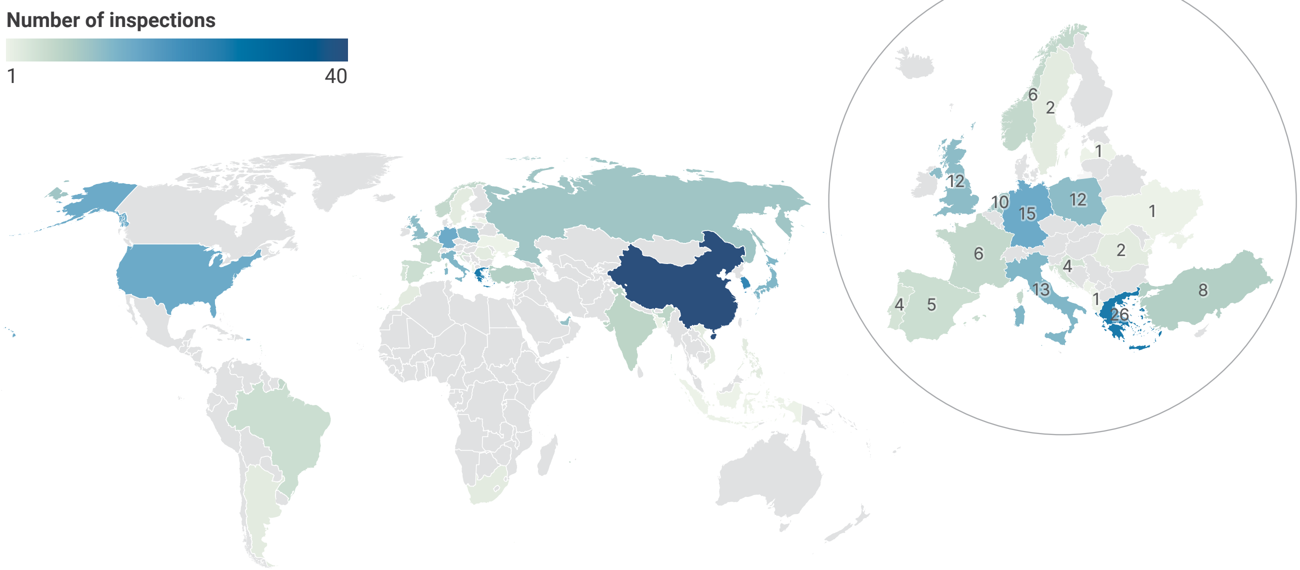
Table 25: Number of classed ships per type of each EU RO.

	Tankers	Bulk carriers	General cargo	Containerships	Ro-Ro Cargo	Passenger ships	Other cargo	Fishing	Other work vessels
ABS	355	232	10	151	11	3			84
BV	464	203	474	181	28	185	13	233	987
CCS	22	43	12	19					1
CRS	12	7	6		2	204		75	32
DNV	556	166	444	499	128	300	24	380	738
IRCLASS	5					2			
KR	20	19	6	13	1	2			
LR	406	246	203	128	73	123	18	45	320
ClassNK	56	234	11	21	3				1
PRS	2	3	28	1	3	37	1	44	68
RINA	253	116	207	39	110	457	20	24	531
RS	13	7	30	4		47	4	19	8

Source: EMSA Services

The process of recognising a classification society at EU level is triggered by a request from a Member State. This initial assessment is carried out by the European Commission based on reports from EMSA, which has been entrusted with the task of carrying out the required inspections. In addition, there is a regular assessment of each RO – in principle once every two years - also based on reports from EMSA. The inspections take place in head offices and selected regional, field and site offices of the classification societies and include visits to ships. Since EMSA started operations in 2004, some 300 inspections of RO have been conducted in different geographical areas (Europe, Asia, North and South America, Middle East and Africa) as indicated in the following map.

Figure 74: Geographical distribution of EMSA's inspections to RO since 2004.



Source: EMSA Services

As a result of these inspections, more than 5,000 findings have been identified. However, in the figures below, only those findings encountered in inspections carried out since 2009 under the current regulation 391/2009[46] are shown. In this period 186 inspections took place with 3,643 findings identified:

As a consequence of the findings, RO have adopted corrective actions, either on a voluntary basis or at the European Commission's request. At least once every two years, the consolidated results of the visits, inspections and assessments are discussed with the Member States, thereby providing valuable information to national administrations for the purpose of their own monitoring of the RO they authorise in the framework of the Directive.

Figure 75: RO inspections – findings on compliance with statutory requirements (including ISM) by category.

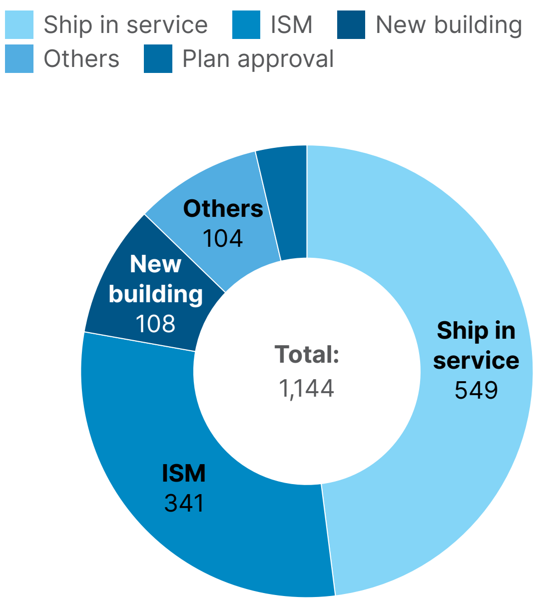
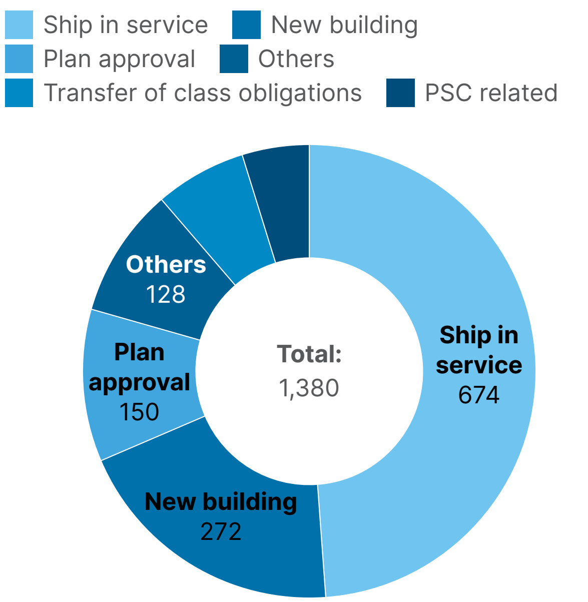


Figure 76: RO inspections – findings on compliance with own rules and procedures by category.



Source: EMSA Internal Data

46 Regulation 391/2009 replaced Directive 94/57/EC.

These findings come from the inspections of the 12 IACS members, which have the highest reputation within classification societies worldwide in terms of professionalism, knowledge and quality of procedures. For example, according to EQUASIS statistics, ship detention rates are in general higher for ships not classed by IACS members. In this regard, it is important to note that, according to the same source, a substantial part of the world fleet is classed by classification societies that are not IACS members and, therefore, not subject to the same internal quality systems and external inspections like those of EMSA. Therefore, it is not possible to know how the remaining 158 Classification Societies implement the relevant Conventions onboard ships.

In terms of the inspections carried out, there are some elements which need to be noted. One of them is related to the obligations regarding the transfer of class set out in Article 10 of Regulation (EC) No 391/2009, aimed, among other things, at preventing ships from changing class in order to avoid carrying out necessary repairs. It also obliges the EU ROs to set common standards concerning cases of transfer of class where special precautions are necessary, such as ships older than 15 years and the transfer from a non-EU recognised organisation to an EU recognised organisation. As can be seen in the table below, there is a high number of class transfers between EU RO:

Table 26: Number of ships transferred between EU RO over the past 5 years based on the date of request for transfer.

EU RO	No. lost ships	No. gained ships	Net gain-loss	Fleet size
ABS	2,384	1,308	−1,076	8,256
BV	2,322	2,404	82	8,710
CCS	194	855	661	4,506
CRS	16	62	46	400
DNV	3,328	1,620	−1,708	9,108
IRS	102	598	496	1,300
KR	409	730	321	2,802
LR	1,985	1,626	−359	8,760
NK	1,926	914	−1,012	8,593
PRS	80	404	324	486
RINA	667	2,553	1,886	4,547
RS	284	441	157	3,037

Source: IACS (https://www.iacs.org.uk/ship-company-data/transfer-of-class/)

Data downloaded on 26/10/2021.

A ship may change classification society for various reasons, including a change of shipowner or other commercial reasons. But another potential cause can be a disagreement between the shipowner and the classification society on the extent of any ship repairs or maintenance that may be required. Consequently, the shipowner may wish to appoint a classification society which imposes less stringent requirements.

Although IACS requirements and EU regulation have tightened the procedures, this area still needs continuous monitoring as well as the acceptance into class of ships not built under the supervision of an EU RO. EMSA inspections continue to establish findings in these areas, in particular regarding compliance with class rules and statutory requirements during the class entry surveys.

Finally, it is also worth mentioning that the regulation also lays down a system of penalties in case of non-compliance, although so far, no penalty has been imposed.

The following table illustrates the different degrees of delegation of authority by EU flag states to ROs in the process of issuing the main regulatory safety certificates required by the SOLAS Convention.

As can be seen, on many occasions, EU flag states delegate the survey work, but not the certificate issuance, to maintain some control over the process. The surveys carried out for cargo ships within the SOLAS framework are delegated in more than 75% of the cases while for passenger ship safety the authority on surveys and certificates is the least delegated (largest share of 'No delegation').

Table 27: Degree of EU MS delegations of authority to RO in the issuing process of the main regulatory safety certificates required by SOLAS.

Certificate		Full delegation	Partial delegation	No delegation
Passenger ship safety	Survey	74%	0%	11%
	Certificate	56%	0%	30%
Cargo Ship Safety Equipment	Survey	78%	4%	4%
	Certificate	63%	4%	19%
Cargo Ship Safety Radio	Survey	78%	4%	4%
	Certificate	67%	4%	15%
Cargo Ship Safety Construction	Survey	85%	0%	0%
	Certificate	74%	0%	11%
Load Line	Survey	81%	4%	0%
	Issuance of certificate	74%	0%	11%

Source: GISIS (https://gisis.imo.org/)

Data is left blank for 15% of the certificates due to under-reporting.

Quality Assessment and Certification Entity (QACE)

At EU level, Regulation (EC) No 391/2009 required ROs to set up and maintain an independent quality assessment and certification entity with the main objective of assessing and certifying the RO quality management system. The entity was founded in November 2010 with the name 'QACE – Entity for the Quality Assessment and Certification and of Organisations Recognised by the European Union'. One of the recognition criteria that a RO must fulfil is to have its quality management system certified by the above-mentioned entity.

The European Commission, with EMSA's assistance, assesses the development and operation of QACE, which is also ISO certified, and reports on the results and follow-up of its assessments to the Member States at the Committee on Safe Seas and the Prevention of Pollution from Ships (COSS).

QACE publishes an annual report every year[47] with collective recommendations for ROs. Based on the analysis of audit findings from 2020, QACE concluded that that the two primary reasons for the findings, common to all ROs, are errors in:

- Job execution - delivery surveys and audits of ships, and inspections of their equipment, which occasionally are not in full compliance with the requirements of the reference standards and/or RO internal procedures.
- Reference documentation/instructions of the RO – these are not always fit for purpose.

A deeper analysis of the findings under each of the before-mentioned categories shows the underlying causes, common to all ROs:

- Unclear/insufficient/ambiguous guidance on some elements of technical service delivery.
- Process requirements that occasionally do not comply with relevant reference standards.

QACE also concluded that a contributing factor to the root causes was insufficient training of technical staff in process requirements.

3.1.3.2 Oversight of RO

The flag state's responsibilities should not end with recognition of a classification society. There should be a thorough and consistent oversight programme to ensure that the work carried out by the RO is kept within the authorisation conditions and that the safety performance is satisfactory. The RO Code includes guidelines in the oversight programme to be followed by flag states.

The summary results of IMSAS audits (see document III 7/INF.27) indicate that, with respect to the delegation of authority to ROs, the most recurrent findings are related to the administration's oversight programme, the agreement between the administration and the RO, as well as compliance with other relevant provisions of both the RO Code and the III Code.

Table 28: Shortcomings per category on delegation of authority – summary results of IMSAS audits.

Areas of findings	Categories of findings	Number of shortcomings
Delegation of authority	Evaluation of ROs	37
	Agreement	40
	Instructions to ROs	35
	Providing ROs with national legislation	30
	ROs records	17
	Oversight programme	44

Source: IMSAS audits (document III 7/INF.27 in https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/III-7th-Session.aspx)

47 2020 QACE Annual Report: QACE-2020-Annual-Report-.pdf

Under the area of implementation, the most frequent categories of root cause were lack of technical capability and poor technical instructions/guidelines, as well as lack of training programmes, which significantly contributed to non-effectiveness in the areas of implementation, enforcement, and delegation of authority. This information indicates that an inadequate oversight of RO leads to increased risk to safety and pollution prevention.

In an attempt to improve the situation, and support flag states in their oversight efforts, the IMO has created an informal body, the International Quality Assessment Review Body (IQARB)[48], without any legal personality or authority for binding decisions, to assess the certification process of recognised organisations. Accordingly, IQARB assesses the work of the Accredited Certification Bodies (ACB) which are certifying the quality system of the ROs. Currently, IQARB is in a trial phase and has assessed the certification bodies of the IACS members[49] with a positive outcome. The long-term vision is that IQARB could be an entity established under an international legislation framework, with its own standards for qualifying RO, where the scope of application could be extended to all RO at large [10].

At EU level, the oversight programme is regulated by Directive 2009/15/EC, which stipulates that each Member State shall, on a biennial basis, monitor every RO acting on its behalf and share the results of this monitoring with the European Commission and the other Member States. It is noted that the Ex-Post Impact Assessment on the Implementation and Effects of the Third Maritime Safety Package[50] indicated that the implementation of Directive 2009/15/EC on Common rules and standards for ship inspections and survey organisations did not result in a change of the monitoring process of the recognised organisations by Member States.

3.1.3.3 Remote surveys

During the COVID-19 pandemic, regular mandatory surveys still had to be carried out to ensure the safe and effective functioning of maritime activity. A high level of safety had to be ensured, while at the same time protecting the health of everyone involved in the survey process, including surveyors and crews. Accordingly, in this extraordinary situation, ROs, when authorised by the relevant flag state, carried out remote surveys and audits of ships where the physical attendance on board of surveyors was not possible. This created a new situation in the maritime world, where remote surveys came to replace physical surveys.

Accordingly, EMSA conducted a focused campaign in 2020-2021 on how EU ROs were deploying remote surveys in response to the COVID-19 pandemic. The preliminary results of the campaign highlighted:

- The urgent need for harmonisation of requirements for the use of remote methods for surveys, audits and other services offered by ROs to define what could be considered as a remote survey or audit and to precisely describe the conditions and circumstances under which these activities could be performed.

- That the verification and validation of remote surveys and audits during subsequent physical inspections should be mandatory, until the level of assurance and equivalence compared to the services and activities performed with (physical) attendance of qualified exclusive surveyor or auditor could be ensured.

To address these issues, the EU, together with other co-sponsors, proposed two new outputs at MSC 104 – one to regulate remote surveys and ISM Code audits, and the other to develop guidelines for remote inspections and verifications in the field of maritime security, which were accepted and added to III Agenda as a single item. The EU will continue working at IMO level to ensure that remote surveys should not lead to reduced assurance and effectiveness when compared to physical surveys.

48 https://www.imo.org/en/OurWork/IIIS/Pages/IQARB.aspx

49 ACS has an internal Quality System Certification Scheme (IACS QSCS). Audits and assessment of IACS members compliance with the QSCS are now carried out by independent external Accredited Certification Body(ies) ("ACB").

50 Study by EPRS | European Parliamentary Research Services Ex-Post Impact Assessment Unit PE 536.331 - October 2015.

3.2 Port State Control

3.2.1 Introduction

In a nutshell, Port State Control (PSC) involves the inspection of ships flagged in a different state than that of the port visited, to verify that the condition of the ship and its equipment comply with the requirements of international conventions and applicable EU legislation. The purpose of PSC is also to ensure that the ship is properly manned and operated to maintain maritime safety, security, and pollution prevention. Although the responsibility for compliance mainly lies with the flag state, PSC is intended to be a 'second line of defence' against substandard shipping in the EU and around the globe.

The PSC regime was established by the IMO through Resolution A.466(XII) Procedures for the Control of Ships, adopted on 19 November 1981, and is applied through international cooperation agreements - the so-called Memorandums of Understanding (MoU). Regional memoranda of understanding on PSC have been created around the world with the aim of sharing information, best practices, and procedures to harmonise ship inspection processes. Nine regional agreements on PSC were concluded: Europe and the North Atlantic (Paris MoU); Asia and the Pacific (Tokyo MoU); Latin America (Acuerdo de Viña del Mar); the Caribbean (Caribbean MoU); West and Central Africa (Abuja MoU); the Black Sea region (Black Sea MoU); the Mediterranean (Mediterranean MoU); the Indian Ocean (Indian Ocean MoU); and Riyadh MoU. The US Coast Guard has also established a specific PSC regime.

At European level, the main regime is the Paris MoU, which was established in 1982 after the grounding of the VLCC Amoco Cadiz, which caused a massive oil spill along the French coast. This incident raised considerable political and public concerns in Europe and resulted in demands for much more stringent maritime regulations covering living and working conditions on board ships, safety of life at sea and prevention of pollution from ships. Nowadays, the Paris MoU has 27 members, including all EU Member States with seaports, as well as Canada, Iceland, Norway, the Russian Federation and the United Kingdom.

Following the Erika and Prestige oil tanker accidents in 1999 and 2002, EU safety standards for maritime transport were considerably strengthened with the adoption of maritime safety legislation known as the 'Erika packages'. In this context, Directive 2009/16/EC on Port State Control, recasting the existing Directive 1995/21/EC, was adopted in 2009 as part of the third package. While the Paris MoU expects its Member States to apply the international conventions on ship safety, pollution prevention and working and living conditions developed by the IMO and ILO, the EU PSC regime goes further by legally enforcing the application of international and relevant EU standards.

PSC in the EU is based on the idea of targeted inspections by establishing a priority system which factors in risk elements for each ship, e.g., the type of ship, its age, EU RO/non-EU RO, etc. The Directive stipulates the inspection effort of each EU port state through annual quantitative inspection targets, also known as annual inspection commitment. EMSA provides all EU Member States and Paris MoU Member States with the necessary technical support to decide which ships should be inspected and to report the results of the inspection via the THETIS inspection database. At the same time, in collaboration with the Paris MoU Secretariat, EMSA offers initial and ongoing training for port state control officers to ensure that inspections are carried out following a harmonised approach at all European ports.

Table 29: Legislation on Port State Control.

	Level	Instrument	What it regulates
Legislation	International	SOLAS Chapter XI-1 Reg. 4 Res. A.1138(31) III Code	Procedures for Port State Control.
		Paris MoU	Harmonised system of port state control involving 27 states (coastal EU MS, EFTA MS, Canada, Russian Federation and the United Kingdom). The system covers the waters of the European coastal states and the North Atlantic basin from North America to Europe.
	EU	Directive 2009/16/EC	Port State Control regime at EU level.

3.2.2 Regulatory framework

Table 29 shows the regulatory framework at international and EU level on Port State Control.

3.2.3 Relevant data and analysis

Ships subject to PSC in a given state are those ships calling at its ports which fly the flag of a different state, and which fall under the scope of the international conventions in force accepted by that state. In general, this encompasses all ships except fishing vessels, warships, naval auxiliaries, wooden ships of a primitive build, government ships used for non-commercial purposes, and pleasure yachts not engaged in trade.

The activity of port state control therefore depends on the number of calls made by eligible ships. Between 2016 and 2019, the number of port calls and individual eligible ships calling within the Paris MoU region of the EU was stable (see Figure 77). In 2020, the impact of the COVID-19 pandemic on the European shipping traffic is clear in the graphs.

Between 2016 and 2019, more than 70% of the eligible ships for PSC calling at EU ports were inspected under the Paris MoU. During the second quarter of 2020, many national health authorities restricted PSC inspections, leading to a sharp reduction in the overall number of inspections carried out. After restrictions were lifted, most Member States restarted their inspection efforts, even going beyond their original targets. Nevertheless, overall, the percentage of ships inspected dropped to 58%.

Figure 77: Number of port calls at EU ports by ships eligible for PSC. Evolution in the past 5 years.

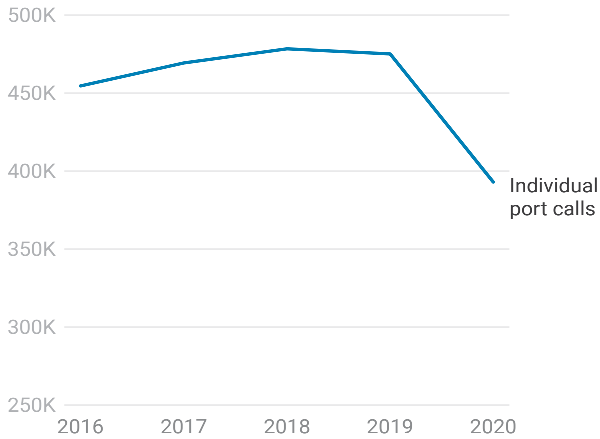
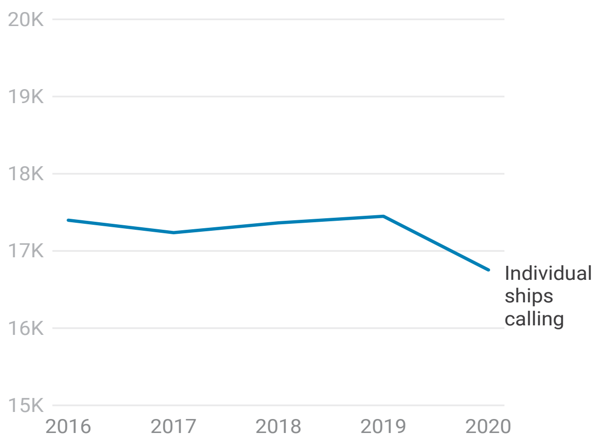


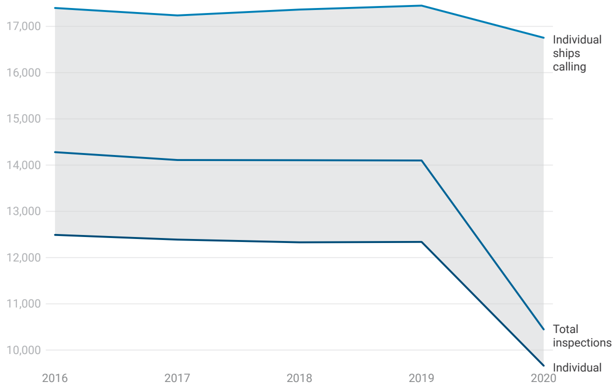
Figure 78: Number of individual ships eligible for PSC calling at EU ports. Evolution in the past 5 years.



Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

Port states excluded: Canada, Russian Federation, Montenegro, United Kingdom. Ships at anchorage are also excluded.

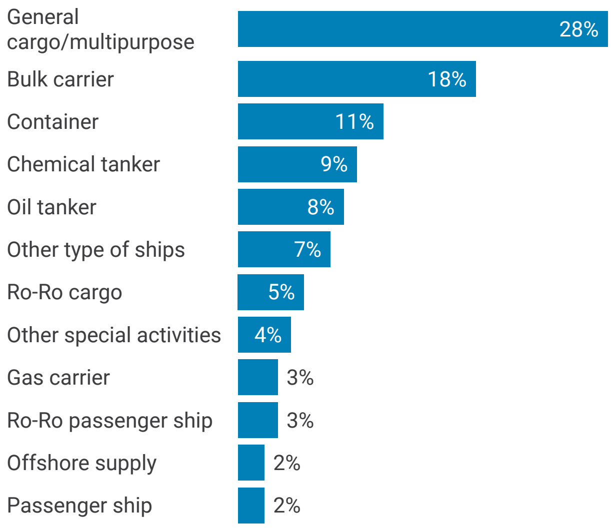
Figure 79: Number of individual ships inspected, and total PSC inspections carried out by EU MS.



Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

Port states excluded: Canada, Russian Federation, Montenegro, United Kingdom. Ships at anchorage are also excluded.

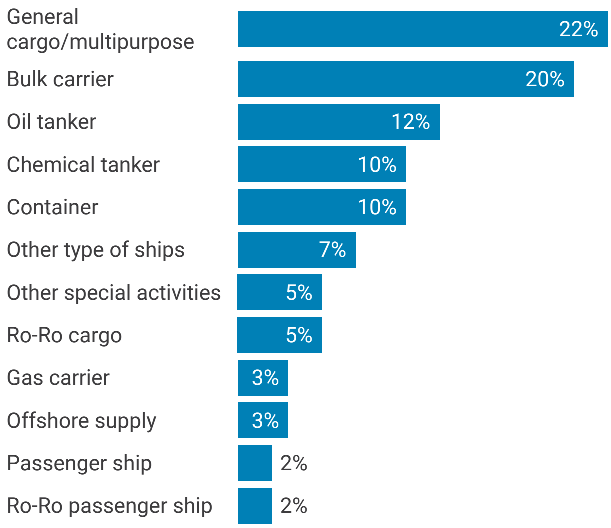
Figure 80: Distribution of PSC inspections per ship type.



Each ship is attributed a ship risk profile in THETIS that depends on the type of ship, age, performance of the flag and recognised organisation and historical parameters such as the number of deficiencies found during previous inspections, detention rate, etc. The risk profile determines when the ship is to be inspected, the inspection frequency and the type of inspections to be carried out. The inspection frequency for high-risk ships is once every 5-6 months, for standard risk ships it is once every 10-12 months and for low-risk ships it is once every 24-36 months. Additional inspections may be also triggered by overriding or unexpected factors than can jeopardise the safety of the ship. This means that some ships may be due for inspection more than once a year. Thus, the total number of inspections is naturally higher than the number of individual ships inspected.

Regarding the order of inspections, precedence is given to ships that have already passed their window for inspection and ships with an overriding factor. Examples of ships with overriding factors are: ships involved in a collision, grounding or stranding on their way to port; ships which have been manoeuvred in an unsafe manner; ships accused of having discharged harmful substances into the sea; ships reported by another Member State; ships that have been suspended or withdrawn from their class for safety reasons after the last PSC inspection; or ships that cannot be found in the database. According to the regulation, all ships in those conditions must be inspected by PSC.

Figure 81: Distribution of the number of calls in the EU per ship type.



Source: EMSA/THETIS

The type of ship is also a factor in the calculation of the ship risk profile, with chemical tankers, gas carriers, oil tankers, bulk carriers, and passenger ships all considered to have higher risk. Over the past 5 years, 50% of all port calls and inspections correspond to ships of those types. However, general cargo/multipurpose ships, although not in the list of ship types of higher risk, constituted 28% of PSC inspections, even though they represent 22% of port calls. An explanation for this higher inspection rate could be other risk factors, like their flag, or that they are certified by a recognised organisation based outside the EU. In general, the share of inspections is lower than the share of port calls only in the case of oil tankers.

PSC includes different types of inspections, namely initial inspections, more detailed inspections, and expanded inspections. In an initial inspection of a ship, the documentation required to be kept onboard according to maritime legislation and the international conventions is checked and the rectification of possible previously found deficiencies is checked along with the overall condition of the ship. A more detailed inspection can be carried out when the inspector decides that the condition of the ship, its equipment, or its crew does not substantially meet the relevant international requirements. Expanded inspections can be carried out on board ships with a high-risk profile if not inspected in the previous 6 months, passenger ships, oil tankers, gas, chemical tankers or bulk carriers older than 12 years of age if not inspected in the previous 12 months. In addition, all the aforementioned categories of ships can be subject to an expanded inspection at any time in case of overriding or unexpected factors, as can ships subject to re-inspection following a ban[51]. This type of inspection makes it possible to evaluate the effectiveness of the safety systems, procedures, and their implementation by the crew.

Figure 82 presents data on the percentage of inspections with and without deficiencies per ship type. As can be seen, general cargo/multipurpose ship is the ship type in which the percentage of inspections without deficiencies is lowest (40%).

Table 30: Distribution of type of inspection per ship type.

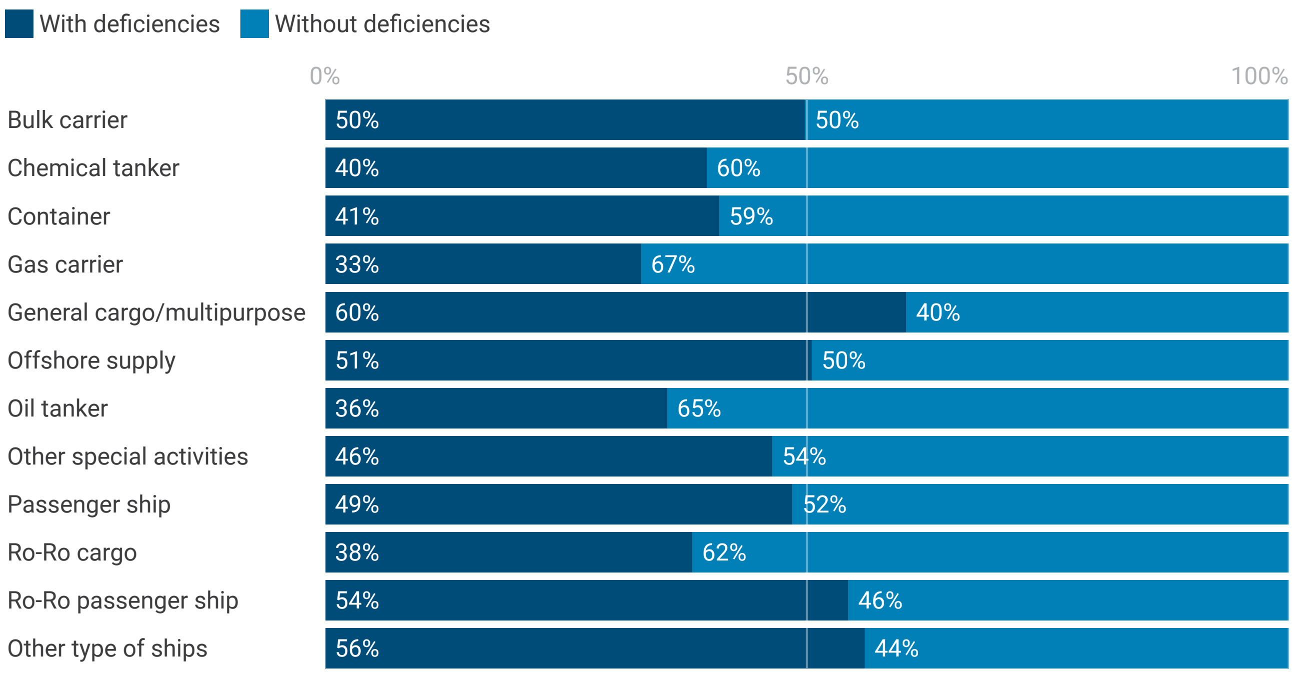
Type of ship	Initial Inspection	More Detailed Inspection	Expanded Inspection
Bulk carrier	37%	36%	27%
Chemical tanker	34%	31%	35%
Container	52%	48%	0%
Gas carrier	41%	26%	34%
General cargo/multipurpose	37%	57%	6%
Offshore supply	53%	47%	0%
Oil tanker	36%	25%	39%
Other special activities	60%	40%	0%
Passenger ship	12%	27%	61%
Ro-Ro cargo	58%	41%	1%
Ro-Ro passenger ship	0%	22%	78%
Other type of ships	42%	47%	11%

Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

Port States excluded: Canada, Russian Federation, Montenegro, United Kingdom. Ships at anchorage are also excluded.

51 When the ship is refused access to ports in the Paris MoU region

Figure 82: Percentage of individual inspections with and without deficiencies found per ship type.



Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

Table 31: Distribution of found deficiencies per main conventions and ship type.

Ship type	SOLAS	Marpol	MLC	STCW	Load Lines	ISM	COLREG
Bulk carrier	53%	9%	22%	3%	7%	6%	1%
Chemical tanker	53%	11%	20%	3%	6%	6%	1%
Container	61%	8%	17%	2%	5%	5%	1%
Gas carrier	54%	12%	21%	3%	4%	5%	1%
General cargo / multipurpose	54%	9%	19%	4%	6%	6%	1%
Offshore supply	54%	16%	16%	4%	5%	5%	1%
Oil tanker	54%	11%	19%	4%	6%	5%	1%
Other special activities	52%	16%	17%	6%	7%	2%	2%
Passenger ship	63%	8%	16%	3%	4%	4%	1%
Ro-Ro cargo	53%	11%	21%	2%	5%	7%	1%
Ro-Ro passenger ship	69%	7%	13%	3%	4%	4%	0%
Special purpose ship	59%	15%	13%	5%	5%	3%	1%
Other type of ship	51%	14%	19%	6%	7%	3%	1%

Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

During an inspection, one or more deficiencies may be identified and included in the PSC inspection report. Each deficiency has a code corresponding to a shortcoming in a requirement laid out in international conventions. The distribution of identified deficiencies per main convention, in Table 31, shows that, on average, and independently of the ship type, at least one out of every two deficiencies issued during PSC inspection are safety-related.

The distribution of deficiencies by specific SOLAS chapters, in Table 32, shows that those related to fire safety are most frequently reported, independent of the type of ship inspected. Defects relating to Chapter II-1 (construction, structure, stability, machinery, and electrical installations), Chapter III (lifesaving appliances) and Chapter V (safety of navigation) make up the remaining deficiencies identified and are more or less equally distributed. It is worth noting that the percentage of fire safety deficiencies in the RoPax category is the same as that found in the special inspection regime addressed in the next section (40%).

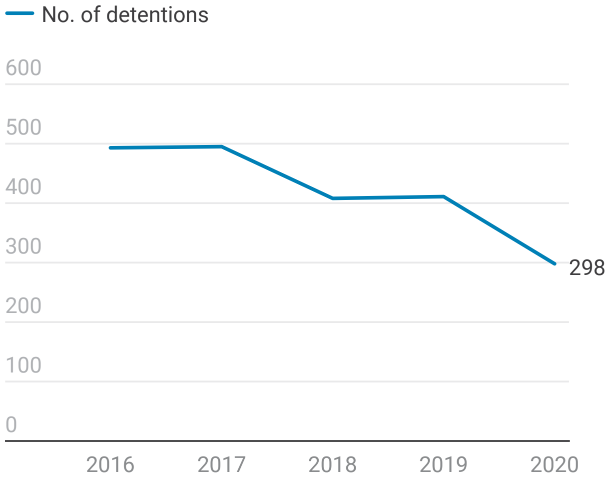
Some deficiencies found during inspections might be so hazardous to the safety, health, or the environment as to constitute grounds for detention of the ship. In those circumstances, the detention order is not lifted until the hazard is removed, or until the ship is authorised to proceed to sea under certain conditions. The number of detentions in EU Member States has been consistently falling over the past five years, which is a positive indicator of the safety of the ships calling at EU ports. As shown, the ship type with the highest percentage of detentions is the general cargo/multipurpose ship type with 48%. This figure is disproportionate to the percentage of inspections carried out in these ships (22%). Accordingly, these ships apparently present a lower safety level in general than the other ship types.

Table 32: Distribution of deficiencies found per SOLAS chapter and ship type.

Ship Type	Chapter II-1	Chapter II-2	Chapter III	Chapter IV	Chapter V	Other
Bulk carrier	22%	29%	18%	3%	18%	9%
Chemical tanker	21%	35%	19%	3%	15%	7%
Container	24%	24%	12%	2%	13%	25%
Gas carrier	23%	36%	21%	2%	16%	3%
General cargo / multipurpose	20%	27%	19%	5%	24%	6%
Offshore supply	16%	27%	18%	4%	27%	7%
Oil tanker	22%	36%	17%	3%	17%	5%
Other special activities	15%	26%	18%	5%	32%	4%
Passenger ship	23%	29%	21%	3%	18%	5%
Ro-Ro cargo	26%	35%	13%	2%	18%	6%
Ro-Ro passenger ship	26%	39%	19%	2%	8%	4%
Special purpose ship	20%	28%	15%	4%	27%	5%
Other type of ships	18%	25%	16%	6%	30%	5%

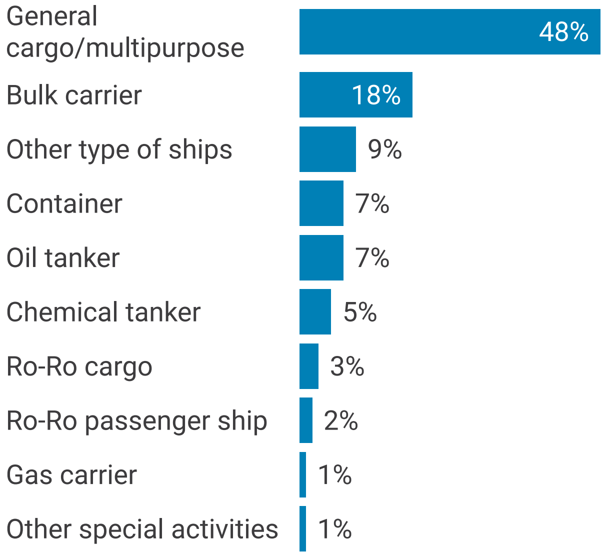
Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

Figure 83: Number of detentions per year. Evolution over the past 5 years.



Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

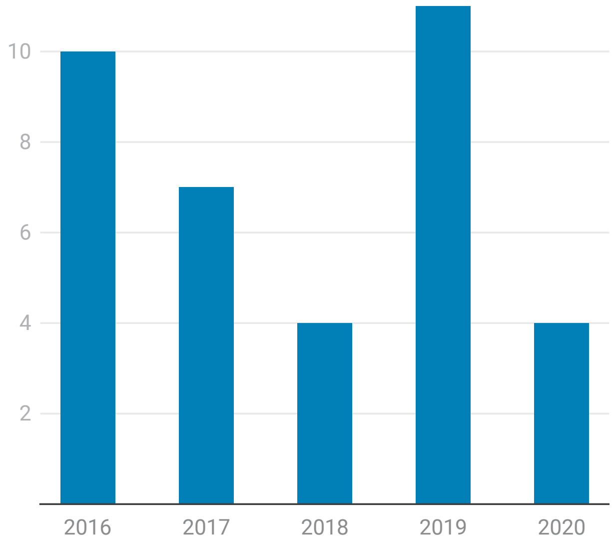
Figure 84: Distribution of the number of detentions per ship type.



Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

There are some reasons for which a ship is refused access to ports in the Paris MoU region. This can be because the ship has been subject to multiple detentions, when the ship proceeds to sea without complying with the conditions determined by the authority in the port of inspection or does not call at the agreed repair yard following a detention. Figure 86 shows the number of ships for which authorities of EU Member States have issued refusal of access over the 2016-2020 period:

Figure 85: Number of refusals of access issued by EU MS.



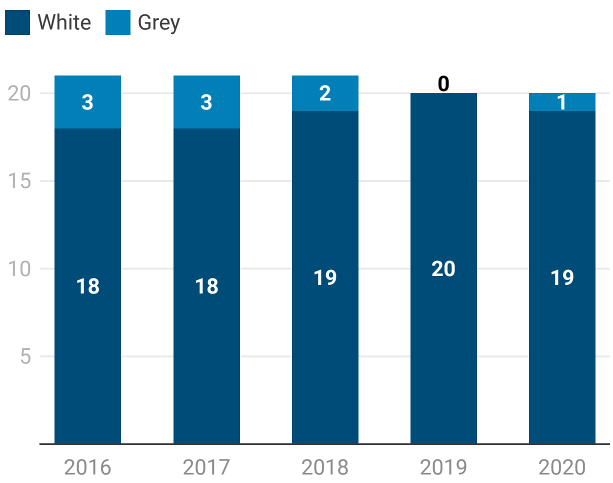
Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

It is worth noting that if a ship is refused access and then sold to another company, the refusal of access is not revoked.

The 'White, Grey and Black list' (WGB) represents the flag state performance in the context of PSC. It is calculated using a statistical formula based on the total number of inspections and detentions over a three-year rolling period for flags that have been inspected at least 30 times during that period. In the graph below, the evolution of the EU MS flags within this classification is represented. Currently, only 1 EU MS flag is in the grey list.

The RO performance is established by the Paris MoU based on the number of inspections, detentions and deficiencies recorded.

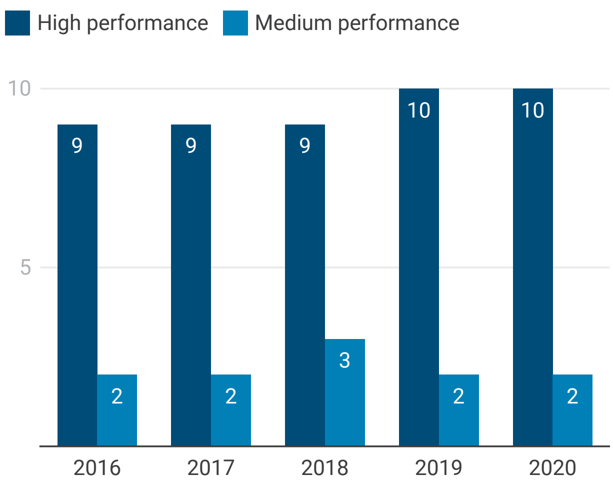
Figure 86: EU MS flags performance according with the WGB. Evolution over the past 5 years.



Source: Paris MoU (https://www.parismou.org/)

In 2018, 2019 and 2020, the performance of one Member State could not be taken into account because the number of ships registered under its flag that were subject to PSC inspection was not sufficient.

Figure 87: Performance of EU recognised organisations. Evolution over the past 5 years.



Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

IRS became an EU RO only in 2018.

3.3 Special Survey Regime for RoPax and HSC on regular voyages

3.3.1 Introduction

Following several high-profile accidents, including that of the RoPax Estonia in 1994 with more than 800 deaths, the EU decided to implement a specific survey regime for RoPax and HSC on regular voyages between EU ports, or between an EU port and a port of a third country, irrespective of flag. This regime, established in 1999 through Directive 1999/35/EC, requires more regular inspections to these two types of ships in view of their intense activity, quick turnaround time and the high number of persons being carried.

In 1999, the EU consisted of 15 Member States, and a significant number of ro-ro passenger ships and high-speed passenger craft regularly travelled between EU and non-EU countries. Given that the EU today has 27 Member States, most of these same voyages are now made within the EU. It was therefore necessary to update the inspection regime to reflect the changes in EU membership, while taking into account the progress made in the implementation of the PSC regime set up by Directive 2009/16/EC and the relevant experience gained. Consequently, and within the REFIT programme of passenger ship safety legislation carried out by the European Commission, the EU adopted Directive (EU) 2017/2110 on 15 November 2017 on an inspection system for the safe operation of ro-ro passenger ships and high-speed passenger craft in regular service, amending Directive 2009/16/EC and repealing Council Directive 1999/35/EC.

The main design characteristic that differentiates a RoPax from a conventional passenger ship is the undivided long deck for vehicles. This design characteristic implies that there is a higher risk of capsizing if this space is flooded, compared to a conventional passenger ship where the compartments have a more limited length. A similar reasoning can be applied regarding the spread of fire on a ro-ro deck compared with that of a conventional ship.

Therefore, for this type of ship, it is essential that all the safety elements on the ship intended to decrease the before-mentioned risks are in adequate and continuous operating condition.

Another important aspect relates to the potential shift of vehicles, including large trucks, in poor weather conditions. The shift of vehicles can negatively influence the stability of the ship as well as increase the risk of fire given that, depending on the size of the ship, the vehicles on this deck can together have several tonnes of fuel in their tanks. Therefore, it is essential to ensure that all the cargo securing devices are in adequate operational condition.

A key safety element of these ships relates to the watertightness of the openings (ramps) for vehicle embarkation. The watertightness and proper closing of these openings must be ensured while at sea to avoid a rapid flooding of the vehicle deck.

Some of these ships also have internal hoistable ramps which must be both watertight and in adequate operational condition to avoid mechanical failures which could cause the ramp to come loose.

All these safety considerations are even more pressing due to the tight schedule and intense activity of RoPax and HSC. Cars must be unloaded, and passengers must disembark, to be replaced by others for the next journey, often several times a day. The wear and tear of equipment which has a substantial bearing on the overall safety of the ship, such as the embarkation ramps, internal hoistable ramps, and vehicle securing devices, is significant.

The Staff Working Document from the European Commission (ref. SWD (2015) 197) indicates that, in 2015 and in relation to the domestic fleet, while vessels with ro-ro capacity (ferries and HSC) represent 49% of the fleet, they account for 80% of accidents. During the document's consultation period, national experts confirmed that a special inspection regime for these vessels was necessary.

The results of the specific surveys are reported in the EU's database (as part of THETIS) managed by EMSA.

One of the key elements of this system is to ensure that each ship is inspected twice per year. The scope of this regime includes two groups of ships: the first group refers to those which operate domestically and are flagged in the same country of operation; while the second group covers those ships operating from an EU Member State to a third country and which are flagged in that EU Member State, e.g., a Spanish-flagged ship operating between Algeciras (Spain) and Tangier (Morocco).

In October 2018, EMSA published guidance on Directive (EU) 2017/2110[52] to support the Member States in the implementation of the Directive. The aim of EMSA's guidance is to assist Member States in their efforts to fulfil the requirements of Directive (EU) 2017/2110 and Directive 2009/16/EC, in relation to the inspection of ro-ro passenger ships and high-speed passenger craft in regular service. It is a reference document that provides both technical information and procedural guidance, thereby contributing to harmonised implementation and enforcement of the provisions of the directive.

3.3.2 Regulatory framework

Table 33 shows the regulatory framework at EU level on the special regime of RoPax and HSC on regular voyages.

Table 33: Legislation on special regime of RoPax and HSC on regular voyages.

	Level	Instrument	What it regulates
Legislation	EU	Directive (EU) 2017/2110	Establishing a system of inspections for the safe operation of ro-ro passenger ships and high-speed passenger craft in regular service.

52 http://www.emsa.europa.eu/publications/inventories/item/4353-emsa-guidance-on-directive-eu-2017-2110.html

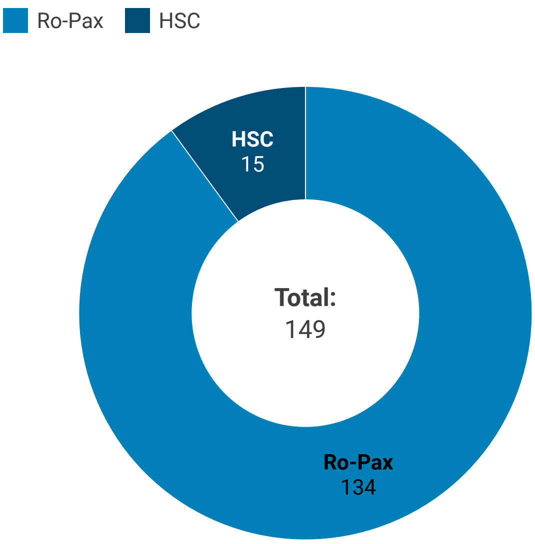
3.3.3 Relevant data and analysis

Considering the significant change in the scope of this directive since its entry into force on 21 December 2019, the data available is limited to 2020, which was the year of the COVID-19 pandemic. The data from previous years would not be comparable in the context of this analysis. The number of inspections and ships inspected in this period is included in the following graphs:

Figure 88: RoPax flag state inspections carried out by EU Member States in 2020 relating to Directive (EU) 2017/2110.

Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

Figure 89: Number of inspections carried out by EU Member States in 2020 relating to Directive (EU) 2017/2110 per ship type.



Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

Considering that in 2020 there were about 110 domestic RoPax and 185 domestic high-speed craft with the flag of the Member State where they were operating, it is clear that not all the ships subject to this directive were inspected – not even once – during 2020 due to the COVID-19 pandemic. Therefore, these numbers do not provide a reference for the future.

The inspection regime is composed of different types of inspections:

- **Pre-commencement** inspection which has to be carried out before a ro-ro passenger ship or high-speed craft starts to operate on a regular service.

- **Regular inspections** which are sub-classified in two types of inspections. Each of which should be carried out once every 12 months and there should be, in general, an interval between them of 4 months. These two inspections are the following:

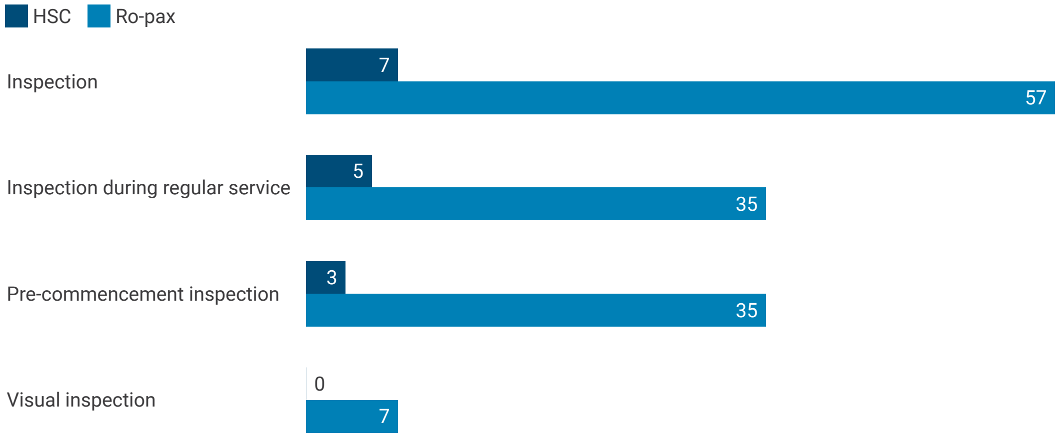
  - **Inspection at port**: this should ensure that the safety requirements, including those relating to construction, subdivision and stability, machinery and electrical installations, loading and stability, fire protection, maximum number of passengers, life-saving appliances and the carriage of dangerous goods, radio communications and navigation, are fulfilled. Emphasis is also given to the familiarisation of crew members with, and their effectiveness in, safety procedures, emergency procedures, maintenance, working practices, passenger safety, bridge procedures and cargo and vehicle operations.

  - **Inspection during a regular service**: this is carried out during a ship voyage and is aimed at ensuring the safety of the vessel during its operation.

- **A visual inspection** can be carried out if, due to unforeseen circumstances, there is an urgent need for the rapid introduction of a replacement ro-ro passenger ship or high-speed passenger craft to ensure continuity of service.

The following graph shows the number of inspections carried out in 2020 per type:

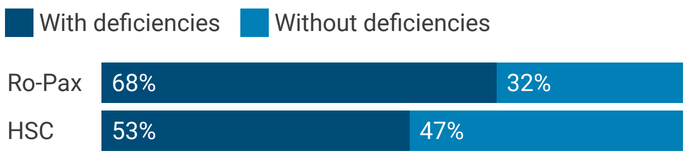
Figure 90: Number of inspections carried out by EU MS in 2020 relating to Directive (EU) 2017/2110 per type of inspection and ship type.



Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis

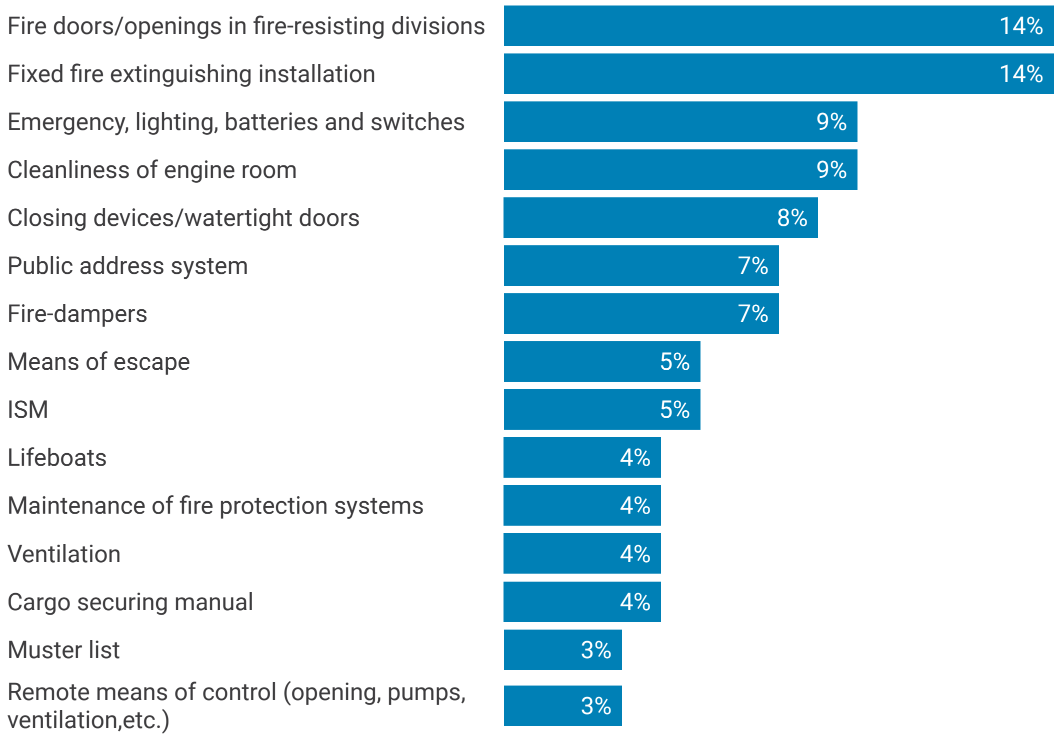
In terms of deficiencies found, the following graphs summarise the results:

Figure 91: Inspection results – percentage of inspections where deficiencies were identified.



Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

Figure 92: Top 15 deficiencies identified in inspections of RoPax and HSC.



Source: EMSA/THETIS (https://portal.emsa.europa.eu/web/thetis)

The ships under the scope of this Directive are subject to more frequent and detailed inspections than other ship types, which greatly increases the probability of finding deficiencies. The inspections can prevent a ship from operating if the deficiencies found are considered serious enough. In 2020, only one ship was prevented from operating following an inspection.

Deficiencies related to fire safety in general represent almost 40% of the deficiencies reported during inspections. Fire safety is an area that receives particular attention during inspections, including fire drills and testing of fire prevention, detection, and fire-fighting systems. Keeping fire safety elements in good working condition is essential to avoid catastrophic events in these ships. As has been indicated in previous sections, the average age of these ships, their design characteristics, the retrofitting concerns, and the gaps found during previous studies, means that fire safety is a key aspect in these ships to which industry and authorities must pay constant attention.

3.4 Cycles of visits monitoring the implementation of EU legislation

The EU has several pieces of legislation dealing with the essential elements of maritime safety and the prevention of pollution, which must be enforced. The European Commission is entrusted with monitoring the implementation of legislation and has delegated to EMSA the task of visiting Member States to report on their degree of compliance with these legal acts. On this basis, the European Commission can take the appropriate decisions to amend the legislation or initiate specific actions to ensure that Member States fulfil their obligations. Cycles of visits to Member States, at the request of the European Commission, have become one of the main tasks of EMSA since it was founded in 2002. Through these cycles, valuable information has been collected on the implementation of the body of EU maritime law, and best practices to support Member State administrations have been developed.

This chapter presents an overview of how EMSA organises its visits and includes the underlying objectives, the methodology, and the work carried out at the end of each of the cycles to analyse the degree of implementation of the respective pieces of legislation and to assess the effectiveness and efficiency of the related measures adopted by the Member States. Some aspects which have emerged from this activity over the years are presented at the end of the chapter.

3.4.1 The visit methodology

The main objective of the visits is to assess the effective implementation of EU maritime legislation by Member States. The visits also offer an excellent opportunity to measure the extent to which the application of the requirements, as set out by the relevant legislation, is harmonised in all Member States, thus ensuring a level-playing field throughout the EU.

Visits to Member States also offer specific added value in terms of building up trust and confidence at EU level on the uniformity and effectiveness of the implementation of EU law.

Each visit not only serves to identify non-compliances, for which the Member States must provide corrective actions, but also offers direct feedback to the Member State and gives input to improve the implementation of the requirements of EU law. At EU level, the horizontal findings arising from the cycles of visits to the Member States serve to analyse areas of common concern in legislative implementation, as well as identifying best practices and lessons learnt on the effectiveness and cost-efficiency of the measures in place. As a direct consequence, the visits provide feedback to the policy cycle, and help set the direction for the review and further development of related EU law.

The visit methodology requires that EMSA visits also provide added value for the Member States. The inclusion of EMSA technical experts in the visiting teams provides an immediate opportunity for the relevant officials of the Member States to have detailed technical discussions on various important aspects of the applicable legislation which is being addressed during the visit.

Finally, the results of the visits feed into EMSA's prioritisation of its own tasks, including assistance to the European Commission and the Member States, capacity building at national level, and the provision of guidance for further developments in different areas and activities.

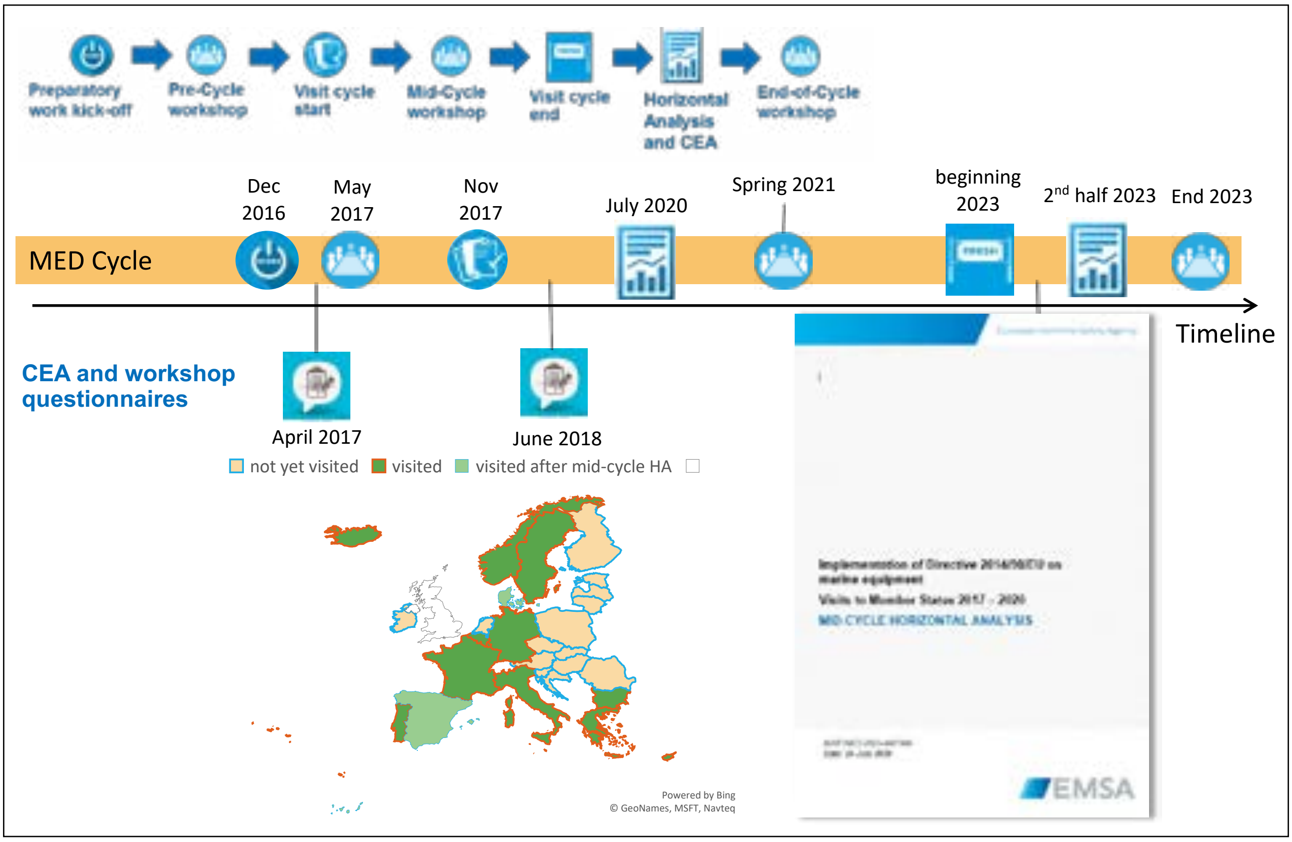
3.4.1.1 The start of a cycle

The visits to Member States are generally organised in cycles of four to five years and entail visits to all the EU and EFTA Member States to which the respective legal acts of EU legislation apply.

The European Commission is responsible for deciding which legal instrument should be the subject of a particular cycle.

This choice could be based on the need to assess the efficacy of a new piece of legislation in meeting its intended goals and objectives, the usefulness and/or the need to update older versions of EU legislation, or as a result of specific requests or concerns expressed by Member States or other stakeholders. Following the decision by the European Commission to initiate a cycle of visits, EMSA organises an ad-hoc pre-cycle workshop which is attended by the European Commission and delegates of the relevant Member States' competent authorities. In this pre-cycle workshop, the purpose, scope and objectives of the visit cycle are presented. All participants have the possibility to provide information and details that may be of assistance to the European Commission and EMSA when carrying out the visits.

Figure 93: Example of a visit cycle timeline – Marine Equipment Directive (MED) visit cycle.

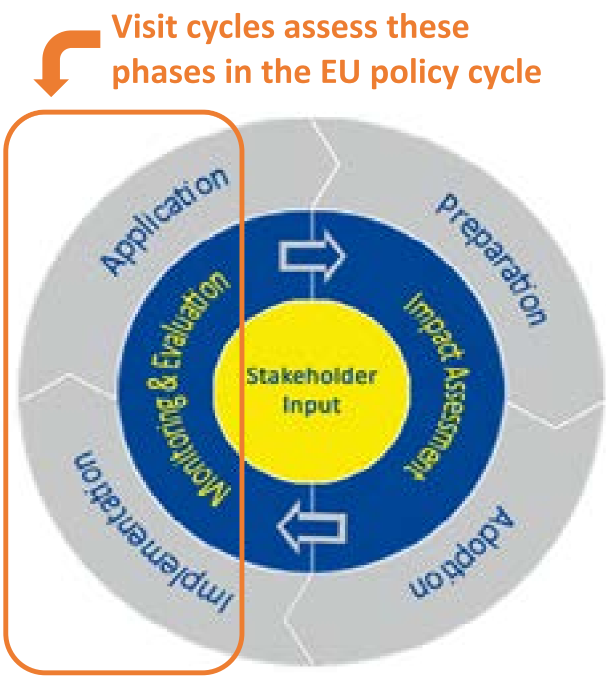


Source: EMSA Services

3.4.1.2 The process approach within the EU policy cycle

Prior to a cycle of visits, the relevant piece of legislation is analysed, and its articles and requirements are sorted into logical processes. The resulting process breakdown structure provides a general overview of the logical sequence of activities that Member States must carry out when implementing the legislation. This facilitates the organisation of the findings that will be established during the visits and the understanding of how the legislation is implemented and enforced by each Member State.

Figure 94: The EU policy cycle.



Source: EC

Each process involves the compilation of specific requirements from EU law that translate into actions or duties related to each other. The piece of legislation in question is therefore organised by main areas of activity when it comes to implementing its mandate.

The process breakdown structure is framed within the so-called EU policy cycle framework. The four phases which regulate the life cycle of all EU law, also referred to as the EU Policy Cycle, are: preparation, adoption, implementation, and application.

Preparation and adoption are the two initial phases through which the legislation becomes alive. They are not relevant for the cycle of visits carried out by EMSA. Indeed, the purpose of a cycle of visits is not to evaluate the legislation, but rather to assess the extent to which Member States have correctly and efficiently implemented it. Therefore, during a cycle of visits, the aim is to assess the compliance, effectiveness and cost-efficiency of the measures put in place by the Member States during the subsequent implementation and application phases of the EU policy cycle, along with the underlying monitoring activity.

Specifically, these phases can be considered as the overarching processes defined as follows:

- **Implementation**: The process by which Member States give force to a specific piece of EU Law by adopting appropriate implementation measures into their national legislation and providing the means to achieve the legislative mandate.
- **Application**: The task of enacting the relevant mechanisms and legislative framework for the specific purpose of meeting the requirements of the legislation.
- **Monitoring and evaluation**: Systematic tracking of progress and information related to the main evaluation criteria, including relevance, coherence, EU-added value, effectiveness and efficiency, during the implementation and application phases, for future improvements of the EU Law under assessment.

This process analysis takes the implementation and the application phases as the basis for the development of subsequent sub-processes, also called core-processes, that characterise every piece of legislation.

Each process involves a set of specific requirements that specify correlated actions and duties.

In Figure 95 are some examples of process breakdown structures as applied to the Marine Equipment Directive (MED) and the Bulk Carriers Loading and Unloading Safety Directive (BULK).

3.4.1.3 Organisation of visits to Member States

Based on the initial request for a cycle of visits, its defined scope, the outcome of the pre-cycle workshop and the process approach, EMSA develops a methodology for the cycle of visits which is sent to the European Commission for approval. Questionnaires, visit plans, reporting format, etc. are all prepared prior to the start of the cycle of visits.

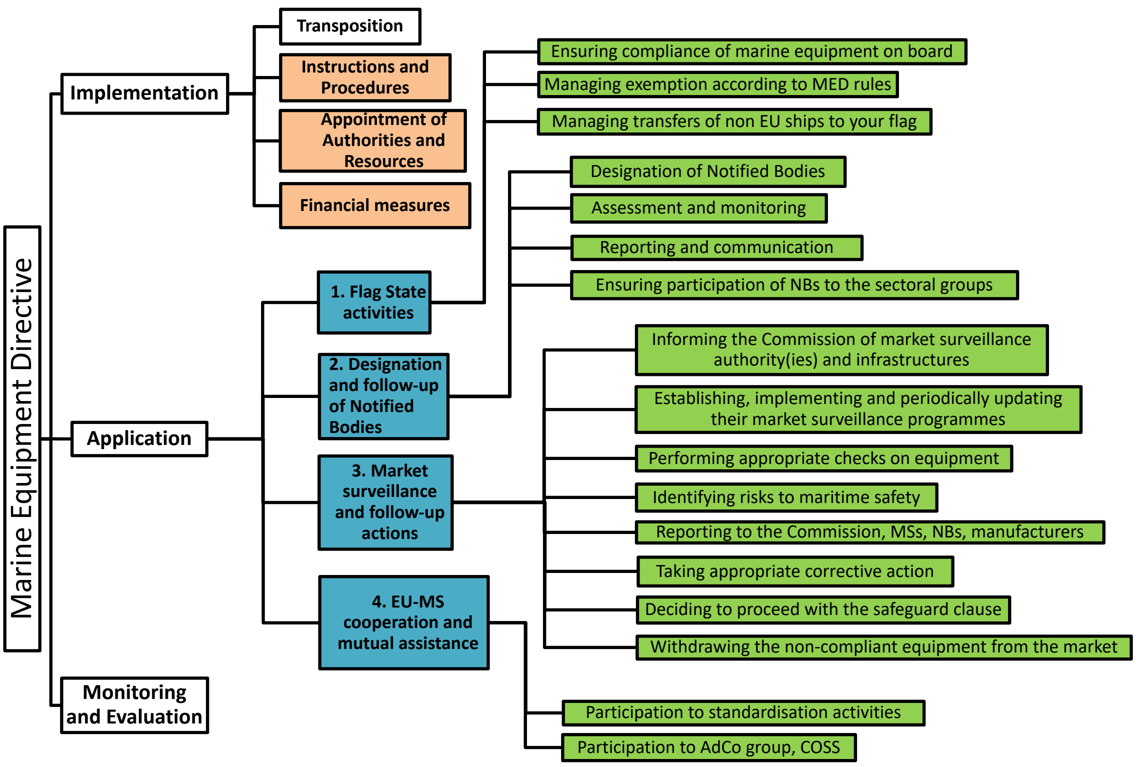
Preparatory work for each individual visit usually starts around four to six months in advance, with EMSA informally contacting the relevant representative of the Member State to agree on the dates for the visit and to discuss other practical arrangements.

Generally, the visits are performed within four to five working days. A visit includes document review, verification of facilities, staff interviews and examination of sample files. While the approach may vary according to the piece of legislation, a 'top-down' approach is generally applied throughout. A visit begins with meetings at the central competent authority and then proceeds to designated authorities at national, regional, and local levels as well as to other relevant institutions. While remote work is prioritised to minimise on-the-spot visits, field work is key to understanding how procedures and processes are translated into effective working practices. Visits to ships, terminals, ports or equipment manufacturers, shadowing of notified bodies or Member States' officers while performing their monitoring duties, are essential components of every visit.

Following each visit, the EMSA team prepares a comprehensive report reflecting the outcome of the visit, including a detailed description of the situation as encountered. The report is sent to the European Commission and to the Member State visited.

Problematic aspects are reported as findings, categorised as either shortcomings[53] or observations[54]. The report includes all relevant details of the findings and the related documentary evidence.

Figure 95: Example of block diagram with the process breakdown structure used for the Marine Equipment Directive.



Source: EMSA Services

Note: the core application processes are in blue; the preliminary implementation processes in orange; and the activities in green

53 Shortcomings are defined as "Full or partial failures to implement, or inadequate implementation of, a particular requirement of the Directive".

54 Observations are defined as "Remarks about something identified in relation to the implementation of the Directive that may lead to shortcomings if not addressed".

3.4.1.4 The horizontal analysis framework

After a cycle of visits has been concluded, or when it is deemed appropriate, EMSA analyses the reports and produces a horizontal analysis (HA). The purpose of the HA is to assist the European Commission and the Member States in assessing the level of implementation and effectiveness of related measures throughout the EU, highlighting, on the one hand, those elements of a piece of legislation that do not appear to work efficiently and the difficulties of implementation by Member States due to their particular circumstances and on the other hand, good practices and lessons learnt on the effectiveness and cost efficiency of the measures in place that could be shared among Member States. HA thereby contribute to a continuous improvement of European maritime safety.

The HA does not assess the performance of individual Member States, but looks at the horizontal EU-wide dimension, based on issues and practices identified across all the Member States visited. Therefore, horizontal analyses help to establish a level playing field and to explore opportunities for further harmonisation.

A horizontal analysis is an adapted risk assessment analysis to assess how an EU law is effectively implemented in the EU. EMSA follows a so-called assessment matrix approach, whereby, as in a SWOT[55] matrix, the findings and issues are grouped into four categories: horizontal problematic issues (weaknesses); horizontal successful implementation areas (strengths); good practices; and ways forward.

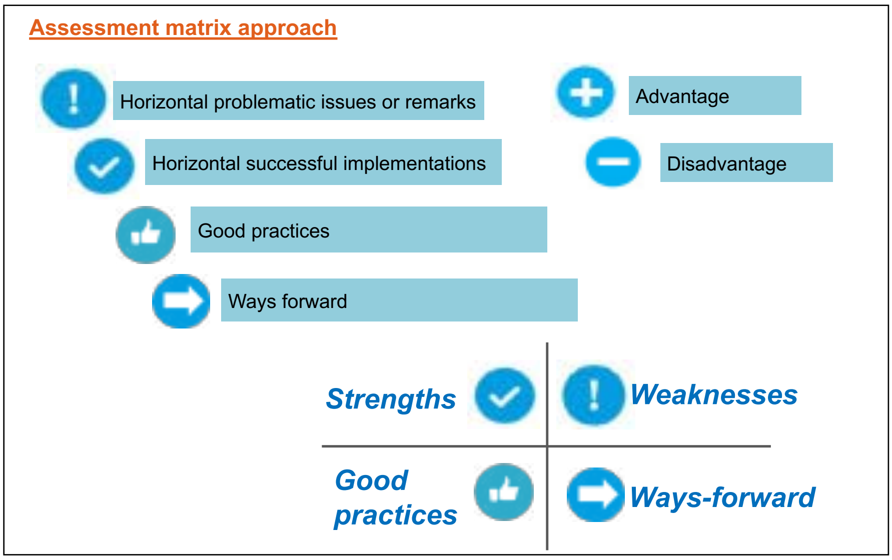
A way forward is intended as an action proposed or recommended to possibly consolidate strengths, minimise weaknesses or problematic areas, and generally to improve the implementation. The idea is that the strengths (elements which are well implemented across the EU and work well) are often witnessed through good practices established in some Member States which can support other states in addressing problematic areas (weaknesses or areas to improve). Each group of similar findings are then analysed with perspective, trying to identify possible root-causes and potential consequences to highlight possible preventive and mitigating actions and, subsequently, ways forward.

Figure 96: HA looks at the EU-wide performance of the implementation of a directive.

Source: EMSA Services

55 SWOT – Strengths, Weaknesses, Opportunities, Threats.

Figure 97: The assessment matrix used for Horizontal Analysis.



Source: EMSA Services

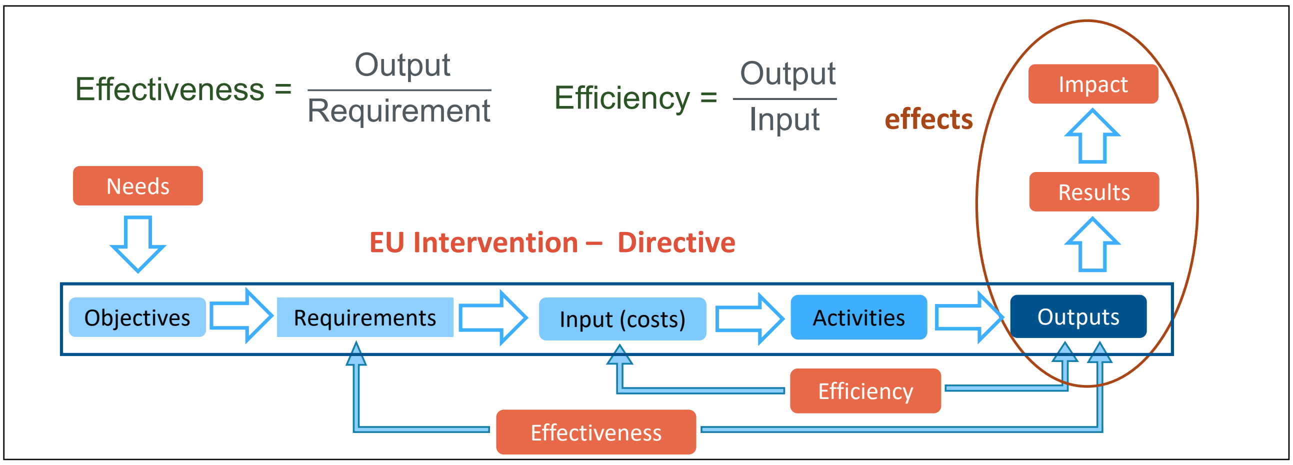
In a nutshell, horizontal analyses are aimed at consolidating strengths, minimising weaknesses, making improvements by sharing examples of good practices taken from other Member States and presenting ways forward recommended by EMSA.

3.1.4.5 The cost-effectiveness analysis

As an integral part of the horizontal analysis, EMSA has developed a cost-effectiveness analysis (CEA) methodology based on the so-called 'intervention logic' applied to the initial phases of the policy cycle, like for instance during the impact assessment work which precedes the formulation and adoption of a directive. The CEA model is a tool to identify and assess the main cost elements put in place by Member States when implementing and enforcing EU law. The cost-effectiveness analysis does not evaluate the directive itself but the way in which the Member States have adapted their own national framework to implement its requirements. Therefore, the CEA provides a comparative analysis of the main outputs and associated cost indicators when it comes to implementing and enforcing a piece of legislation.

The word 'effectiveness' refers to the extent to which the different objectives and goals of a piece of legislation are met; the more goals achieved, the higher the effectiveness. When implementing and enforcing a piece of legislation, effectiveness is generally linked to the fulfilment of a set of requirements laid down in the legislation.

Figure 98: The CEA model – The 'intervention logic' of a directive.



Source: EMSA Services

The word efficiency relates to the way in which inputs (resources) are converted into outputs (results), characterising thus the transformation efficiency. To achieve the EU law's objectives (effectiveness), Member States need to comply with a number of minimum implementation and enforcement obligations which involve an investment of their own resources.

The CEA model identifies several variables that may describe and differentiate the national institutional and operational environment, and that may feature in relevant cost-effectiveness ratios able to describe the extent to which a Member State is effective and efficient in the implementation of the requirements of each piece of legislation in comparison with other Member States.

The effects of the implementation, at the level of regulatory compliance, are the units of output that must comply with the requirements (measure of effectiveness). The effects, at a higher societal level, refer more to the impact that the piece of legislation should have in meeting the initial needs (measure of impact, e.g., reduce the risk of future marine casualties, enhance safety at sea, prevent maritime pollution, etc.).

3.4.1.6 The conclusion of a cycle

Once the horizontal analysis of a cycle of visits has been completed, a workshop is organised to present the results of the horizontal analysis report, while providing Member States with a forum in which to share both lessons learnt and best practices as well as to identify future training needs.

The possibility of an additional workshop following a mid-cycle horizontal analysis is often considered on a case-by-case basis with a view to eliciting the benefits of the Member States sharing best practices.

3.4.2 The most relevant results of the visit cycles

Ten horizontal analyses have been carried out from 2016 to date, aggregating some 1902 findings and consolidating and evaluating information described in 194 reports of visits to EU and EFTA Member States in relation to the following directives:

- Marine equipment (MED, end-of-1st cycle, and mid-2nd cycle)
- Registration of persons on board ships (PAX)
- Vessel traffic monitoring and information system (VTMIS) including places of refuge
- Port State Control (PSC, end-of-2nd cycle and mid-3rd cycle)
- Accident investigation (AI)
- Training of seafarers (STCW, mid-cycle)
- Safety of bulk carrier loading and unloading (BULK, mid-cycle)
- Sulphur content in marine fuels (SULPHUR, mid-cycle).

Another cycle of visits, related to three directives on passenger ships safety (PSS), has started and is still in its initial phase. The following table summarises the information of the above-mentioned visit cycles.

The horizontal analysis reports are available to Member States' competent authorities on the EMSA e-Portal.

The following paragraphs will describe some relevant elements of the cycles of visits, including common areas such as organisational and cooperation aspects, training matters in the various directives' implementation, issues related to inspection and monitoring activities, enforcement and sanction issues, and some examples of good practices in terms of cost-effectiveness. There will not be an analysis on the implementation of each directive, but rather a more transversal approach looking at issues that have emerged during these visit cycles.

Table 34: Summary information on the visit cycles.

Visit cycle on directive:	Period of visits	Status of the cycle	HA report issued on:	Visits to Member States[56]	Number of findings
MED (1st cycle)	2010-2014	Completed	19/04/2016 (End-of-Cycle report)	12	30
PAX	2012-2015	Completed	20/05/2016 (mid-cycle report)	11	73
VTMIS	2009-2016	Completed	21/03/2017 (End-of-Cycle report)	49[57]	390
PSC (2nd cycle)	2012-2016	Completed	31/08/2017 (End-of-Cycle report)	25	259
AI	2012-2017	Completed	26/03/2018 (End-of-Cycle report)	30	390
STCW	2014-2022	On-going	19/09/2018 (mid-cycle report)	15	344[58]
PSC (3rd cycle)	2017-2022	On-going	28/11/2019 (mid-cycle report)	14	107
SULPHUR	2016-2022	On-going	25/06/2019 (mid-cycle report)	14	133
MED (2nd cycle)	2017-2024	On-going	24/07/2020 (mid-cycle report)	13	91
BULK	2018-2024	On-going	25/02/2021 (mid-cycle report)	10	85
PSS	2020-2027	On-going	mid-cycle HA report planned for 2025	-	-

Source: EMSA Services

3.4.2.1 Organisational and cooperation aspects

The implementation and application phases are important segments in the life cycle of every piece of EU legislation. It is in those phases that Member States invest resources, for instance, to acquire new assets, such as ICT systems, equipment, facilities and/or possibly recruit new staff. In some other cases, existing assets may be reused and adapted to the new purposes; staff engaged in other parts of the administration may be reallocated to the new tasks. The purpose is to correctly apply the legislation's requirements in an effective and efficient way.

A horizontal implementation area, common to many Directives, refers to the ways Member States arrange their organisational structure and allocate these necessary resources, not only to comply with the legislation requirements but also to do it in the best possible, cost-effective way. It includes all the activities that a Member State must carry out to put in place an organisational framework ensuring that the requirements of the piece of legislation under scrutiny are fulfilled. In most cases, this presupposes the existence, or requires the establishment, of a national competent authority and related systems to ensure compliance by the national authorities and other stakeholders, with their respective requirements and responsibilities.

56 At the time of the HA report, including EU Member States, and Norway and Island (EFTA States).

57 Some Member States were visited twice.

58 Including those established in relation to the relevant maritime Administration and those in relation to the MET institutions.

Organisational benefits deriving from implementing EU Directives

In general, the implementation of a Directive allows Member States to set up a legal framework and it is an opportunity to rethink their organisational structure. This is a common strength established in many of the visit cycles. New organisational set-ups are redesigned in a more effective way. All visit cycles highlighted that the organisational arrangements established by the Member States, following the implementation of new Directives, improved the EU-wide maritime safety level. Many examples can be brought forward; the following is a non-exhaustive list:

- The implementation of the 'vessel traffic monitoring and information system' Directive has greatly contributed to the development of policies related to places of refuge, identifying competent authorities dealing with cases of ships in need of assistance. In some Member States, the same directive was the trigger for the creation of national systems for monitoring dangerous or potentially polluting goods.

- The implementation of the 'accident investigation' Directive contributed to the improvement of the very serious casualties investigation, the publication of accident reports within prescribed deadlines, and the submission of data to EMCIP[59]. Most of the Member States have set up legal frameworks and allocated resources for independent investigation bodies, providing them with necessary investigative powers.

- The implementation of the 'bulk carrier loading and unloading safety' Directive has contributed to the improvement of the safety of bulk cargoes loading/unloading procedures and the awareness of risks involved with such operations. Thanks to the directive's implementation, Member States identified all terminals and bulk carriers that fall under the scope of the directive and established systems for communication and exchange of information between bulk carriers and terminals. The required 'terminal representatives' have been appointed in almost all Member States, indicating a good level of overall terminal management structures – an important condition for the effective management of loading and unloading procedures. The enhanced communication between vessels and operators, and the correct completion of the documented procedures, were some of the major benefits related to the implementation of the directive by Member States.

- The implementation of the 'marine equipment' Directive produced, for instance, an EU-wide improvement as regards the surveillance of the marine equipment market and manufacturers, and how the notified bodies are actually acting on behalf of the EU Member States' administrations, which was almost negligible before its adoption. By and large, most Member States now have organisational structures to conduct proactive market surveillance campaigns to ensure that barriers are placed against sub-standard marine equipment that could jeopardise safety on board. Member States organised themselves to cater for an active participation in many international cooperation projects and platforms such as the ADCO MED[60] forum and systems such as RAPEX[61] and ICSMS[62] for market surveillance of marine equipment.

Harmonisation of procedures and cooperation among EU Member States

The maritime business is a global one and safety cannot be dealt with in isolation. Therefore, all EU maritime safety Directives contribute to reducing the risks in the maritime business. When the various Directives' requirements are correctly implemented and enforced, Member States contribute to a safer maritime sector, and avoid the risk of safety competition within the EU. Member States have established competent authorities that, albeit with different organisational set-ups, adapted to the national administrative and organisational features and share the same ultimate objective of the various maritime safety directives. This harmonised approach proved to be the best way to ensure a safer maritime sector in the EU.

To ensure a level-playing field regarding compliance with EU Directives, the Member States, in various contexts, have established harmonised procedures that enhance cooperation and communication among themselves, and with all stakeholders. An interesting example is the establishment of harmonised communication procedures for marine equipment with all the market operators (e.g., the notified bodies and manufacturers, through activities such as conformity assessments, market surveillance, etc.). This facilitates free movement of marine equipment within the EU market as well as cross-border cooperation among Member States, while at the same time ensuring a level playing field in the marine equipment sector.

Another example of good cooperation among Member States is the Permanent Cooperation Framework (PCF) for the Investigation of Accidents in the Maritime Transport Sector. The PCF made the development of various common guidelines possible and also formed an active and efficient framework for cooperation among investigation bodies to exchange and discuss a wide range of aspects.

The forum of the Cooperation Group on Places of Refuge is another example of how Member States have endowed themselves with a structure to exchange experiences, identify best practices and establish necessary contacts to proceed in situations leading to a request to grant a place of refuge.

59 The European Maritime Casualties Information Platform

60 Administrative Cooperation Group for Market Surveillance

61 Community Rapid Information System

62 Information and Communication system on market surveillance

Budget and staff

For some Member States organisational problems refer primarily to budgetary and staff issues. Member States have significant differences in the number of personnel employed to ensure the implementation and application of the various Directives. It emerged that, on some occasions, the number of staff is not proportionate to contextual factors that characterise the Member State, such as the number of port districts, number of ship calls, the annual PSC inspection commitment, the length of the coastline, the registered fleet, the number of equipment manufacturers, the number of accidents, among other factors. There are significant differences across the EU in relation to the number of competent authorities' personnel (Full Time Equivalent, FTE) dedicated to the activities related to the various Directives. Some Member States have staff dedicated to the activities related to each of the Directives, some have staff pools dealing with various parts of Directives while others have appointed dedicated personnel, tasked to perform close monitoring of all the information required to be recorded in the different information systems (national information system, SSN, THETIS, EMCIP, etc.).

Most Member States have adopted a partial or even full delegation of some activities, mainly related to the flag state obligations, to private organisations, namely recognised organisations. For instance, recognised organisations are entrusted by Member States with the statutory surveys and the consequent renewal and/or endorsement of statutory certificates. The full delegation is a common practice for the maritime administration to reduce personnel and related costs, while keeping a high level of technical knowledge by using the expertise of recognised organisations.

The distribution of personnel in various locations, mainly port cities, was another organisational aspect that emerged during the visits to Member States. For instance, it was noted that the PSC officers in some Member States were not efficiently distributed among port districts. As a result of this distribution, some PSC officers in some ports were overloaded with the high number of calls by ships eligible for inspection (leading to the risk of missed and/or less accurate PSC inspections in peak work periods) while other PSC officers in other ports were relatively less burdened. Very often the organisational arrangements made to carry out these activities have an impact on the degree of flexibility of the geographical relocation of staff to where there is more need, like for example, when the coast guard is in charge of the activities.

Independence and conflict of interests

Another key organisational aspect refers to the independence that entities involved in the maritime safety domain need to have. National investigation bodies, recognised organisations and notified bodies responsible for the conformity assessment of marine equipment need to be fully independent from the organisations they assess, act in a confidential, objective and impartial manner, and have at their disposal personnel with technical knowledge and sufficient experience to perform their tasks. For instance, in the case of accident investigation bodies, independence from the maritime administration ensures impartial accident investigation and unbiased decision-making power that avoids a scenario in which other interests could conflict with the task entrusted to them. This implies the attribution of necessary powers, in terms of budget and staff which for some Member States appears not to be proportional to their needs.

Technologies to improve organisational efficiency

In order to run their organisation efficiently and minimise the problem of reduced human resources, Member States have been implementing many of the Directives' requirements, making extensive use of existing technologies to efficiently improve the functioning of their maritime administrations and ultimately safety. Examples of technological improvements are represented by the extensive use of SafeSeaNet (SSN), which became the exchange platform through which Member States share their information and reuse information provided by other Member States. In addition, THETIS, The Hybrid European Targeting and Inspection System for the PSC inspection regime, is now supported by efficient systems in place for the proper and complete recording of ship call information at national ports and anchorages in SSN and THETIS, which, together with the close monitoring of these activities, resulted in 100% availability of the information needed for PSC activities.

3.4.2.2 Capacity building

The implementation of any piece of legislation requires competent staff in the maritime administrations. Normally, Member States already have well trained personnel in their administrations, skilled to carry out many of the activities required. In other cases, or when skills must be periodically refreshed or updated, new training opportunities must be designed and carried out by the Member States.

Training of personnel represents an inevitable cost for the Member States to provide relevant staff with an adequate level of competence and knowledge to carry out the activities required by the various Directives. In addition, training may also be useful to update the staff involved in relation to new legal and/or technological developments and good practices across Europe.

Harmonisation of training schemes

In general, a positive outcome of the implementation of EU maritime safety legislation is the attempt to establish common training schemes, mostly harmonised at EU level.

For example, in relation to the Directive on PSC, Member States have made significant efforts to implement the harmonised EU training scheme, developed for the purpose of training and assessment of the competence of PSC officers. In terms of compliance with this scheme, certain criteria have to be fulfilled, comprising both compulsory activities, such as carrying out at least ten PSC inspections per year and conducting the Distance Learning Programme's (DLP) courses on Paris MoU inspection procedures, and others that contribute to gaining the minimum number of points required in a five-year period.

Training is not only carried out in a classroom but also with more informal exchange among colleagues, such as periodical meetings involving all PSC officers to share experience gathered from their daily activities and facilitate the discussion of subjects related to new legislation, changes in existing instructions, the outcome of Paris MoU/IMO/EMSA relevant meetings and trainings, etc.

However, there are still areas where the training of staff is not harmonised among Member States and substantial differences are present in relation to the amount of time invested in both the theoretical and practical training. There are Member States with fully fledged training schemes and others where there are no formal training standards, training achievement structures, or proper qualification schemes (such as regular assessment of staff knowledge).

Each Member State may organise and deliver training as they deem most appropriate (e.g., internal, on-the-job and/or external training, training provided by EMSA, etc.), as long as their staff, particularly newly employed members, have an adequate level of competence and technical knowledge to carry out the activities related to the maritime safety Directives.

Different approaches to training may create gaps in the EU-wide maritime safety enforcement framework, while a better harmonisation of the national systems among Member States could improve the overall effectiveness and efficiency of the measures put in place, avoiding possible distortions and harmonising maritime safety practices across EU Member States.

EMSA's role as a training provider

In this context, EMSA also supports Member States, by organising training for PSC officers, making the eLearning modules (DLP) available through the Maritime Knowledge Centre system (MaKCs) and the activities of the EMSA Maritime Academy. Since 2008, EMSA also provides RuleCheck, a digital library of all IMO and ILO Conventions, for use by PSC officers, and staff of maritime administrations at large, to enhance the quality and accuracy of PSC inspections.

The EMSA Academy aims to become an EU-wide and global centre of excellence for the design, development and delivery of quality learning services outside formal education in the maritime domain. It supports the acquisition and development of knowledge, skills and competencies through teaching and learning and by adopting curricula and professional development pathways to satisfy learning needs and expectations of beneficiary individuals and organisations.

Learning services offered by the Academy cover a wide range of areas of maritime safety, maritime security, the human element in maritime operations, prevention of and response to marine pollution, Search and Rescue, and include profiles for flag State Inspectors, Port State Control Officers, Auditors and Assessors, Accident Investigators, Vessel Traffic Service (VTS) Operators, and Maritime Rescue and Coordination Centre (MRCC) operators.

From the feedback received by Member States and from the high rates of attendance, it was noted that the training provided by EMSA is appreciated and considered useful. All the information gathered by the delegates participating in EMSA's training are then shared and distributed internally to other colleagues of their respective competent administration.

3.4.2.3 Inspections and monitoring activities

There are common aspects in the various pieces of legislation on how Member States must monitor and check, directly or indirectly, all other maritime stakeholders, such as ship owners, ship builders, ship management companies, crew, ships under other flags, equipment manufacturers, ports, terminals, notified bodies, recognised organisations, etc. It is paramount that all involved parties correctly carry out their obligations and take their part in the safety chain. These monitoring and enforcement activities aim at reducing the risk of overall safety being jeopardised by failures or reduced quality applied by the various safety players. Monitoring also includes internal or self-monitoring over the national competent administration ensuring that all the verification activities carried towards external stakeholders are correctly functioning. In general, a proper implementation of the monitoring process by the Member States' competent authorities is key to avoiding other problems passing undetected due to loopholes or inefficiencies in the supervision of other stakeholders.

Monitoring can be realised in various forms, such as inspections on board ships under the PSC regime, flag state inspections and surveys on board ships, inspections of terminals during loading and unloading of bulk carriers, the audits of recognised organisations and notified bodies, including checking on their subcontractors.

These inspections can be part of planned and periodical cycles, or unannounced, random, or targeted, following various criteria specific for each field and piece of legislation.

An area where inspections are key to ensure safety is port state control. An efficient port state control system should seek to ensure that eligible ships calling at ports and anchorages within the EU are regularly inspected. The PSC system is implemented through the inspections performed under the Paris MoU PSC regime, with the aim of inspecting all ships on a frequency determined by their risk profile, with ships posing a higher risk being subject to a more detailed inspection carried out at more frequent intervals.

Each Member State has specific targets in terms of the number of inspections to be carried out in a year, and this commitment depends on various factors including the annual number of ship calls in its ports. Member State competent authorities must regularly monitor that this commitment is achieved.

Several good practices to improve the efficiency and effectiveness of the PSC system have been established during the visits. For instance, in some Member States, the PSC Head Office closely monitored the PSC activities, even setting specific targets for the number of inspections to be carried out by each PSC office. These targets were regularly monitored and adjusted by the PSC Head Office to ensure compliance with the national annual inspection commitment. In some Member States, the national PSC Head Office had appointed dedicated personnel to perform close monitoring of all the information required to be recorded in the different information systems (national information system, SSN, THETIS). On other occasions, the inspection reports were validated by qualified PSC officers different to the PSC officers who had performed the inspections and submitted the reports. Consequently, the validation tool in THETIS was being used as a quality control tool. In some Member States, the PSC Head Office, in close cooperation with the Human Resources department, continuously monitored the PSC officers' qualifications to satisfy their needs in each local office.

This PSC self-monitoring activity proved to be effective, producing a significant improvement in the compliance with the Member States' inspection obligations over the last five years.

Monitoring private organisations with delegated functions

Some challenges are related to the proper monitoring of third parties to whom Member States have delegated crucial safety roles. For instance, in the marine equipment area, the designation and follow-up of notified bodies appears to be a crucial, yet also a challenging process. Marine equipment certification is mainly in the hands of a few entities, highlighting again the critical role of proper monitoring carried out by the national notifying authority and coordination of the private companies carrying out certification. Notified bodies play a very important role in the process of marine equipment approval. If the technical assessment of the notified body fails, then the whole Directive's system would fail. This aspect may be critical considering the relatively few personnel allocated by national competent authorities to the designation and follow-up of notified bodies. Limited human resources may, but should not, constitute an obstacle for Member States to ensure an adequate level of monitoring of notified bodies and guarantee a level playing field among them.

Member States carry out extensive verifications of marine equipment on board vessels primarily during the newbuild phase. After that, only random checks are performed in the subsequent verifications. These verifications are carried out by means of periodical or unannounced surveys, with a focus on ensuring that marine equipment is kept in satisfactory condition and suitable for the service for which the ship was certified.

Many good monitoring practices were established during the cycle of visits for the Marine Equipment Directive, such as: Member States conducting on-site verifications of laboratories and test sites used for conformity assessment purposes; carrying out audits of notified bodies including checks of the conformity assessment procedures they use for marine equipment of manufacturers based in non-EU countries.

Every ship is made of hundreds/thousands of pieces of equipment from the simplest to the highly technologically sophisticated ones. A proper monitoring of these products is key to ensuring safety of ships. Therefore, there is a need to designate national market surveillance authorities, endowing them with related infrastructure, drawing up market surveillance programmes that include checks on pieces of equipment (comprising documentary verification, tests on board and sample checks), the identification of specific equipment posing a potential hazard and all the related actions to communicate the outcome of these activities to interested parties. Another example of a successful implementation of the Marine Equipment Directive is the fact that most Member States currently have a market surveillance programme and perform many activities in this respect. Market surveillance programmes and activities are carried out to a varying extent and level of effectiveness. Some of these programmes are purely reactive, whereas in some other Member States they are designed to be proactive.

Most Member States have adopted a partial or even full delegation of various flag state obligations to private organisations, namely the EU recognised organisations. In some Member States, ships flying their flags are surveyed jointly by flag state surveyors and RO surveyors. The higher number of verifications (and consequently, high annual person-hours for on-board verifications) undertaken by the personnel of these flag state administrations indicates an attempt to verify the compliance with the international conventions on board and, at the same time, a substantial monitoring over the RO work. In other Member States the activities carried out directly by the flag state authorities seem to be negligible in comparison to the activities delegated to and carried out by ROs. A possible reason for this approach seems to be the limited resources available to the maritime administrations concerned. Member State administrations regularly monitor and verify the activities carried out by Recognised Organisations by directly auditing them and, in some cases, also by observing, or jointly carrying out, surveys onboard with RO surveyors. In several Member States, however, the verifications and the monitoring[63] conducted by the flag state authorities on ROs seem to be limited in comparison with the activities delegated to them.

Recalling that flag state activities are assigned to Member States by the various Directives, it is the responsibility of their administrations to properly verify and monitor their delegated work performed by the entrusted entities. This is also why correct audits and monitoring is paramount for Member States to ensure that the delegated functions are properly carried out.

63 As laid down in DIRECTIVE 2009/15/EC on common rules and standards for ship inspection and survey organisations and for the relevant activities of maritime administrations.

Another significant example of monitoring activity is that of bulk carrier loading and unloading operations at terminals. This process covers all the inspection activities that a Member State must carry out in order to verify that loading and unloading operations are compliant with Directive 2001/96/EC and all their relevant stakeholders meet their respective responsibilities. Member States must regularly verify that terminals comply with the requirements of the Directive, whereby the verification procedure must include unannounced inspections during loading or unloading operations. It could not be established with objective evidence that regular and/or unannounced inspections of all bulk terminals were consistently and properly carried out in all Member States. At the same time, good practices were noted in some Member States, e.g., a national competent authority kept a detailed overview of inspections carried out in its bulk terminals, through good cooperation and periodical requests for information to all its regional offices; another Member State used a dedicated checklist to provide guidance to the attending inspectors, thus improving the quality of the verification and ensuring that no requirements remained unchecked. In another Member State, the questionnaires used during the planned inspections also formed part of the Quality Management System and covered all the aspects of the abovementioned directive.

3.4.2.4 Enforcement and penalties

An area common to many pieces of legislation refers to the ways in which Member States make sure that the relevant mechanisms and legislative framework are used, and the requirements followed by all stakeholders. Enforcement measures are to be defined and enacted to ensure compliance; these include the set-up of penalty systems, and mechanisms to verify that sanctions are applied for breaches of the legal requirements.

- **The variety of sanctioning systems in the EU**

According to the PSC regime, Member States may sanction ships for serious non-compliance by detaining the ship until compliance is reinstated, and in the most extreme case by banning the ship from calling in its ports. The number of detentions and their rates over inspections slightly vary across the Member States. Frequent serious non-compliance leading to repetitive detentions will be sanctioned by banning the ship from the ports in the Paris MoU PSC region for a certain period.

While detaining a ship is a universal measure, the number of detention days and the amount of various fees collected, e.g., to cover the beyond-normal inspection costs of the detained ships, vary significantly among Member States. In general, the total sum collected by each Member State does not seem to be proportional to its number of detentions (also due to the different severity of the detected breaches). Indeed, the average amounts of fees collected per detention seem to be quite small and variable across Europe.

Member States may apply fines and other criminal or administrative penalties for the breaches that lead to detention, based on their national legislation.

Penalty systems for breaches of the requirements established in the Directives are exclusively the competence of Member States, hence a variety of national systems exist in Europe. The various Directives require Member States to lay down the rules on sanctions but leave to them the choice of which type (administrative or criminal) to apply and what the severity of the penalties should be. EU Directives only state that the penalty system should be devised in an effective and dissuasive way with payment amounts proportionate to the economic advantage possibly gained by the operator by the act of not respecting the law.

There are some differences emerging from the comparison of the penalties for infringements adopted by the Member States. Some Member States apply penalties based on general clauses in their national laws. In other Member States there are dedicated clauses adopted for the national implementation of the EU legal act. Some fines are issued directly by officials/inspectors using an administrative procedure. In other cases, fines are issued by a court with a judicial procedure (to whom the official/inspector concerned must send the evidence) that is responsible for determining the administrative fine and/or the criminal sanction. In general, the application of the two different regimes depends on the seriousness of the infringement. Less serious infringements are mainly handled and sanctioned by the maritime administration, while more serious ones, may fall under the competence of a court.

The financial amounts of fines imposed with penalties appears to greatly differ among Member States. Their proportionality and dissuasiveness are questionable considering that in some Member States the fines, even if they can be quite severe theoretically, appear to be moderate in practice.

Better cooperation towards more harmonised national sanction systems and their application in particular could improve the effectiveness of the safety regime enforcement, avoiding distortions, loopholes, and perceived more favourable treatment among Member States. Uneven application of penalties and the variety of such systems may undermine the level playing field principle of the EU regulatory framework.

In most visited Member States a system of penalties had been established in relation to many pieces of legislation, but sanctions were rarely, if ever, issued for most of the violations of the national legislation implementing the European legislation. When some stakeholders deliberately and continuously take illegal actions undermining the purpose of the legislation, a fair and effective penalty system may also be conducive to a culture of harmonised implementation and exemplary practices by all the involved parties, proving to the compliant stakeholders that their efforts are worthwhile. In any case, a fair penalty system should always be accompanied by further awareness building and promotion of a fully-fledged safety culture and quality shipping.

4. When things go wrong

4.1 Places of refuge

4.1.1 Introduction

When an accident happens at sea potentially involving pollution, fires, chemical products or similar issues, it can be difficult to find a safe place to shelter the ship, unless a system has already been agreed. As a direct result of maritime accidents in European waters, like those of the tankers Erika and Prestige, EU Member States and all parties to the UN Convention on the Law of the Sea (UNCLOS) had to create a system to help ships in need of assistance.

The solution found was the development of the places of refuge concept to handle ships in distress and to provide them with an appropriate location for emergency use.

In accordance with Directive 2002/59/EC "a 'ship in need of assistance' means, without prejudice to the provisions of the SAR Convention concerning the rescue of persons, a ship in a situation that could give rise to its loss or an environmental or navigational hazard".

A place of refuge is one "where a ship in need of assistance can go to stabilize its condition and reduce the hazards to navigation, protect human life and the environment". Suitable places of refuge may include ports, inlets, lee shores, coves, fjords, bays, or any place of shelter near the coast.

Accordingly, national authorities must draw up contingency plans to manage emergencies at sea, including a list of places of refuge that could be used should the need arise. However, the situation may become more complex if the accident happens in international waters close to the coast of more than one state. In these cases, it is essential to have pre-established communication links between the competent authorities and ports of the Member States involved, to facilitate cooperation.

When a ship has suffered an incident at sea, sometimes the best way to prevent further damage or pollution from its progressive deterioration is to lighten its cargo and bunkers, and to repair the damage. Such an operation is best carried out in a place of refuge, as it is rarely possible to deal satisfactorily and effectively with a marine casualty in open sea conditions.

For maritime incidents outside the jurisdiction of Member States, cooperation and coordination are essential to determine which state is in the best condition to provide a place of refuge.

Because of the many variable factors involved in an incident (e.g., the condition of the sea, weather, the condition of the vessel, required and available facilities, and equipment) and the variety of risks involved when bringing a ship in need of assistance into a place of refuge, a decision to grant access to a place of refuge can only be taken on a case-by-case basis.

While Directive 2002/59/EC provides for the legal framework, a more detailed approach is needed to handle an incident efficiently. The EU Operational Guidelines and the regular tabletop exercises, detailed in the next section, are intended to cover this need by providing practical guidance to the competent authorities of Member States and the other main parties involved in managing a request for a place of refuge from a ship in need of assistance.

Historical examples of incidents show that challenges are posed when an incident occurs on the high seas or outside the jurisdiction of any one Member State.

4.1.2 Regulatory framework

Table 35: Legislation on places of refuge.

	Level	Instrument	What it regulates
Legislation	International	IMO Res. A.949(23)	Guidelines on places of refuge for ships in need of assistance.
		Convention on Maritime Search and Rescue (SAR Convention)	Rescue of persons in distress at sea.
	EU	EU Operational Guidelines on Places of Refuge	Provides guidance for competent authorities and the main parties involved in managing a request for a place of refuge from a ship in need of assistance.
		Directive 2002/59/EC	Requirement for MS to draw up and make available the plans to accommodate ships in distress, in the waters under their jurisdiction.
	National	National plans addressing the issue of places of refuge as required by Directive 2002/59.	

4.1.3 EU Operational Guidelines on Places of Refuge [64]

To support the implementation of this important issue, the EU Member States and EMSA developed EU Operational Guidelines on Places of Refuge. These guidelines were drafted in 2014 and are updated on a regular basis. The relevant stakeholders representing various maritime industry sectors were consulted during the drafting process. Subsequently, the guidelines were presented to the European Commission, European Parliament and IMO.

Moreover, EMSA organises regular tabletop exercises (TTX) to support the practical implementation of the places of refuge policy in the EU Member States. The TTX are based on hypothetical case studies, developed to be as realistic as possible, and the representatives of the Member States, European Commission, EMSA and maritime industry (i.e., salvage, class, and insurance) are invited to participate. In fact, as a conclusion of the first exercise of this kind, the need emerged for an instrument that would guide Member States in dealing with places of refuge situations which led to the drafting of the EU Operational Guidelines referred to above. The exercises that followed served to update the guidelines.

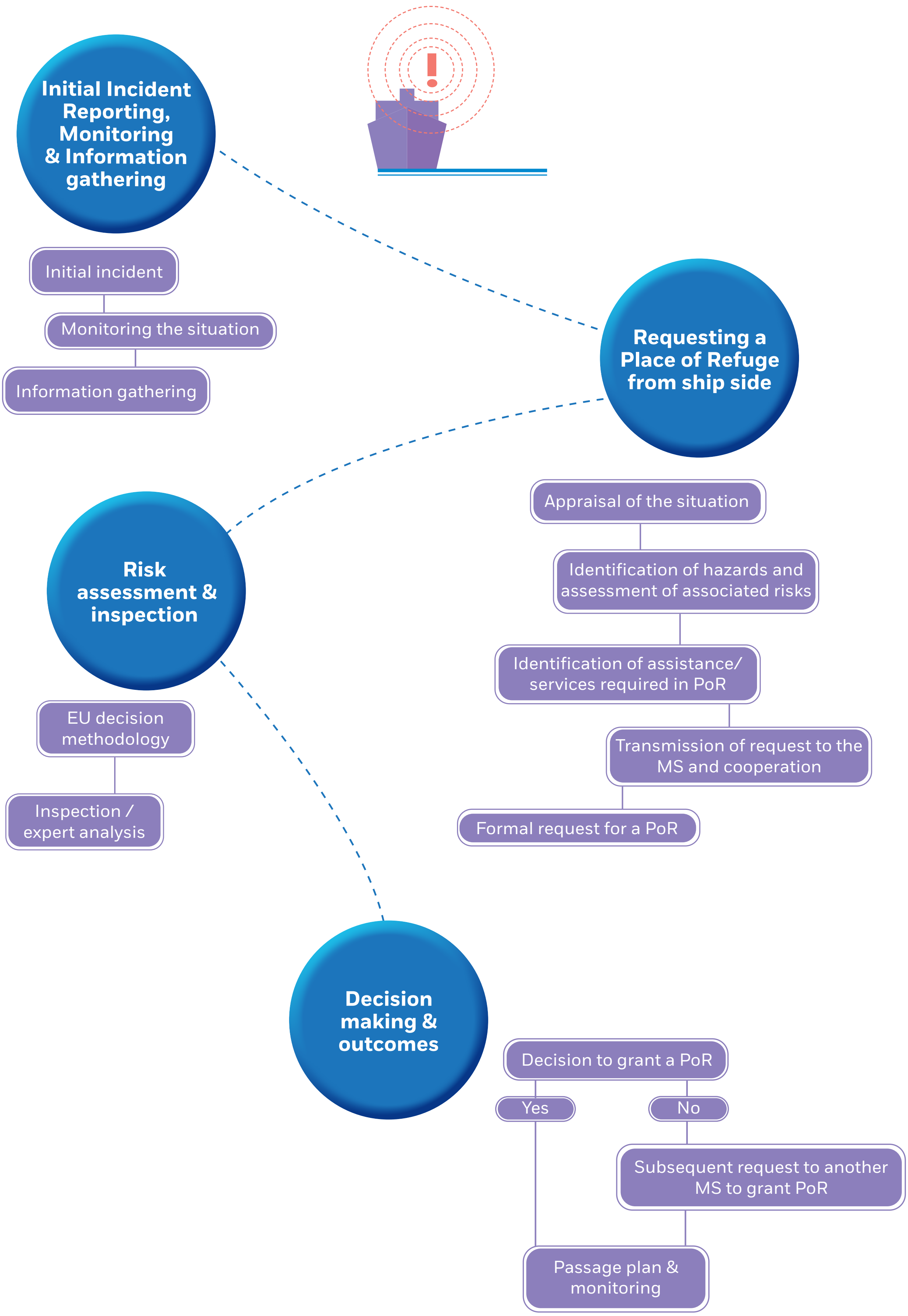
The guidelines cover coordination and procedural aspects in handling a request for a place of refuge when it involves a Member State in waters of its jurisdiction; for situations when involvement of neighbouring MS is required; and for cases when the incident occurs outside the jurisdiction of any one MS.

Regarding coordination, the principle is that each State involved starts to examine their ability to provide a place of refuge and that, in the interest of resolving the situation, there is a direct contact between those competent authorities involved to decide who is best place to take the coordinating role. The guidelines provide detailed information on the roles and responsibilities of key players in a request for a place of refuge.

Figure 99 represents the phases of a place of refuge incident as per the EU's operational guidelines.

64 EU Operational Guidelines on PoR can be downloaded at: https://transport.ec.europa.eu/transport-modes/maritime/eu-wide-digital-maritime-system-and-services/places-refuge-por_en

Figure 99: Flowchart of a place of refuge incident.



Source: EMSA Services

4.1.4 Remote technical support

IT systems and communication tools can be of real utility in cases of ships in distress. For example, it was reported that in the course of the Prestige disaster, the decision to fill two tanks on the port side of the vessel in an attempt to return it to an upright position caused the stresses on the structure to surpass the structural strength of the ship as it was designed. This would have been important information for the crew and salvage team to have before taking the decision they did.

Nowadays, many classification societies offer emergency information services 24/7 for ships in distress as the decision making during the first few hours of an accident are vital for a good outcome. The information provided includes post-damage stability and strength calculations. This information can be very useful for the ship and authorities within the places of refuge framework to take the right decisions.

4.1.5 Pollution

The potential pollution and damage that can be arise from accommodating a vessel in a place of refuge is a sensitive issue. In such cases, the usual national and international liability and compensation rules apply (i.e., the Convention on Limitation of Liability for Maritime Claims (LLMC), the International Convention on Civil Liability for Oil Pollution Damage (CLC), Bunkers, Wreck Removal and potentially the International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS)). Moreover, any ship flying a flag of an EU Member State or proceeding to an EU port regardless the flag is required to hold civil liability insurance as per Directive 2009/20/EC on the insurance of shipowners for maritime claims. A Member State accommodating a vessel in a place of refuge may ask for a proof of valid insurance. However, even when the vessel in question cannot present it, the state must continue with the analysis of the place of refuge request and identify the best course of action for the protection of human life and the environment. Lack of proof of adequate insurance cover cannot constitute a sufficient reason to refuse such a request.

4.1.6 Health crisis

During the initial phase of the COVID-19 pandemic, several cruise ships were refused access to port, thereby creating serious situations in which thousands of people were stranded at sea and denied urgent medical assistance. This global humanitarian crisis resulted from the very rapid changes implemented in the health policies and border restrictions of some countries.

The places of refuge concept, as currently defined, does not appear to apply in this case. The definition of a ship in need of assistance refers to a ship in a situation, apart from one requiring the rescue of persons on board, that could give rise to the loss of the vessel or an environmental or navigational hazard.

Furthermore, Directive 2002/59/EC does not address health crises onboard ships; it appears that a pandemic outbreak of the kind witnessed during the COVID-19 crisis was not contemplated in any of the situations described in the relevant legal instruments.

Both cruise operators and port authorities are now better prepared to respond to such situations, should they occur again. However, at legislative level, there has been no change to the current framework.

Directive 2002/59/EC and the EU Operational Guidelines on Places of Refuge do not address health-related safety issues directly and, therefore, any intention to use them for this purpose in the future will entail either a modification of these instruments or a relevant broad interpretation of the current legal texts and, perhaps, a more tailor-made drafting of the EU Operational Guidelines to address specific health-related safety issues.

4.2 Search and rescue

4.2.1 Introduction

Search and Rescue (SAR) is one of the most critical topics within maritime safety. The United Nations Convention on the Law of the Sea (UNCLOS) already included the obligation to render assistance to ships in distress and the establishment of a SAR service at State level. This was later complemented in 1979 when the SAR Convention was adopted at a Conference in Hamburg with the aim of developing an international search and rescue system for people in distress at sea.

The Convention describes preparatory measures which should be taken, including the establishment of rescue co-ordination centres. It also outlines operating procedures to be followed in the event of emergencies or alerts and during SAR operations.

To implement the SAR Convention, the world's oceans have been divided into 13 search and rescue areas, in each of which the countries concerned have delimited search and rescue regions (SRR) for which they are responsible.

Material investments, such as the installation of shore-based facilities and liabilities issues required by the Convention have been obstacles to widespread ratification. Therefore, a revised Annex to the Convention, which entered into force in January 2000, was adopted in 1998 to clarify the responsibilities of Governments and promote a regional approach and co-ordination between maritime and aeronautical SAR operations. The number of States party to the convention reached 113, representing 80% of the world fleet. Each State party undertakes to make available to the IMO and other States the information related to their search and rescue facilities, including contact details of their maritime rescue centres and medical services. This information is available through the Global Integrated Shipping Information System (GISIS) which is a free public use information system developed by IMO.

4.2.2 Regulatory framework

Table 36: Legislation on search and rescue

	Level	Instrument	What it regulates
Legislation	International	UNCLOS Article 98	Duty to render assistance. The establishment, operation and maintenance of SAR services in every coastal state.
		International Convention on Salvage	Duty to render assistance.
		Convention on Maritime Search and Rescue (SAR Convention)	Preparatory measures and operating procedures to be followed in the event of emergencies or alerts and during SAR operations. Definition of search and rescue areas.
		SOLAS Ch. V Reg. 7	Search and rescue services to be provided by the state including distress and coordination arrangements in their area of responsibility.
		STCW Convention and Code	Minimum requirements for certification of officers including the competences of responding to distress signals at sea and coordinate search and rescue operations.
	EU	Directive 2002/59/EC	Establishment of a Community vessel traffic monitoring and information system helping to ensure the immediate reporting by the master of a ship sailing within their SAR region.
		Directive 98/41/EC	Provision of number of people onboard passenger ships and their personal information, facilitating the management of SAR operations.
		Regulation (EU) No. 656/2014	Rules for surveillance of the external sea borders in the context of operational cooperation.
	National	Each party must draw up and keep up to date a plan explaining the national organization for search and rescue including the authorities engaged in SAR, the strategy, resources and description of operational oversight.	

4.2.3 Overview of SAR in the EU

According to the SAR Convention, each state party must draw up and keep up to date a plan explaining the national organisation framework for search and rescue. It must include the public or private authorities engaged in SAR, the strategy adopted, resources, and a description of the operational oversight provided. Depending on the regulatory architecture of each state, the plan could be spread across several laws, decrees, or orders.

Therefore, SAR competence lies at national level. Furthermore, the convention allows for the conclusion of bilateral or multilateral agreements by the coastal states or parties concerned to cooperate and coordinate SAR services in specific areas. The aim of these agreements is to clarify the areas of SAR responsibility and establish cooperation arrangements and complementary protocols among relevant national competent authorities. There is no obligation to notify the IMO of these agreements.

Some examples of bilateral agreements in different EU regions are:

- Baltic Sea: Estonia, Finland, Russia and Sweden.
- North Sea & English Channel: Belgium, France, the UK.
- Atlantic: France, Spain.
- Mediterranean Sea: France, Italy, Spain.

Within each state, maritime rescue coordination centres (MRCC or RCC) have been created to coordinate SAR operations in their respective areas of responsibility within the Search and Rescue Region (SRR) when a distress call is received. If the incident is reported to a MRCC/RCC, but is not in its own SRR, the centre will need to coordinate with another MRCC/RCC for a possible orderly transfer of responsibilities so that assistance can be given.

It is notable that SOLAS requires all ships to carry an up-to-date copy of Volume III of the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual. This manual aims to harmonise maritime SAR functions, operational models, and promote international forms of cooperation. The manual is published jointly by IMO and the International Civil Aviation Organization (ICAO) and provides guidelines for a common aviation and maritime approach to organising and providing search and rescue (SAR) services.

4.2.4 Passenger Ships

Passenger ships have a special status within the SAR framework. SOLAS includes a specific provision for passenger ships engaged on international voyages, which obliges them to have on board a plan for cooperation with appropriate search and rescue services in the event of an emergency. This document, known as the SAR cooperation plan (SARCP), is developed in collaboration by the ship operator, the management company and the search and rescue services based on the IMO Guidelines (MSC.1/Circ.1079). The aim of this plan is to enhance the link between ship, company and the SAR authorities of the relevant state(s) and includes direct contact details of the three parties to avoid unnecessary delays. To assess the efficiency of the SARCP, regular exercises are organised.

There are two different operational situations regarding the SARCP plan:

- Passenger ships operated on fixed routes, e.g., ferries: the plan is kept by the relevant Rescue Coordination Centre. Companies must collaborate continuously with the relevant SAR services to complete and maintain the SARCP updated. SAR plan evaluations are planned and organised in collaboration with the MRCC of the Search and Rescue Region (SRR).
- Passenger ships not operated on fixed routes, e.g., cruise ships: it is not necessary for each of the Rescue Coordination Centres (MRCC) through whose region the ship transits to hold a copy of the ship's SAR cooperation plan (SARCP). In this case, the Convention established a centralised repository, a so-called SAR data provider, where most of the plans are stored and available 24/7. This repository is managed and hosted by the UK Maritime Coastguard Agency (MCA). The MCA is responsible for receiving new or updated plans and must ensure immediate access to the SAR plan for companies and MRCC with responsibilities in the areas of operation of the vessels concerned. An updated index with the list of ships using the SAR data provider is available on the website of the MCA.

The SARCP is complementary with existing emergency response plans already established and implemented by companies and ships in the context of the International Safety Management (ISM) Code.

It is also worth mentioning that the SARCP is not mandatory for passenger ships engaged on domestic trade regardless of the number of passengers carried or the distance to coast and SAR means.

At EU level, there is a legal instrument developed to facilitate the SAR activities of passenger ships: Directive 98/41/EC. Its main objective is to provide SAR authorities with data on the number of people onboard passenger ships to facilitate their work, and to be able to access some information about passengers which can be provided to authorities, families, etc. The information to be recorded, basically the number of people onboard a passenger ship (on short voyages) and their personal information (for longer voyages), is essential for the management of SAR operations by an MRCC. At present, the information is recorded by the operator before departing and is stored by the company registrar but available to SAR authorities only upon request. From 2023 onwards, this information needs to be recorded either in the national single window or AIS so that it is directly available to the SAR authorities without intermediaries.

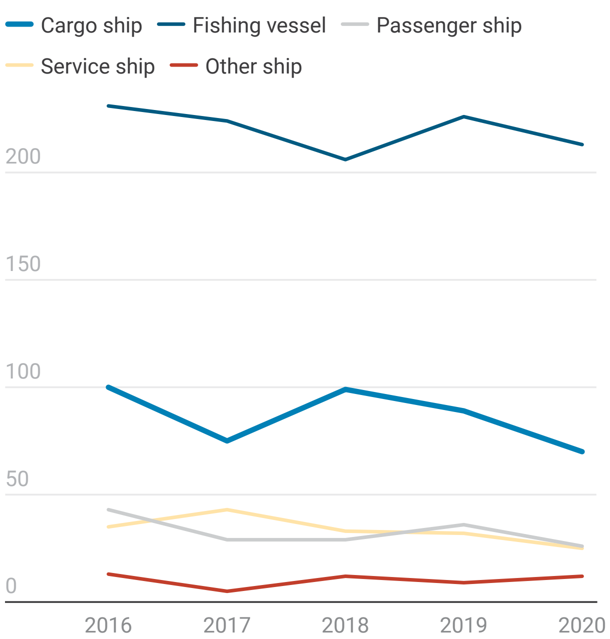
Another emerging issue in this field is SAR in remote areas. Although this issue is not limited to passenger ships, they are a focus of attention due to the large number of people they carry, as does the increase in cruise ships visiting the polar zones, both in the Arctic and Antarctic. A massive SAR operation in any of these remote areas with limited maritime traffic and available SAR resources is a challenge for which that the maritime community should be prepared.

4.2.5 SAR Operations

In terms of SAR operations, data from EMCIP in Figure 100 shows that fishing vessels account for most cases in which SAR was activated.

This underlines yet again the higher vulnerability of fishing vessels with respect to other ship types.

Figure 100: Number of EU SAR Interventions over the past 5 years.



Source: EMSA/EMCIP

4.2.6 Use of RPAS in SAR activities

The use of RPAS (Remotely Piloted Aircraft Systems) assets in SAR events is a new feature available to SAR coordinating authorities. RPAS provide enhanced search through a multitude of specialised onboard sensors that can be used to detect ships, life rafts, objects on the sea's surface, persons overboard, etc. These craft have the ability to stay on-scene to monitor the development of the SAR event and can cover a wider area than rescue ships due to their speed, enabling them to scan the sea's surface more efficiently.

RPAS are unmanned aircraft which are piloted remotely from a ground control station (GCS). For maritime functions, the GCS is located relatively close to the coastline or on-board vessels. Depending on the category of the RPAS, the range, endurance and capabilities of the payloads can vary substantially. For a mid-size RPAS, from 40 to 200kg, it is possible to achieve a range of 500km from the coastline and 800km along the coastline, with an endurance of 4 to 17 hours depending on the type of RPAS and the payloads onboard. If operated from a ship, a trade-off must be made between the performance of the RPAS and the size of the ship (i.e., the larger the RPAS, the larger the ship needs to be, so that the RPAS can be operated safely: smaller RPAS, in general, have lower autonomy and performance).

RPAS equipped for maritime functions typically carry onboard a selection of the following sensors suitable for SAR activities:

- Gimbal/cameras: prime sensor equipped in all RPAS, presenting different resolutions, sensitivity and DRI (detect, recognise and identify) to observe during daylight (EO) and infrared (IR) to be used at night.
- Maritime radar: with Maritime Moving Target Indicator, and optionally with imagery modes for environmental monitoring.
- AIS: AIS signal detection.
- Optical scanners: optical and IR to automatically scan the sea surface for objects of interest.
- Distress sensor (EPIRB 406 MHz): for the collection of distress signals.

- Mobile frequency detection: for the detection of activities at sea.

- Radar detection: for the detection of vessel radars.

Compared to manned aircraft, RPAS typically have a significantly higher endurance and can operate for longer periods. But depending on the size of the RPAS, the speed can be lower than manned aircrafts and searching larger areas of interest could take longer.

RPAS provide live video streaming of the situation at sea, given that the pilots and payload operators are stationed in the GCS instead of onboard the aircraft. This feature can greatly increase coordination capabilities. In addition to the live streaming of the situation, some RPAS can drop equipment such as life rafts or other rescue equipment, similar to manned aircraft.

Based on operational experience, it has been demonstrated that RPAS are capable of supporting SAR events. In some cases, the RPAS has been performing a different task at sea when it is diverted to support a SAR operation. However, on other occasions the RPAS is on standby and is activated at short notice. In all cases, depending on the speed of the aircraft and the distance from the event, the arrival on scene will be coordinated with other assets supporting the activity. In this respect, it should be noted that often, RPAS cannot share airspace with other air assets due to legislative issues, which further complicates the coordination tasks.

Image 10: RPAS image of SAR operation.

Source: EMSA Services

4.2.7 Earth Observation services support to SAR activities

Maritime accidents can take place in remote locations where SAR and surveillance assets may take several days to reach the area concerned. Moreover, in case of more severe accidents, the ship reporting systems can be compromised (e.g., be damaged or lose power), which makes locating the vessel particularly challenging. Earth Observation systems can support maritime safety authorities in these difficult situations, with a combination of high-resolution radar (immune to cloud cover, providing wide area monitoring and operating day and night) and very high-resolution optical coverage (able to detect very small objects on the sea surface as well as provide identification of the vessel, and high-level characterization of its conditions). The combination of these satellite assets, as well as their global near real time availability, makes Earth Observation systems a relevant tool to support search and rescue activities, particularly in remote areas, optimising surveillance efforts and deploying on-scene assets.

Earth Observation products are already systematically requested by Member States in case of maritime accidents, either within or outside of EU waters. Member States can request Earth Observation products at short notice via EMSA to monitor maritime accidents and to support search and rescue operations.

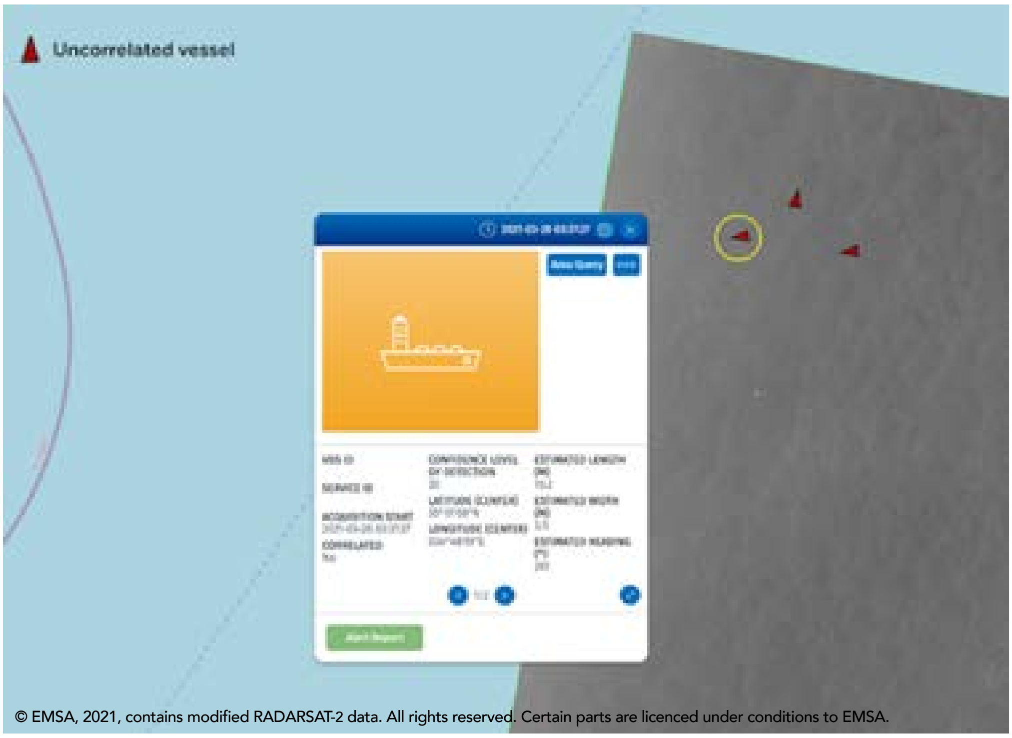
Two examples of activations of Earth Observation services via the EMSA Contingency Plan in support of search and rescue operations in 2021 are given below:

- In March, routine services provided to JRCC Larnaca allowed for the detection of a non-reporting drifting vessel east of Cyprus, which resulted in the rescue of nine passengers (Figure 101).

- In May, EMSA delivered satellite services to MRCC La Reunion following the disappearance of Wakashio Maru No.68. At the time of disappearance, the vessel was around 900 nautical miles off the coast of Madagascar, with 25 people on board. Identification of non-reporting ships in the satellite images provided by EMSA (Figure 102) made it possible to locate the ship, which was followed by the successful search and rescue of the ship and all of its crew.

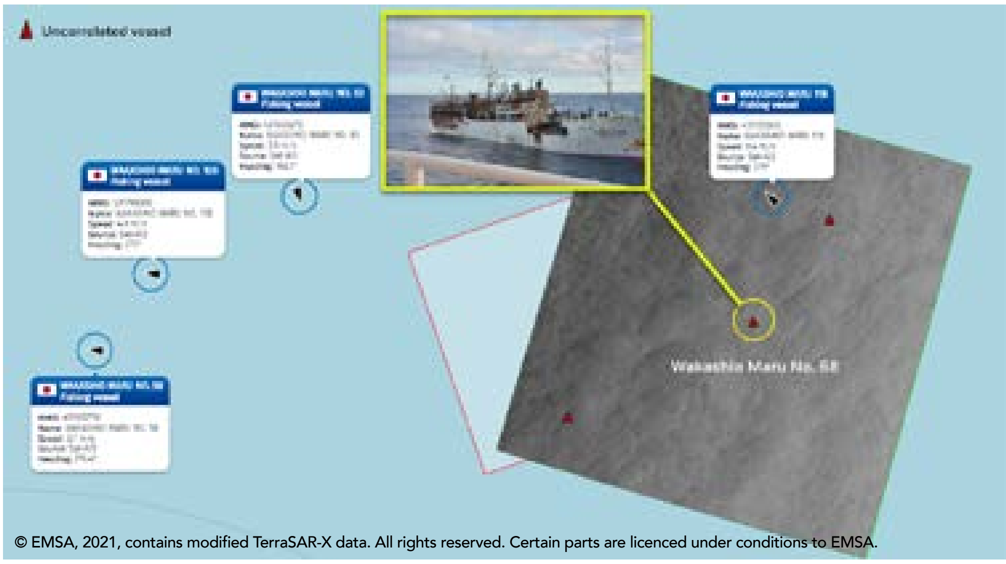
Search and rescue exercises with Earth Observation services for SAR purposes are an effective way for national authorities to gain knowledge of the tools made available by EMSA.

Figure 101: Detection of a non-reporting drifting vessel using EMSA's Earth Observation services.



Source: EMSA Services

Figure 102: Identification of Wakashio Maru No.68 after disappearance off the coast of Madagascar using EMSA's satellite services.



Source: EMSA Services

4.2.8 Use of IMS in support of SAR activities

In addition to the above, there are several information systems that can be useful for authorities dealing with search and rescue. One of them is the Integrated Maritime Services (IMS) system developed at EU level with the cooperation of all EU Member States and available from EMSA.

The integrated and comprehensive maritime traffic picture provided by the IMS allows for the efficient monitoring of SAR activities, highlighting situations of distress and providing an overview of potential SAR means as well as the EU maritime authorities' contacts and locations.

One of the tools offered is the enhanced SAR-SURPIC (Search and Rescue Surface Picture), which provides the positions of all nearby ships during an emergency. It combines various data sources – T-AIS, LRIT, Sat-AIS, VMS - and provides a unique view of the vessels in the vicinity that may respond to a distress situation.

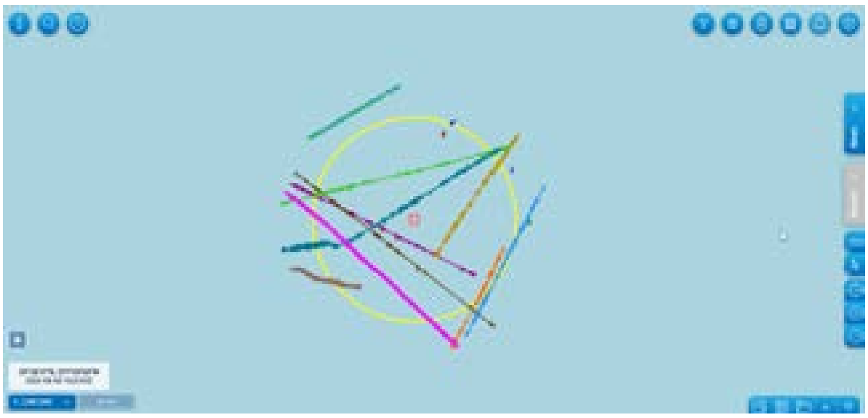
Another tool applicable to SAR is Automated Behaviour Monitoring (ABM), which can alert authorities to potentially dangerous situations. The ABM is linked to Earth Observation imagery, thereby enhancing its effectiveness.

The combination of data from different reporting/tracking systems makes it possible to mark the location of an accident/emergency, track the response vessels and SAR means, display the search patterns, and provide the latest positions of the ship in distress.

Exercises are a very important part of the SAR framework which enhance cooperation and test the preparedness level. IMS can support these exercises with the functions indicated above, plus additional information like the number of persons onboard, the presence of hazardous substances, the accident history of the ships in question, etc. In addition, when there are several Member States involved in an exercise, IMS can facilitate this cooperation by providing a single maritime situation picture.

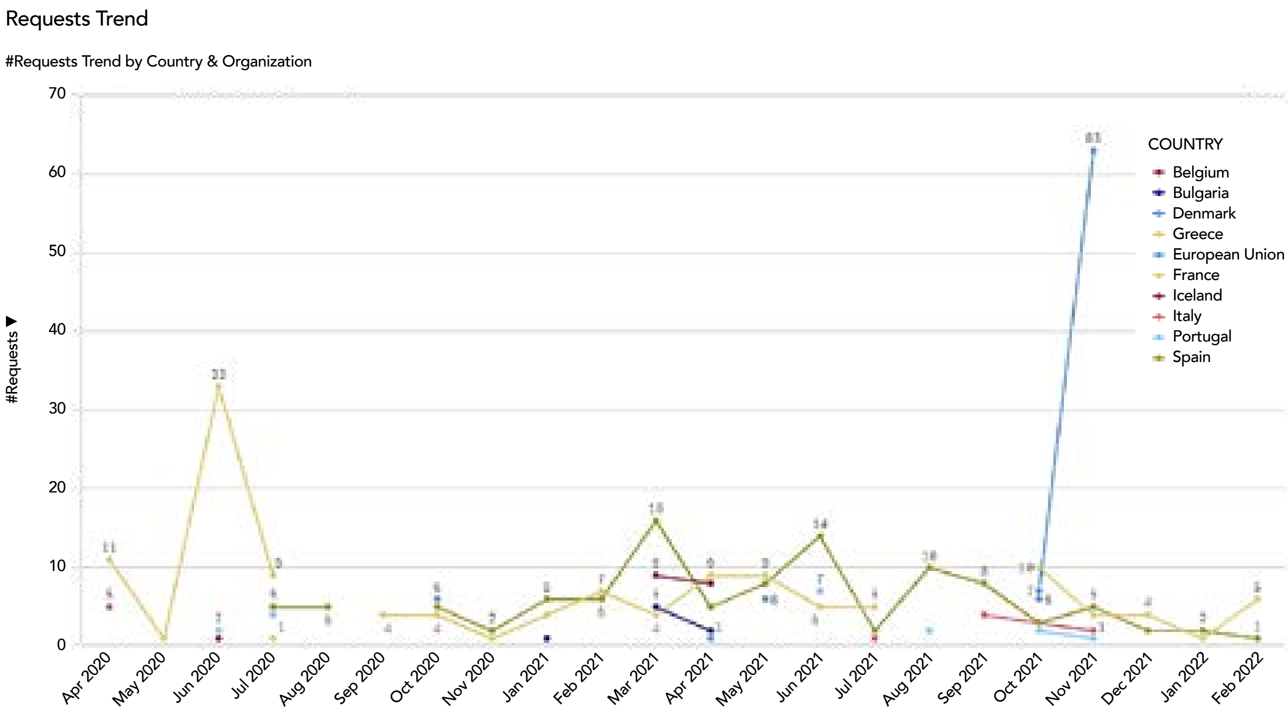
In the future, IMS will expand the SAR toolbox in line with user requirements including drift model visualisation and a chat box.

Figure 103: Example of SARSURPIC output.



Source: EMSA Services

Figure 104: Number of SARSURPIC requests from September 2019 to September 2020.



Source: EMSA Services

Figure 105 (a) and (b): IMS ship tracking.

(a) (b)

Source: EMSA Services

4.3 Accident investigation

4.3.1 Introduction

Despite the prevention and implementation measures in place, accidents continue to happen. In recent maritime safety history, some marine accidents have attracted not only the interest of maritime authorities or shipping companies, but also of the public in general. the Costa Concordia accident on 13 January 2012 (32 fatalities) generated widespread public interest, as did the fire on board the Norman Atlantic on 28 December 2014 (11 fatalities). But there have been other accidents with similar consequences which have not attracted such attention, such as the collision between MV Lady Aziza and Gokbel during which six people lost their lives, on the very same day as the Norman Atlantic accident. Another such tragedy was the sinking of MV El Faro on 1 October 2015, when 33 people died, including six EU nationals. The list of such casualties is long; much longer than one would expect. Few outside the fishing community are aware, for example, that more than 100 people have lost their lives on board fishing vessels over the past five years. Therefore, no analysis of maritime accidents could be complete without referencing the many tragedies that have taken place at sea, a great deal of which have passed unnoticed by those outside the maritime community. Added to this are the thousands of accidents which resulted not in deaths, but in injuries, many of which have had life-changing consequences for those affected.

Marine casualties also affect ships and the marine environment as well as shipping activities, and they cannot be disregarded, whatever their nature, location, or reduced consequences. Therefore, it is crucial to learn from all those events to improve safety measures to prevent the same accident from happening again.

This section outlines the EU approach to safety investigation, describing its founding pillars. It also indicates the main accident trends of EU interest per category of ship and, where possible, it puts forward safety indicators.

The main purpose of accident investigation is to improve maritime safety and prevent pollution by ships to reduce the risk of future marine casualties, by:

- Understanding why marine casualties and incidents occur.
- Preventing or lessening the seriousness of marine casualties or marine incidents in the future; and
- Developing lessons learned after accidents at sea.

4.3.2 Regulatory framework

At international level, the IMO adopted the Casualty Investigation Code in 2008 by resolution MSC.255(84) and made it mandatory. This code put forward standards and recommended practices for a safety investigation into a marine casualty or marine incident.

At EU level, Directive 2009/18/EC (AI Directive) establishes the fundamental principles governing the investigation of accidents in the maritime transport sector. It aims to facilitate the expeditious holding of safety investigations and proper analysis of marine casualties and incidents to determine their causes, ensuring the timely and accurate reporting of safety investigations and proposals for remedial action.

The AI Directive lays down obligations regarding the organisation, conduct and enforcement of accident investigation by the Member States, thereby harmonising safety investigations at EU level. It also establishes an EU reporting framework and data analysis platform.

The scope includes casualties which:

- involve ships flying a flag of one of the EU Member States or
- occur within a Member State's territorial sea and internal waters or
- involve other substantial interests of the Member States, regardless of the seriousness of the accident.

There are other pieces of legislation dealing with accident investigation which are summarised in the following table:

Table 37: Legislation on accident investigation.

	Level	Instrument	What it regulates
Legislation	International	UNCLOS Article 94 (7)	It provides the Duties of the flag State. Inquiry on marine casualties or incidents on the high seas. Cooperation between States.
		MARPOL Art.8, 12	Incidents involving harmful substances: Reporting of incident. Casualties to ships: Casualty investigation
		MLC Reg.4.3	Seafarer Health and Safety Protection and Accident Prevention.
		SOLAS	Special measures to enhance maritime safety. Ch. I, R21–casualty investigations. Ch. XI-1 R6 Additional requirements for the investigation of marine casualties and incidents.
		ICLL	Art.23 – casualty investigation.
		MSC.225(84)	International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code).
		Res. A 1075(28)	Guidelines to assist investigators in the implementation of the Casualty Investigation Code.
		Res. A 1070(28)	IMO Instruments Implementation Code. Enhances global maritime safety and protection of the marine environment and assist States in the implementation of instruments of IMO.
		Res.LEG3(91)	Guidelines on fair treatment of seafarers in the event of a maritime accident.
	EU	Directive 2009/18/EC	Fundamental principles governing the investigation of accidents in the Maritime transport sector in EU.
		Regulation 1286/2011	Adopts a common methodology for investigating marine casualties and incidents developed pursuant to Article 5(4) of Directive 2009/18/EC.
		Regulation 651/2011	Adopts the rules of procedure of the permanent cooperation framework (PCF) established by Member States in cooperation with the Commission pursuant to Article 10 of Directive 2009/18/EC.

4.3.3 Accident investigation at work

4.3.3.1 Main principles

Safety investigations are conducted with the sole objective of preventing marine casualties and marine incidents in the future. In no circumstances are they deemed to determine liability or apportion blame.

The AI Directive establishes that Member States shall ensure that safety investigations are conducted under the responsibility of an impartial permanent investigative body, the so-called Accident Investigation Bodies (AIB).[65]

The Directive classifies accidents according to the severity of their consequences. All very serious[66] accidents must be investigated and in the case of serious[67] accidents, a preliminary assessment must be conducted to decide whether a safety investigation needs to be undertaken. The Common Methodology for investigating marine casualties and incidents (Commission Implementing Regulation (EU) N° 1286/2011) provides elements ensuring a harmonised approach when conducting preliminary assessments. It also provides information about the various steps of a safety investigation, such as evidence to be collected, analysis of information gathered and issuance of the investigation report.

Data on marine casualties and incidents is stored and analysed within the European Marine Casualty Information Platform (EMCIP), presented further in this section.

Operational since June 2011, EMCIP is a database and a data distribution system operated by EMSA, the European Commission and the EU/EEA Member States that aims to deliver a range of potential benefits at national and European level by:

- Improving the information background about marine casualties and incidents;
- Widening and deepening the analysis of the results of casualty investigations;
- Providing at-a-glance information, enabling general risk identification and profiling; and
- Sharing lessons learned and safety issues detected in the course of safety investigations.

The key principles leading safety investigation are summarised in Figure 106.

Figure 106: Key principles ruling an accident investigation.

Source: EMSA Services

65 Twenty-seven AIBs and two Focal Points have been established following the implementation the AID. Contact details of such authorities can be found at https://portal.emsa.europa.eu/emcip-public/#/organizations Landlocked Member States which have neither ships nor vessels flying their flag can identify independent focal points to cooperate in safety investigations.

66 Accidents involving a ship's total loss or death or severe damage to the environment.

67 Not very serious occurrences involving a fire, explosion, collision, grounding, contact, heavy weather damage, ice damage, hull cracking, or suspected hull defect. This category also includes events resulting in immobilization of main engines, extensive accommodation damage, severe structural damage, such as penetration of the hull under water, etc., rendering the ship unfit to proceed, or pollution (regardless of quantity); and/or a breakdown necessitating towage or shore assistance.

4.3.3.2 The Permanent Cooperation Framework for the Investigation of Accidents in the Maritime Transport Sector (PCF)

Commission Implementing Regulation (EU) N° 651/2011 established the Permanent Cooperation Framework for the Investigation of Accidents in the Maritime Transport Sector (PCF) to provide the AIB with an operational platform to cooperate and attain the objectives of the AI Directive. The PCF also enables EMSA to facilitate cooperation and operational support in accident investigation as required by the Agency's founding regulation.

The tasks of the PCF are listed below:

- Enable AIB to share equipment and facilities supporting safety investigations.
- Provide each other with technical cooperation and expertise.
- Share information for analysing casualty data.
- Share information for making safety recommendations at EU level.
- Prepare principles for the follow-up of safety recommendations.
- Prepare principles for adapting the investigative methods to the technical and scientific progress.
- Manage early alerts.
- Establish confidentiality rules for the sharing of investigation data.
- Organise training[68] activities for investigators.
- Develop the EMCIP database schema and notification method together with the European Commission.

The PCF, for which EMSA provides the Secretariat, establishes a work programme foreseeing priorities and targets and meets at least once per year. When there is substantial interest, the European Commission may participate in the meetings or other PCF activities.

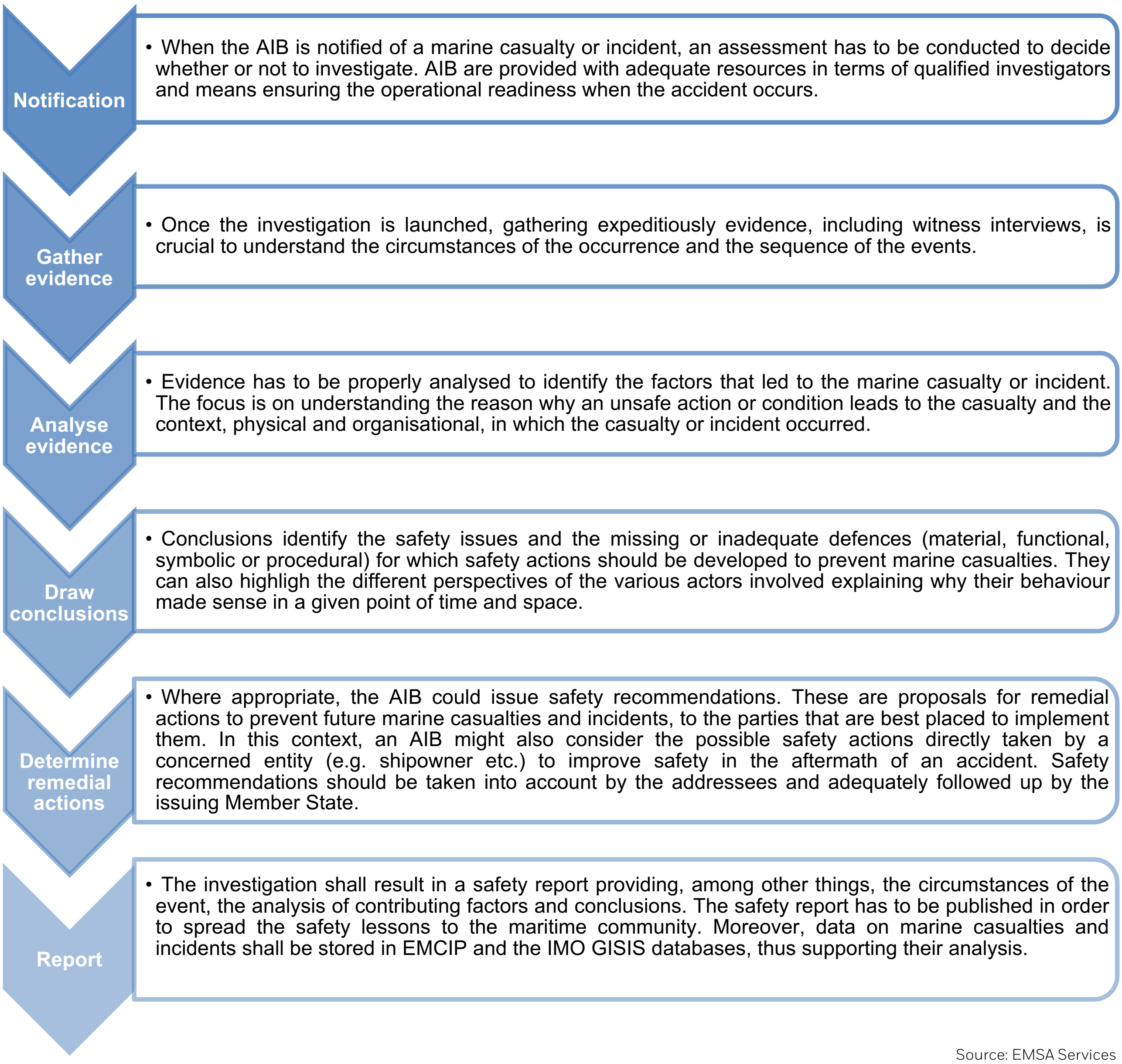
4.3.3.3 Phases of accident investigation

A typical investigation process generally includes the phases and outcome described in Figure 107.

Some of the steps below might be conducted by different AIB of other substantially interested states; therefore, cooperation between the AIB is crucial to ensure an investigation is conducted effectively.

68 In this context, EMSA prepared specific training courses on accident investigation available to the national authorities including the "Core Skill Courses" for beginners, the "Advanced course" for experienced investigators and the brand-new course on "VDR and electronic evidence collection".

Figure 107: The marine safety investigation process.



Source: EMSA Services

4.3.4 The European Marine Casualty Information Platform (EMCIP)

EMCIP provides the means to store data and information related to marine casualties and incidents involving all types of ships including occupational accidents related to ship operations. It also enables the production of statistics and analysis of the technical, human, environmental and organisational factors involved in accidents at sea.

EMCIP is also connected to the IMO Global Integrated Shipping Information System (GISIS), thereby supporting the dissemination of investigation data reported by EU Member States at a global level without any duplication of effort. It is also used to reduce burden of the Member States when complying with their reporting obligations, the Agency having signed agreements related to data provision with EUROSTAT and HELCOM.

Information about marine casualties and incidents is also accessible to the public[69], such as the investigation reports published by the accident investigation bodies and 'anonymized' data about casualties and incidents notified by Member States authorities.

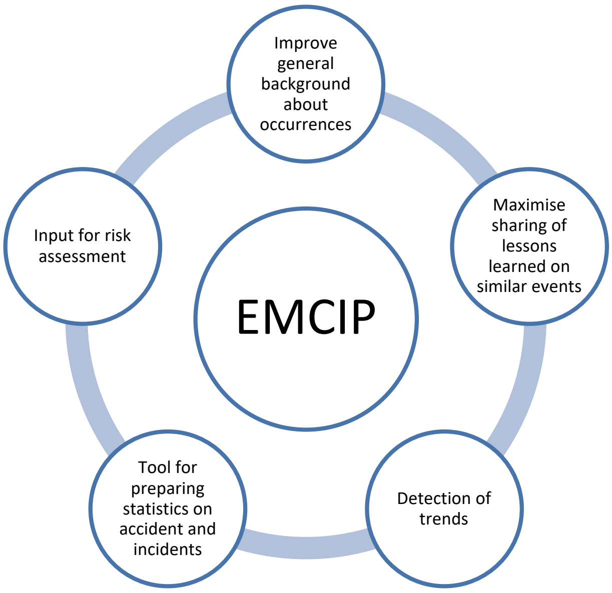
69 EMCIP data public access at: https://portal.emsa.europa.eu/emcip-public/#/dashboard

Figure 108: EMCIP – occurrences from June 2011 to October 2021.

Source: EMSA Services

EMCIP is a powerful tool for sharing knowledge about marine casualties and incidents given its wide scope, comprehensive reporting scheme and data sharing policy agreed by the Member States. EMSA uses EMCIP data extensively for the publications described hereafter. Moreover, this data is used in the context of several safety projects, coordinated studies, or projects (e.g., MASS, FIRESAFE, SAFEMODE, PSS) and to support the European Commission in the revision of safety legislation at EU level.

Figure 109: EMCIP added value.



Source: EMSA Services

4.3.4.1 Annual overview on marine casualties and incidents

As per EMSA's founding Regulation, since 2014 the Agency has published[70] an overview on marine casualties and incidents based on EMCIP data. These statistics refer to accidents and incidents falling within the scope of the AI Directive, i.e., involving ships flying a flag of one of the EU Member States, occurring within EU Member States' territorial sea or internal waters or involving other substantial interests of EU Member States. All these publications are available on EMSA's website.

4.3.4.2 EMCIP Safety Analysis

EMSA has developed a methodology to analyse the findings of the safety investigations reported in EMCIP to detect potential safety issues. This methodology assesses and identifies specific core attributes, like the accident events and the factors that contributed to the occurrences, the safety recommendations issued, and the safety actions taken by the concerned parties.

Three analyses have been published[71] so far with a focus on a specific vessel type each time: fishing vessels, ro-ro passenger ships and containerships.

70 The documents are available at: http://www.emsa.europa.eu/accident-investigation-publications/annual-overview.html

71 The documents are available at http://www.emsa.europa.eu/accident-investigation-publications/safety-analysis.html

4.3.5 Relevant data and analysis

The relevant data in this section contains statistics on marine casualties and incidents in EMCIP. The data covers the period from 1 January 2016 to 31 December 2020 and can be subject to change over time as EU Member States add or update information on older cases. The data provided in this section includes UK flagged ships.

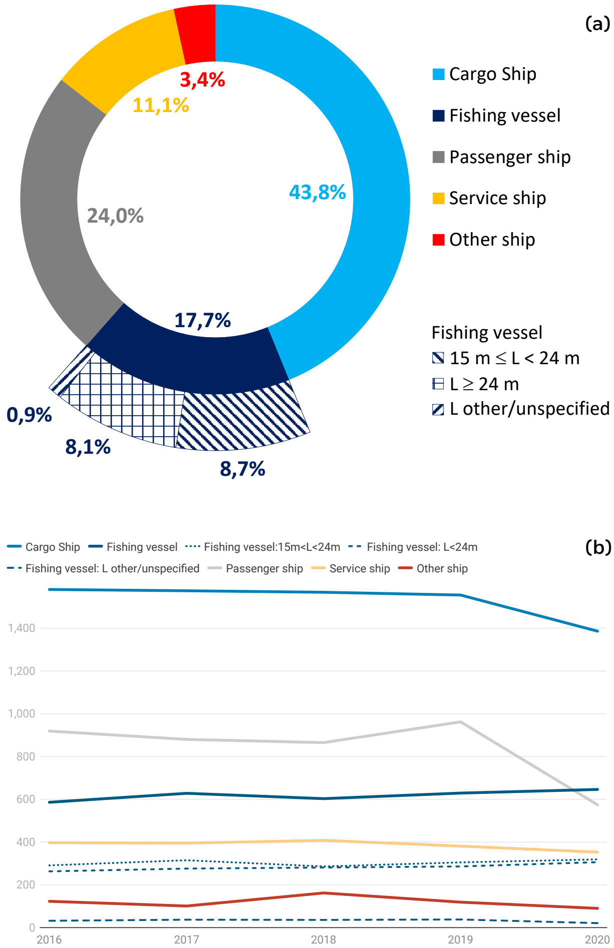
4.3.5.1 Focus on occurrences

This section provides general information about the number of reported marine casualties and incidents that occurred between 01/01/2016 and 31/12/2020, in terms of their severity, the ships involved, fatalities and injuries as well as safety indicators.

Over the 2016-2020 period, an average of 3200 accidents took place every year. Cargo ships represented the main category of ships involved in accidents, a finding that was anticipated, considering that it is the category which includes the biggest proportion of the fleet. As was also expected, the number of occurrences dropped for all ship types in 2020 due to the COVID-19 pandemic, apart from fishing vessels, for which an increase of 6% in the number of accidents was noted. While the merchant fleet usually operates under a corporation with access to credit and capital, fishers depend on their daily activity to survive and, therefore fishing continued throughout the pandemic, particularly as demand for food did not drop during this period.

Ships involved in marine casualties are organised by ship type, divided into cargo ship, fishing vessel, passenger ship, service ship and other ship.[72] Fishing vessels have been categorised by their length overall according to the relevant legislative threshold as indicated in the ship safety section.

Figure 110 (a) and (b): Number of ships involved in marine casualties - Average distribution by ship type and evolution over the past 5 years.



Source: EMSA/EMCIP (https://portal.emsa.europa.eu/web/emcip)

Of all the ship types included in the previous graph, the ISM Code, which governs the safety management on board ships, including the occurrence recording and reporting, does not apply to fishing vessels. It is questionable whether fishing vessels report all occurrences or only those with the worst consequences. For example, the number of occurrences reported for fishing vessels above 24 m is the same as that for ships between 15 m and 24 m, even if the fleet of the latter group is three times bigger.

To draw more objective comparisons between the number of occurrences involving different ship types and the fleet evolution, the following ratios between the number of occurrences involving a ship type and the corresponding fleet sizes were calculated. Calculations only relate to cargo, passenger and service ships flying an EU Member State flag and with an IMO number (i.e., small ships or ships flying a flag from a third country are not counted) and fishing vessels with a EU27 or UK flag with a length above 15 m.

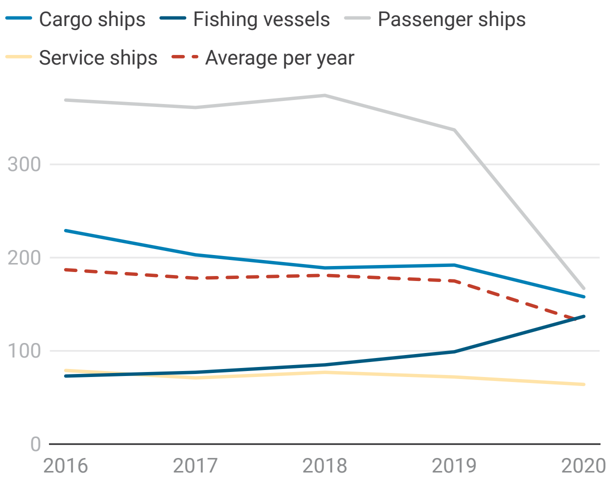
72 The Directive does not apply to marine casualties and incidents involving only ships of war and troop ships and other ships owned or operated by a Member States and used only on government non-commercial service, ships not propelled by mechanical means, wooden ships of primitive build, pleasure yachts and pleasure craft not engaged in trade, unless they are or will be crewed and carrying more than 12 passengers for commercial purposes, inland waterway vessels operating in inland waterways, fishing vessels with a length of less than 15 meters and fixed offshore drilling units. Such vessels are considered within the scope of the Directive only when they are involved in an occurrence together with a ship which is covered by the Directive (e.g., a collision between a cargo ship and a recreational craft or fire on-board an inland waterway vessel while sailing in internal waters).

Table 38: Occurrence indicators. Number of occurrences compared to the fleet size (x1,000)

	2016	2017	2018	2019	2020	Average per ship type
Cargo ships	229	203	189	192	158	194
Fishing vessels	73	77	85	99	137	94
Passenger ships	369	361	374	337	167	322
Service ships	79	71	77	72	64	72
Average per year	187	178	181	175	131	170

Source: EMSA/EMCIP (https://portal.emsa.europa.eu/web/emcip)

Figure 111: Indicator on the number of occurrences per ship type – Evolution over the past 5 years.

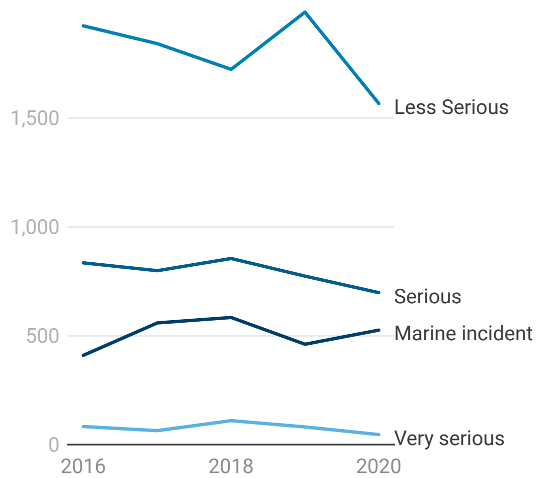


Source: EMSA/EMCIP

This ratio indicates the annual probability for an EU Member State-flagged ship of the relevant category to have an occurrence. Obviously, this is not a risk indicator as such, as the consequence of the incident can vary from very severe (a fatality or the loss of a ship), to non-severe (for example, a minor injury where there is less than 72 hours of incapacitation). Looking at the indicators, it appears at first glance that passenger ships are those with higher risks, which is not the case in reality. A likely main cause of the higher ratio is a greater reporting of passenger ship casualties, based on more advanced safety management systems and staff availability, whereas fishing vessels will most probably report only those incidents which are more severe, or which have more significant consequences. It must be noted that the reporting of accidents has an associated administrative burden, which in cases where the resources are scarce, the incentives to avoid it are important. Therefore, this indicator merely provides the probability of occurrence regardless of the seriousness. Still, it is notable that the indicator related to fishing vessels has continuously increased over the period and almost doubled from 2016 to 2020. This raises concerns about safety issues and their impact on board fishing vessels over the years. In terms of cargo ships and service ships, an overall improvement has been noted since 2016.

Marine casualties are catalogued by their severity as very serious, serious, less serious, and marine incidents. The following graph presents the occurrences classified by their severity:

Figure 112: Number of marine casualties - Evolution by severity in the past 5 years.

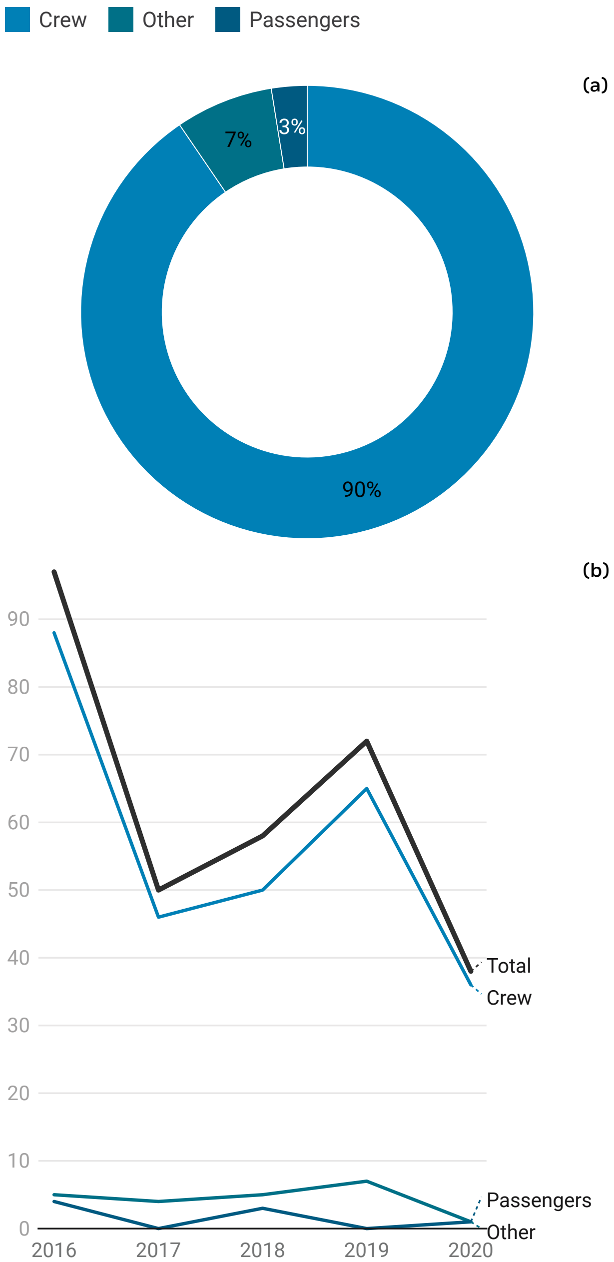


Source: EMSA/EMCIP (https://portal.emsa.europa.eu/web/emcip)

Occurrences with consequences such as loss of life, loss of ship or severe damage to environment (very serious) represented 2.4% of all occurrences. Accidents with consequences such as damaged ships unfit to proceed, serious injuries or non-severe damage to the environment (serious) showed a total of 24.9%. Casualties that led to consequences not mentioned above represented 56.8% of all incidents reported. Finally, the percentage of accidents where there were no such consequences, (marine incidents) was 15.9%. Some variations over the period are visible in the figure, but the proportion of occurrence severity remained reasonably constant.

The number of fatalities is summarised in the following figure:

Figure 113 (a) and (b): Number of fatalities - Average distribution by category of person and evolution over the past 5 years.

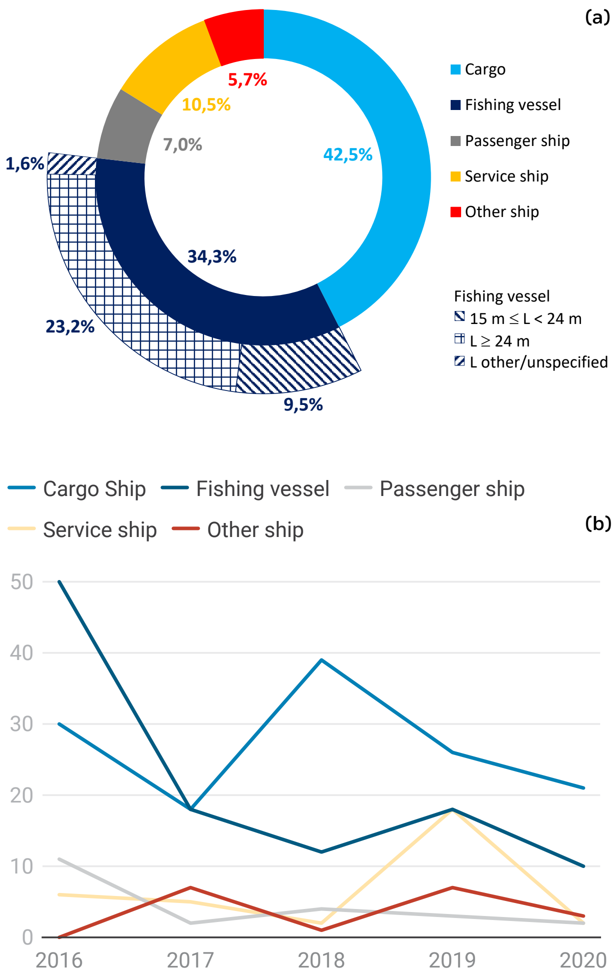


Source: EMSA/EMCIP (https://portal.emsa.europa.eu/web/emcip)

Fatalities in marine casualties are catalogued by the category of the affected person: crew members, passengers or others (e.g., stevedores). The overall number of fatalities has decreased from 97 to 71 from 2016 to 2019 (the figure of 2020 may be unreliable due to COVID-19). 90% of those affected by marine casualties in the past five years were crew members, as they perform operational tasks, some of them with associated risks. With regard to passengers, the annual number of fatalities is always below 10, which in comparison with the more than 400 million of passengers transported to or from EU ports annually, is low.

The fatalities per ship category are summarised below:

Figure 114 (a) and (b): Number of fatalities - Average distribution by ship type and evolution over the past 5 years.

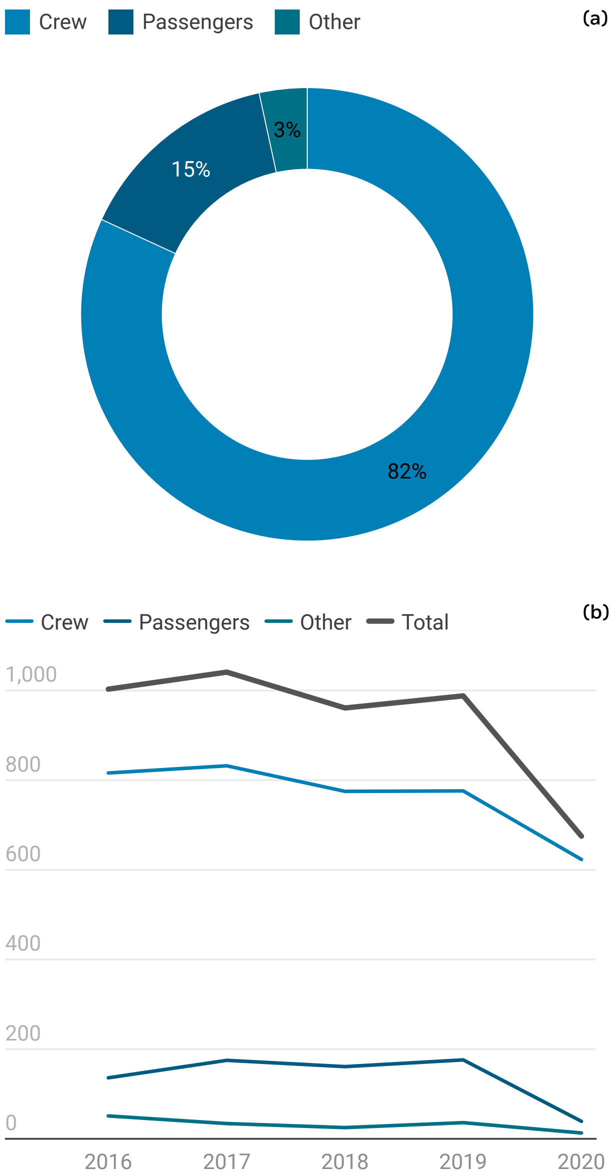


Source: EMSA/EMCIP (https://portal.emsa.europa.eu/web/emcip)

The highest number of fatalities occurred in accidents involving cargo vessels, followed by fishing vessels.

Injuries in marine casualties are shown below by the category of the affected person: crew members, passengers or others.

Figure 115 (a) and (b): Number of injuries – Average distribution by category of person and evolution over the past 5 years.

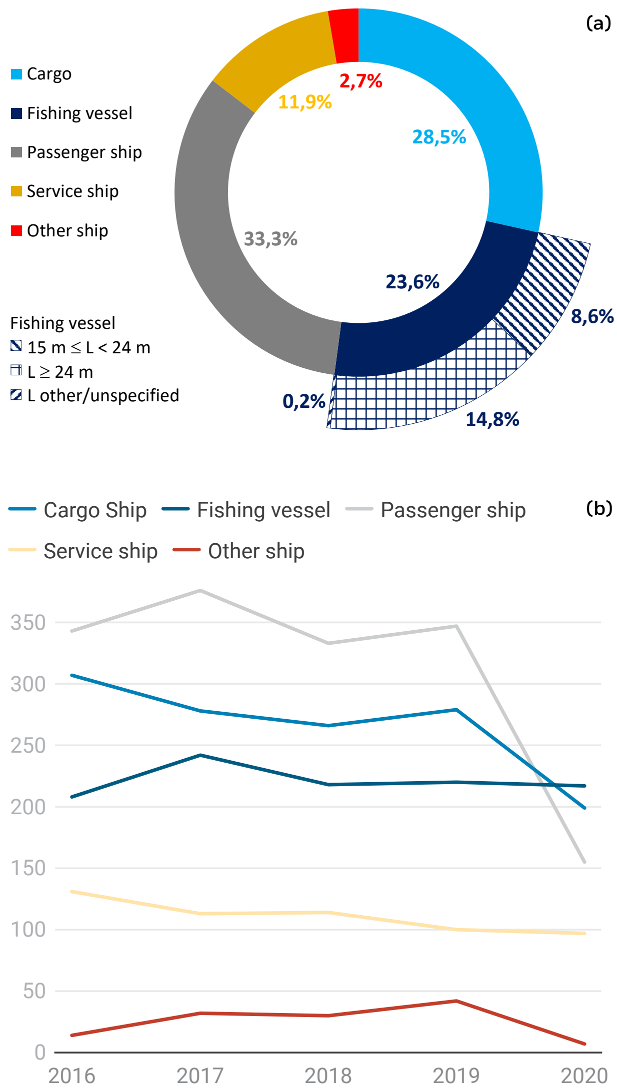


Source: EMSA/EMCIP (https://portal.emsa.europa.eu/web/emcip)

As expected, the conclusions on injuries are similar to those on fatalities: the highest numbers correspond to crew members as they are those performing riskier tasks at sea.

The injuries per ship category are summarised below:

Figure 116 (a) and (b): Number of injuries – Average distribution by ship type and evolution over the past 5 years.



Source: EMSA/EMCIP (https://portal.emsa.europa.eu/web/emcip)

In terms of the type of vessel where injuries took place, passenger vessels were reported more often than any other category. This can be explained by the same argument indicated above, the more developed safety management systems that report even the slightest injury, and also by the high number of people carried onboard these ships, both in the passenger and crew category.

4.3.5.2 Safety recommendations and actions taken

Safety recommendations are where the main lessons learnt coming from an accident investigation are concentrated. They are proposals from the accident investigation authority with the intention of preventing accidents. Each recommendation is addressed to a relevant party involved in maritime safety: authorities, ship owner, recognised organisations, etc.

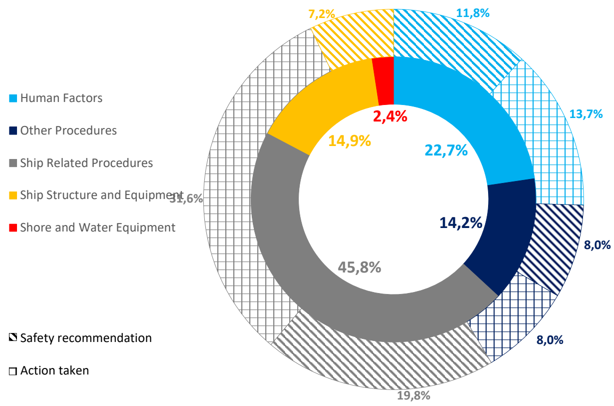
On the other hand, an 'action taken' is an action already implemented by one of the relevant stakeholders during the accident investigation process, before the publication of the report, with the intention of preventing accidents or incidents.

These two terms are further categorised into the human factor, ship structure and equipment, shore and water equipment, ship-related procedures and other procedures. According to the overview of maritime accidents published throughout the years, more than 50% of the occurrences were related to human error. However, associated safety recommendations do not necessarily need to be addressed through the human factor category as they could be related, for example, to deficiencies of the safety management procedures onboard.

The following figure shows the distribution of safety recommendations and actions taken by category.

Almost half (45.8%) of the remedial actions targeted ship-related procedures, followed by human factors (22.7%).

Figure 117: Safety recommendations and actions taken.



Source: EMSA/EMCIP (https://portal.emsa.europa.eu/web/emcip)

5. New Developments

5.1 Autonomous and highly automated ships

5.1.1 Introduction

Greater automation in shipping - at a scale never before seen – is knocking on the door of the maritime world. While the most enthusiastic proponents of autonomy predict a future without seafarers onboard ships, it is likely that such a scenario, should it ever happen, will not be immediate and will follow a very gradual approach. Nevertheless, the trend towards increased automation is persistent and is likely to change maritime transport as we know it today.

MASS is the most common term used to refer to ships using greater automation. It stands for Maritime Autonomous Surface Ships which have been defined by the IMO as ships which, to a varying degree, can operate with reduced, or independent of, human intervention or control.

While life at sea is becoming less attractive to younger generations, highly automated systems are designed to significantly change the maritime workforce, shifting roles and responsibilities from operating at sea to onshore and from performing tasks to supervising them. In addition to the societal benefits, many expect that a large percentage of human errors contributing to maritime accidents can be eliminated.

Digitalisation and automation will increase the demand for highly skilled crews. Reskilling, upskilling and new skills will be required. Training seafarers in new technologies will enable them to benefit from new opportunities that arise from technological developments. There will also be a need to reflect the demands of new technologies to an updated STCW.

While it would be irrational to ignore the potential of technological advancement in the field of automation to provide an improvement to safety, it must be kept in mind that increased automation will neither eradicate accidents nor remove the need for human intervention, at least in the initial decades of its implementation.

5.1.1.1 Automation and Autonomy

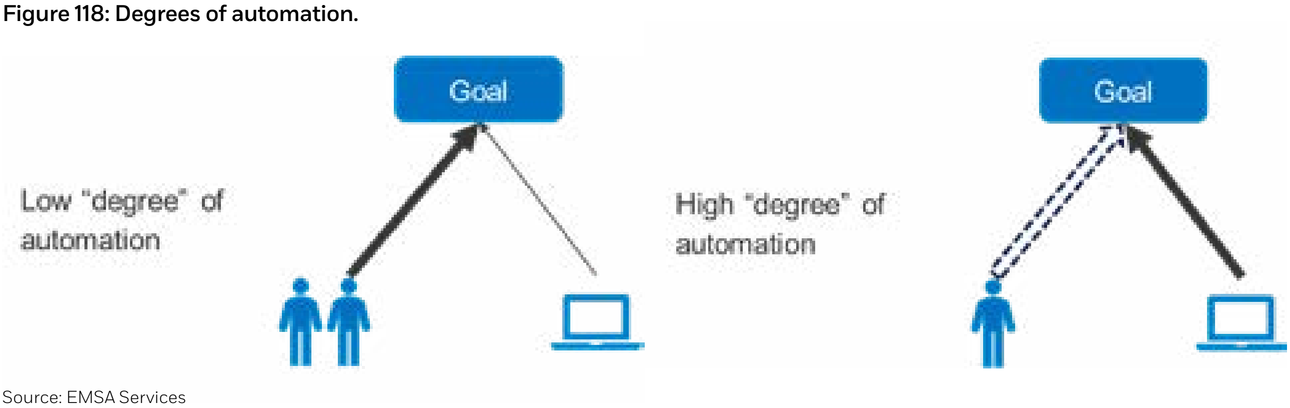
Automation has been defined as "the execution by a machine agent (usually a computer) of a function that was previously carried out by a human" [11]. Hence, a process that is automated is one that is performed without human assistance. However, it is important to note that the process is still pre-defined by humans and, accordingly, the potential for human error is not totally excluded.

Autonomy is linked to the term 'autonomous' and implies that apart from executing pre-defined processes, the system can perform under the uncertainties of the external environment and adjust to them or to potential failures without human intervention. For this reason, the term autonomy can be understood as 'technology operates alone'. However, the degree of autonomy can vary and accordingly, the terms autonomous, highly automated, and fully automated ships are used in practice.

There is a fine line between the number and essence of sequential functions that can be automated - the degree of automation - and the moment that system is said to be performing autonomously – the level of autonomy. In the end both terms automation and autonomy refer to the use of technology with the purpose of transferring functions from humans to technology, and at times it can be challenging to distinguish between a system making use of automation or being autonomous to some degree.

Levels or degrees of autonomy or use of automation are typically used interchangeably to describe the incremental use of technology in a system. The levels usually range from no involvement of technology at the lowest level, to technology being responsible and executing all actions at the highest level. From the regulatory point of view however, these degrees of autonomy are useful to be able to impose application to or exemption from specific parts of the regulations.

Figure 118: Degrees of automation.



Source: EMSA Services

5.1.2 Regulatory developments

The main challenges related with autonomous ships are not related to the technology available but rather to the regulatory framework. The IMO's Maritime Safety Committee (MSC) started the discussion around automated ships as early as 1964[73].

However, only recently the IMO embarked in the process of addressing MASS holistically, carrying out Regulatory Scoping Exercises (RSE) on the different areas, including safety, to find any potential gaps and identify the best way forward to regulate them. The safety work on the RSE initiated in June 2017 following a proposal indicating that there was an urgent need to clarify how MASS operations might be addressed in IMO instruments. The RSE assessed the relevant IMO instruments under the remit of the MSC and identified provisions which apply to MASS differentiating those that:

- prevent MASS operations,
- do not prevent MASS operations,
- need some amendment or clarification to allow MASS operations.

The MSC completed a RSE on MASS in May 2021. The list of high-priority outstanding issues that have been identified include:

- the definition of the role of the shipmaster and how the various responsibilities and obligations placed upon the master could be applied to MASS;
- the functional and operational requirements of any remote-control centre and whether or not a remote operator should be considered a seafarer.

73 MSC VIII/11, 9.3.1964

Finally, the MSC decided to open a new output on "Development of a goal-based instrument for maritime autonomous surface ships (MASS)", with a target completion year of 2025 with a view to prepare a mandatory instrument to address MASS operations.

Similarly, the IMO Legal Committee completed an RSE at its 105th session for the instruments under its remit. It concluded that, in general, MASS could be accommodated within the existing regulatory framework of its conventions without the need for major adjustments. However, it also noted that conventions not under the auspices of IMO, such as UNCLOS and MLC, 2006, might need to be considered in the IMO's future work on MASS. Thus, if IMO develops an instrument regulating MASS operations, terminology and definitions will have to be developed in coordination between the committees.

Lastly, the IMO Facilitation Committee (FAL) postponed the finalisation of the RSE to May 2022.

During this transitional period, it is expected that any project involving increased automation or remote operation, and thereby not complying with the applicable rules, shall make use of the IMO's Guidelines for the Approval of Alternatives and Equivalents[74]. These guidelines describe the procedure to be used in the design process to get the approval of special projects out of the usual standards.

In the regulatory area it is also important to note that the IMO approved Interim Guidelines for MASS trials[75], drafted in a high-level manner. They indicate that "trials should address the risks to safety, security and protection of the environment. The risks associated with the trials should be appropriately identified and

74 IMO, 2013, Guidelines for the Approval of Alternatives and Equivalents as provided for in Various IMO Instruments, MSC.1/Circ.1455

75 IMO, 2019, Interim Guidelines for MASS trials, MSC.1/Circ.1604

measures to reduce the risks to as low as reasonably practicable and acceptable should be put in place."

At European level, EU Operational Guidelines for MASS trials[76] were finalised and published in December 2020. The main objective of these guidelines is to develop procedures to be used for designating test areas or a ship safety zone when conducting trials of MASS-related systems and infrastructure. These guidelines also address the risks and vulnerabilities inside and outside the determined area/zone by ensuring the safety of navigation and consider environmental interests and third-party interests, as well as any monitoring and communication issues from the land side, including how in the future vessel traffic services may have to interact with MASS in all conceivable situations taking into consideration and complementing, as far as possible, the IMO Interim Guidelines for MASS trials.

5.1.3 Commercial projects

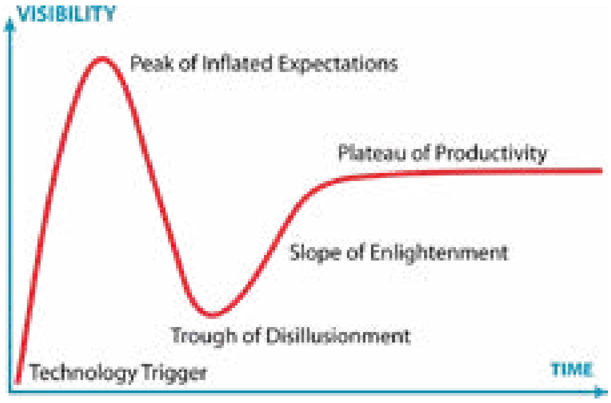
At the moment there is, at least partially, still scepticism in the shipping industry towards autonomy. A survey by UK-based seafaring union, Nautilus International, has found "scepticism towards autonomous shipping and an overwhelming belief such vessels will be a threat to safety at sea".

Regardless of the advantages in terms of safety and sustainability that increased automation might bring, it will still be difficult to implement without a functioning and profitable business model that is endorsed by society and industry. When businesses are assessing the value of a new technology, they often use a tool called the Gartner Hype Cycle, which is a graphical representation of the perceived value of a technology over time as expectations and hype play out against actual adoption and performance [12].

It is obvious that until a certain amount of commercial projects are operational and profitable, it will be difficult to go up the slope of enlightenment and enter the plateau of productivity. Currently, there is a growing number of small, unmanned surface vehicles being used for naval or oceanographic purposes and several initiatives under development for the application of MASS. Those initiatives can be split into four main groups:

76 European Commission, 2020, EU Operational Guidelines for safe, secure and sustainable trials of Maritime Autonomous Surface Ships (MASS)

Figure 119: The Gartner Hype Cycle.



Source: Jeremykemp at English Wikipedia, CC BY-SA 3.0

- **Short sea shipping container feeders:** This business case is typically observed in Northern Europe and concerns ships that are expected to become fully unmanned after a trial period. Their operation concerns short routes with personnel going onboard on a daily basis for maintenance, cargo handling and other operations. These ships are, in general, electric.

  The most prominent example of this category is the Yara Birkeland, operated by the Norwegian company Kongsberg in collaboration with Yara, a Norwegian chemical company. This ship, shown in the picture below, is considered a pioneer in this area. There are two other relevant projects, one for ASKO Maritime (a Norwegian grocery distributor) and another for the Anglo Belgian Shipping Company. In September 2021 it was announced that the AV Zhi Fei, a Chinese-built 300 TEU autonomous cargo ship was set to enter service the following month on a short-sea route between Dongjiakou and Qingdao.

Image 11: MV Yara Birkeland.

Source: Knut Brevik Andersen, Wilhelmsen Ship Service © Yara International ASA

- **Protected waters passenger ships**: These are small non-SOLAS ships operating in ports, channels, etc. in the form of cable ferries. At the moment, such projects are limited to simple crossings and are fully unmanned. A pilot project is ongoing in Trondheim (milliAmpere, milliAmpere II), Norway.

Image 12: The full-scale autonomous ferry prototype milliAmpere II.

Source: NTNU

- **Remotely controlled tugboat**: These are also related to operations in port, and pilot projects and demonstrations have already taken place. In October 2021, Nelly Bly completed the world's first 1,000+ miles autonomous voyage during a Sea Machines demonstration, departing from Hamburg, then sailing around Denmark and back, with its operators located in the US.

- **Manned cargo ships with increased automation (eventually with reduced crew on board)**: These projects are typically ocean-going cargo ships of different sizes (one example is the Nippon Yusen Kaisha ship trial performed in accordance with IMO guidelines). The functions that are expected to be automated are mainly related to navigation functions, such as those of the officer on watch, route planning, route execution, basic manoeuvring, etc. Here, the human role shifts to active supervision of the system.

5.1.4 EU-funded research projects

EU funded research has a pivotal role in the development of technology and implementation models for MASS. The MUNIN project, finalised in 2015, developed a technical concept for the operation of an unmanned merchant ship and assessed its technical, economic and legal feasibility. It was one of the main precursors in the discussion on autonomous ships. Since then, a number of initiatives and projects have taken place in the EU, including:

- Three major EU funded projects (AUTOSHIP, AEGIS, MOSES) focussing directly on automated and autonomous maritime systems;

- The SkillSea project on the development of educational packages while modernising maritime education and training systems and curricula in line with technological change.

- the EMSA funded RBAT MASS study following the conclusion of the SAFEMASS study;

- the Norwegian funded study SFI AUTOSHIP;

- the European Space Agency funded ESANAV project;

- further EU funded research projects focussing on technologies and systems that are necessary for the implementation of such systems (e.g., PREParE SHIPS, H2H);

- the HUMANE project focussing particularly on the human element in relation to such projects (and the EMSA funded CMORCC on competences for MASS operators in Remote Control Centres).

5.1.5 Challenges and opportunities

The significant technological progress of the last few years can lead to the implementation of increased automation and/or remote operation of ships. Obviously, there are numerous challenges associated to the use of such technologies in the maritime environment.

The main safety challenges associated with autonomous ships, excluding regulatory and liability ones, have been identified in different research papers [13] and can be sub-divided into:

Technological challenges:

Technological	Hardware	Sensors
		Communication
		Fire safety
		Mooring
	Software	Decision system
		Software errors
		Cyber security

The most controversial technological concerns lay on the software side, particularly on the decision system that includes the ability of MASS to avoid collisions with other ships while complying with COLREG and the ability to react and avoid unfavourable weather conditions or other potentially dangerous situations at sea. In today's shipping landscape, reacting to those situations includes following procedural guidelines to some extent but also depends on the critical decision-making of the crew.

In addition, cybersecurity has been labelled "the biggest challenge facing the maritime industry" and its relevance is elevated in the case of systems with a degree of autonomy that rely heavily on information technology while making use of internet communication systems, communication and networking technologies based on satellite communication or terrestrial communication systems.

Human factor:

Human factor	Training	
	Effect of technology on human operator	
	Human centred system design	Migration of workplace
		Presentation of data

The two main challenges are the following:

- The change of paradigm in the training of all the persons involved in the design, construction, and operation of ships, from seafarers and shore-based operators to naval architects, technicians, and engineers.
- The high reliability that is thought to be achieved when deploying these systems also has an impact on the performance of the operator as an over-confidence in the system often results in a lack of vigilance.

Procedural challenges:

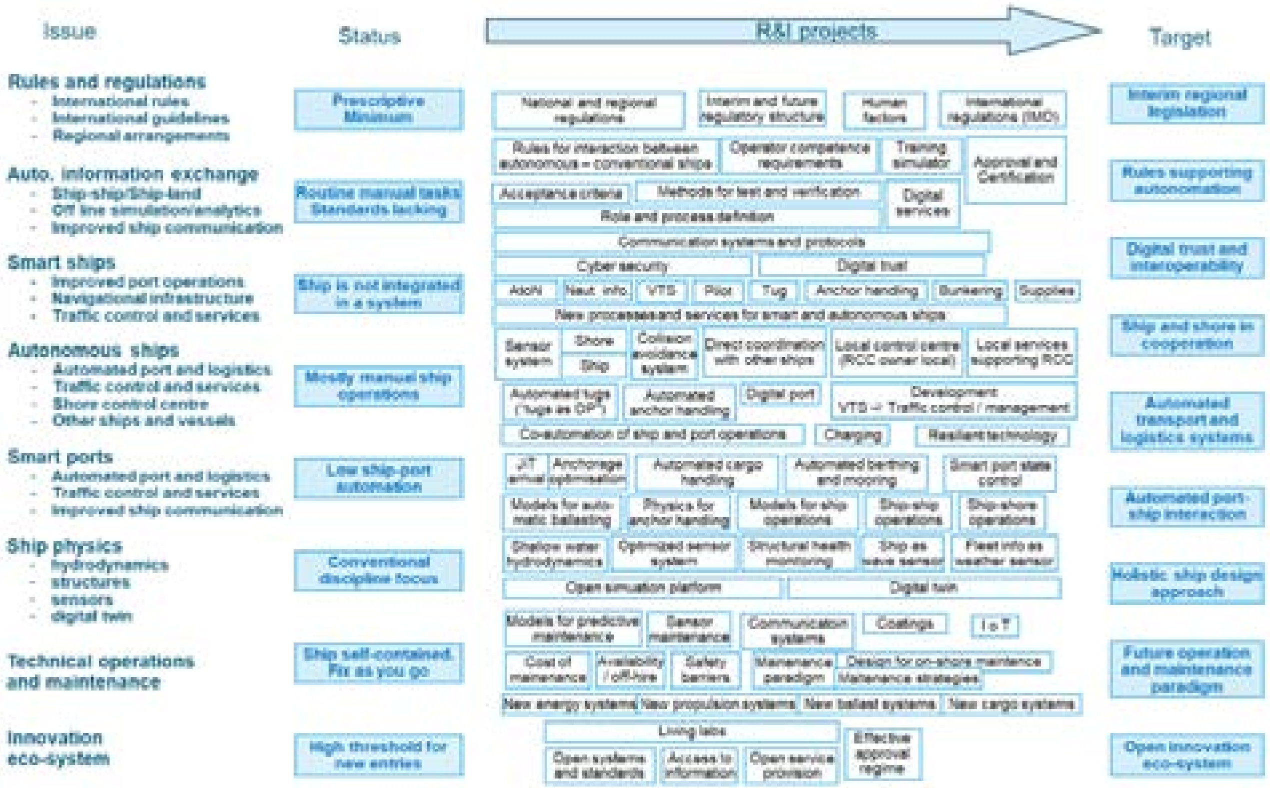
Procedural	Undersirable events	Anticipated
		Unanticipated
	Standard Operations	Navigation
		Maintenance
		Cargo care
		Risk assessment
		Safety controls
		Absence of regulations

- Dealing with unanticipated undesirable events, corrective maintenance at sea, cargo management onboard for cargo that requires maintenance or monitoring.
- As mentioned before, societal consensus and acceptance is also a challenge for this kind of technology.

A complex roadmap:

In order to get a complete picture about the complexity of the issue and the range of work that lies ahead, it is also worth mentioning the work on a collaborative roadmap from the leading maritime research institutes in Norway and Singapore, which identifies the most important research challenges in the journey towards smart and autonomous ships and ports:

Figure 120: R&D Roadmap towards Smart and Autonomous Maritime Transport Systems.



Source: The Research Institutes' Roadmap towards Smart and Autonomous Sea Transport Systems, SINTEF & TCOMS (2020).

Nevertheless, there are also aspirations that the use of these technologies will bring significant benefits on multiple levels and that this should be the main focus of their implementation, namely the potential benefits for the safety, environment and working conditions of seafarers. Eventually, commercial benefits might also be present; however, it needs to be stressed that implementation of these technologies are a means to achieve these goals, and not the goal itself.

There are some interesting reflections on MASS taken from the concluding remarks of the EMSA funded SAFEMASS study[77]:

"The study suggested that potential "ironies of automation"- pitfalls should be avoided and that existing Levels of Automation (LoA) models should be revised to be better suited for use in system engineering. Future efforts made to increase automation should adopt principles of human-centred design and apply established Human Factors Engineering techniques and standards. Due to the inherent complexity of MASS design and operations, system designers should avoid addressing automation at a ship level using overly simplistic LoA models. Instead, automation should be considered at a task and system function level, supported by definitions and models which allow more nuanced evaluations of joint human-system interactions. Such an approach is arguably better suited for determining the MASS systems' and operators' roles and responsibilities in execution of functions across various operational modes.

The need for supervision is directly related to the degree of system reliability (or unreliability). A less reliable system requires more active supervision and frequent intervention. The demands put on RCC operator in various operational modes and scenarios must be taken into consideration when making decisions about how functions are to be allocated between the system and human operator in a best possible way. Such efforts should be made already early in the design stage when defining the MASS Concept of Operations (ConOps). This allows for developing fit-for-purpose automation, which subsequently can be optimized with additional non-technical solutions, such as those introduced via manning and organisation of work staff, procedures, routines and training."

77 SAFEMASS was a study of the risks and regulatory issues of specific cases of MASS developed by DNV in 2020.

5.2 Alternative fuels and power technologies

The environmental challenges and emission targets in shipping imply a need to change the fuels currently in use. However, these new fuels present fresh safety challenges that need to be properly addressed to ensure equivalence to present levels.

This section summarises the different safety challenges stemming from the adoption of new energy and power systems. All aspects related to sustainability, cost-effectiveness, availability, or fuel production/pathways are not covered in this report but can be found in the European Maritime Transport Environmental Report[78].

Alternative fuels and other energy options are presented without relative merit or eligibility, solely focusing on the grounds of their technology maturity, standardisation, regulatory development and highlighting the key challenges associated to their safe use onboard ships.

5.2.1 Introduction

The use of alternative fuels and alternative power systems started more than a decade ago. Initially, the use of LNG as fuel generated great interest as an option to address the issue of air pollution and has thereafter continued to grow based on the experience of the transport of LNG as cargo. The adoption of LNG as fuel for propulsion required the adaptation and introduction of new technological solutions for fuel bunkering, storage, conditioning and multi/dual-fuel engines, among others. While boil-off gas was already used for propulsion in LNG carriers, other ship types ranging from RoPax to Very Large Container Carriers, Cruise ships and small service vessels, have successfully integrated LNG as an alternative fuel.

Other options are currently being considered to meet growing requirements on decarbonisation in maritime transport. Aiming for improvement of the environmental/climate footprint, energy carriers such as biofuels, methanol (MeOH), LPG, hydrogen, ammonia (NH3) or batteries and power systems such as fuel cells, batteries or wind assisted propulsion have been or are being considered. However, they have had limited success to date in terms of commercial application.

78 The European Maritime Transport Environmental Report (EMTER) was jointly produced by EMSA and the EEA in 2021 and is available at http://emsa.europa.eu/publications

In the pictures below, the MV Viking Grace (2013) and the MF Hydra (2021) represent, respectively, the early and the recent days of the shipping journey in the exploration and adoption of alternative fuels and power technologies: the first with the use of LNG as fuel and the second, with the world's first liquefied hydrogen (LH2) application on commercial maritime transport.

Image 13: MV Viking Grace – LNG fuelled RoPax represents still one of the world first LNG fuelled flagships, operating since 2013.

Source: Viking Line Abp

Ship certified according to former IMO Interim Guidelines for LNG fuelled ships.

Image 14: MF Hydra – World 1st commercial ship fuelled by LH2.

Source: Sembcorp Marine Ltd.

Ship of the year 2021 with a liquefied hydrogen capacity of 80m3. Powered by 2x200kW PEM fuel cells and 2x440kW internal combustion generators.

While the Viking Grace enjoyed the application of the former Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships (MSC 285 (86)), the Hydra represents a front-runner project, designed, developed, and launched into operation prior to any relevant regulatory development. Collaborative development, Classification Societies and R&D acceleration are key building blocks in the design, certification/approval and safe use of alternative fuels and power technologies. As experience and knowledge builds up and consolidates through the energy transition in shipping, it is expected that design options, safety risk evaluation and certification processes will become increasingly streamlined and robust, also allowing investment decisions in new technologies to become increasingly less risky. The energy transformation brings cross-sectoral challenges but also synergies and common opportunities. Shipping is expected to benefit from increasing experience with the use of new technologies across all economic sectors.

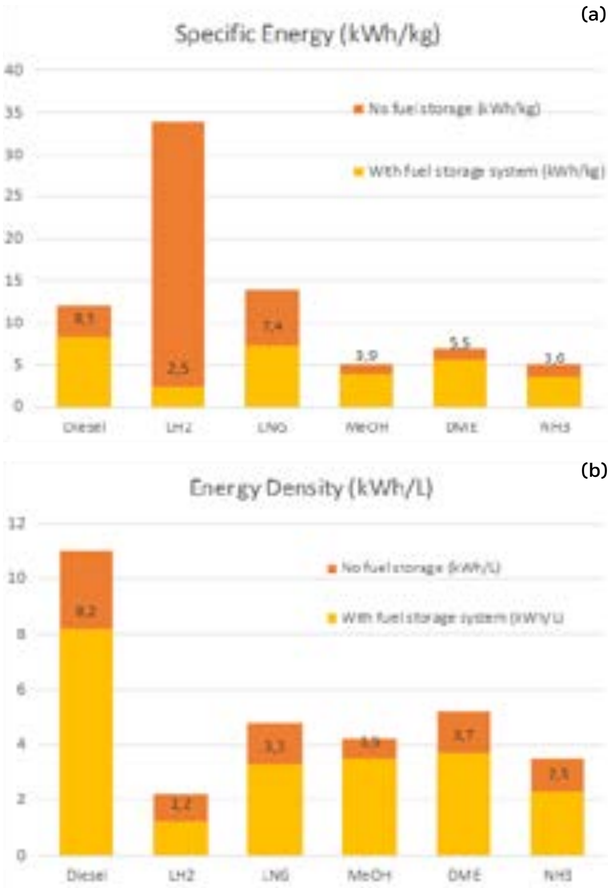
5.2.1.1 Main challenges

Some challenges are quite specific to the maritime transport sector. Apart from cost and the environmental/decarbonisation challenges, the following aspects are of critical relevance for shipping with respect to new energy systems:

- **Energy/ Power Density** – Alternative fuels and power systems have significantly lower energy and power density, in comparison to conventional systems. Their adoption leads to larger ships in the same operating profiles with higher design arrangement footprints for fuel storage, machinery spaces and associated systems. This is an important factor for consideration in the safety of ships using alternative energy/power technologies.

- **Safety** – The vast majority of alternative fuels, with most being either gaseous or low-flashpoint, or both, present different fire hazards. This leads to an immediate need for a conceptual redefinition of the conventional arrangement for onboard energy systems, from bunkering to fuel storage, including energy conversion/combustion and fuel preparation and distribution. Different fuels and power systems represent different challenges, but it is possible to establish a general safety concept approach to the mitigation of risks associated with the use of gaseous and low flashpoint fuels and associated power systems. This is represented by the 'safety layers' approach as per Figure 122.

Figure 121 (a) and (b): Specific energy and energy densities for different alternative fuel systems (with and without fuel storage systems – containment, tank, fuel preparation, inerting system).



Source: EMSA Services

Note: Alternative fuels abbreviations – liquid hydrogen (LH2) and liquefied dimethyl ether (DME),

With a view to determine the cost-efficiency of any specific safeguard, also known as 'risk control option', the Formal Safety Assessment approach can be followed.

Some alternative fuels and power systems, like ammonia or battery installations, for instance, have specific hazards other than gaseous fuels flammability/explosivity. The risk assessment methodologies are nevertheless the same, leading to the identification of relevant adequate risk control options, applicable to the specific arrangement and design under consideration.

Figure 122: Safety layers – safety concept for gaseous and low-flashpoint fuel applications.

Prevention		Mitigation – 1st layer		Mitigation – 2nd layer
Prevent release	1st Accidental event *Loss of containment*	2nd Containment barrier	2nd Accidental event *Ignition, exposure*	Fire detection
		Detection		Fire suppression/ extinguishing
		Avoid ignitable atmosphere		Damage control and impact mitigation
		Prevent ignition		Survivability strategies
		Prevent exposure		Acute toxicity exposure response

Source: EMSA Services

- **Integration** – Ships are complex systems which include within their hull and superstructures several hotel, cargo, and service spaces, often adjacent to machinery spaces and other service-purpose spaces. Design decision-making is often challenged by the need to optimise volume and area arrangements within the ship, maximising cargo areas or hotel with a view to increased profitability and revenue. Alternative fuels and innovative power systems require integration in the entire ship design, minimising safety risks requires often inventive and innovative approaches. Integration engineering is essential for the optimisation of all energy systems onboard and to enhance the safety, reliability and survivability of ships using alternative energy/power systems.

- **Operating profile** – Ships are designed and built according to a well-defined operating profile. This encompasses not only operational parameters, such as speed and autonomy, but also the area of operation.

The choice of alternative energy/power systems is directly affected by both angles of the operating profile. In that sense, both speed and autonomy play an important role in the definitions of 'energy' or 'power' sensitive designs. The former is designed for endurance while the latter is designed for speed or work. Figure 123 and Figure 124 show two examples of such designs, for an LNG-fuelled bulk carrier and a hybrid electric tug. In the bulk carrier, the fuel tank is located aft above deck and in the tug the battery groups are located below the main deck. In the first design, the need for a large amount of LNG fuel is directly related to the requirement for longer autonomy. In the second, the hybrid design decision relates to immediate high-power availability that can be withdrawn from the battery groups. The operating profile is therefore dictating the choice of energy system and the design of the fuel storage area. With alternative energy/power systems, the range of choices for design increases giving more options to naval architects today when compared to the conventional energy systems based on oil.

Figure 123: Tsuneishi Shipbuilding's LNG fuelled bulk carrier design – Kamsarmax GF.

Source: TSUNEISHI SHIPBUILDING Co.,Ltd.

Figure 124: Battery powered tug design – hybrid tug system - IHI Power Systems Co., Ltd.

Source: IHI Power Systems Co.,Ltd

In addition, the area of operation is another aspect related to the operating profile which is highly relevant to the choice of the alternative energy/power. The availability of alternative fuels is not supported by worldwide production and distribution and different fuels may be easier to obtain or bunker in specific locations. While this may now not present an issue with LNG, other alternative fuels face an uneven availability distribution in different regions and areas of operation. Thus, it is important to take into consideration the area of operation when deciding on an alternative fuel for a specific application. Electrification is also an energy solution for which the choice of region/ports of operation can be quite relevant. Unavailability of sufficient onshore power supply and charging infrastructure may dictate the choice for a different energy system.

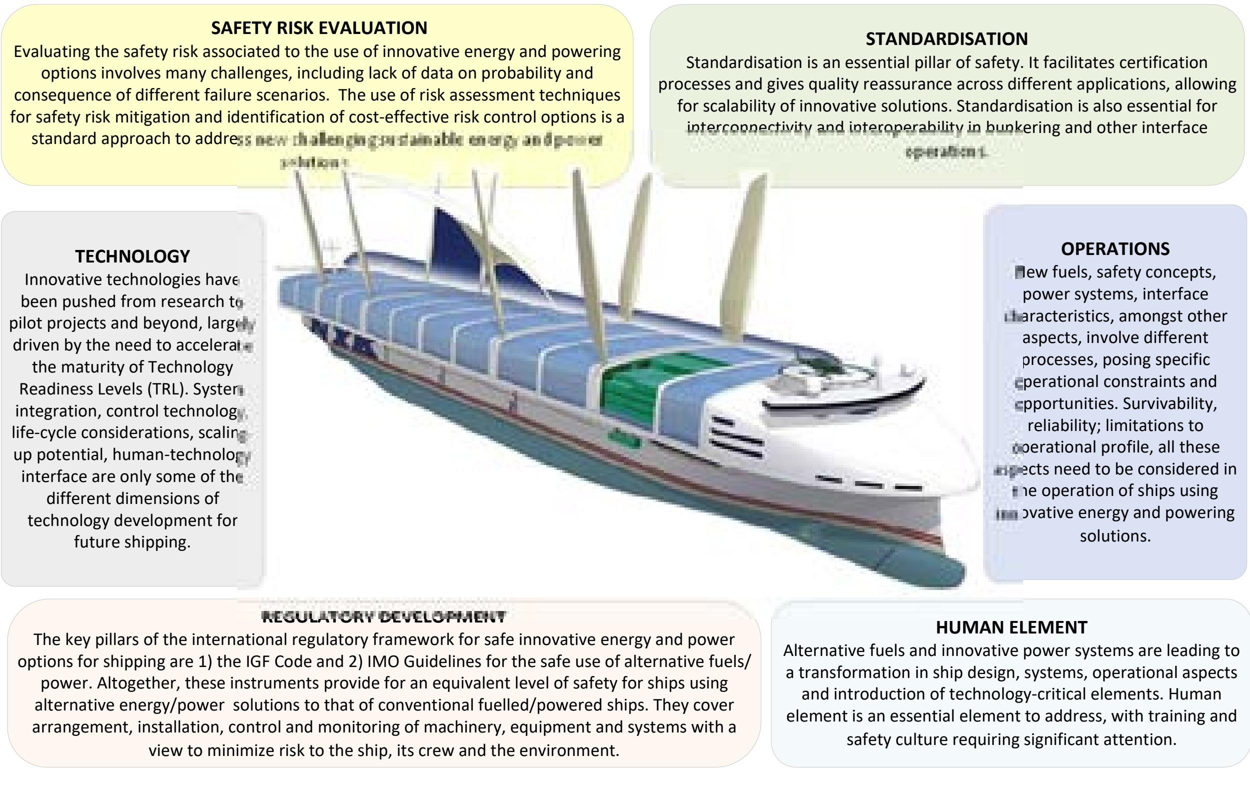
Each of the areas mentioned represents certain challenges for the adoption of alternative energy/power systems in maritime transport. The drivers for change and energy transformation are undeniably air pollution and GHG reductions, and the consequent societal pressure, but the safe adoption of such technologies is an equation with many variables.

5.2.1.2 Safety dimensions

Developing adequate criteria for safety is a prevailing challenge, multiplied by the number of different options available for fuelling/powering ships. Establishing a 'safety equivalency' with conventional fuelled/powered ships is not an easy exercise, especially following a century of experience with oil-based power. International standards are needed to ensure a harmonised development of the necessary safety equivalency criteria. Knowledge is still developing but it is important to ensure that risk assessment techniques and alternative design-based approval are an international common ground to promote safety.

Different dimensions should be considered for the safe use of alternative fuels and new powering technologies, which are, altogether, contributing to the mitigation of associated safety risks. Lower flashpoint, flammability and explosivity, toxicity, health hazards, pressurised and cryogenic storage, corrosivity, and reactivity are examples of the safety hazards that can be posed by different alternative energy technologies. Furthermore, safety hazards associated with integration and operation should be considered. The diagram in the figure below highlights the six selected dimensions to be taken into account when ensuring the safe use of alternative fuels and power technologies.

Figure 125: Six dimensions of the safe use of alternative fuels and powering technologies.



Source: EMSA Services

In the next subsections, different technology options for alternative fuels and powering systems are presented, together with their developing regulatory framework, highlighting for each the main challenges within the safety related dimensions presented before.

5.2.2 Alternative fuels

The introduction of alternative fuels poses new safety risks mostly related with their distinct chemical properties.

Hydrogen, for example, when stored as a liquid, needs to be kept at temperatures close to absolute zero. If there is a failure scenario involving loss of containment of cryogenic liquids, it might affect unprotected steel with brittle cracks, expand to hundreds of times its original volume and become flammable as it turns back to gas. In addition, there is the potential for an explosion if confined explosive atmospheres are formed and ignited. This would be a serious problem if it occurred below deck, where ships generally store their fuel and where the main structural elements are located. Moreover, hydrogen is also far easier to ignite than fossil fuels.

On the other hand, if methanol ignites, its flames are almost impossible to detect without specialised thermal imaging assistance. Indeed, all alternative fuel options with low-to-zero carbon content such as methanol produce a flame that emits light outside the visible range. Therefore, prevention, ventilation and detection principles need to apply. Buoyancy is another important characteristic of these fuels. Such fuel properties may require a radical change in routine ship design regarding such aspects as the position of venting and gas detection.

The current risk management framework is designed to meet the demands of traditional fuels. The properties that characterise alternative fuel options and the need for larger quantities onboard due to the before-mentioned generally lower energy density of those fuels, mean that the safety risks for crew, passengers and others can largely vary from those posed by fossil fuels. Safety standards will be achieved through risk-based development of relevant provisions to ensure that ships using alternative fuels are considered safety equivalent to conventionally fuelled ships. Onboard, more sophisticated risk mitigation measures are required, including specific equipment and safeguards. These require improved knowledge and skills to design, manufacture, inspect, install, commission, survey, operate and maintain.

The next sections present the technology, safety considerations and regulatory developments associated with the use of selected alternative fuels. The selection of alternative fuels is based on their current use in vessels in service like in the case of LNG and methanol, and the potential for their future use derived from results in R&D, pilot projects, and currently available literature. In addition to LNG and methanol, LPG, hydrogen, biofuels, and ammonia are included in the present section.

A summary table of the information related to the safe use of those alternative fuels is included in Annex 3.

5.2.2.1 Liquefied Natural Gas (LNG)

- **General**

LNG is understood as natural gas, given that compressed natural gas is of less relevance for maritime transport due to its energy density. The main component of liquefied natural gas (LNG) is methane (CH_4), the hydrocarbon fuel with the lowest carbon content with a boiling point of approximately −163°C at 1 bar of absolute pressure, LNG must be stored in insulated tanks. Natural gas is lighter than air and, following a possible spillage, it vaporises.

The energy density per mass (LHV in MJ/kg) is approximately 18% higher than that of heavy fuel oil (HFO), but the volumetric density is only 43% of HFO (kg/m³). This results in roughly twice the volume compared to the same energy stored in the form of HFO. Factoring in the shape-related space requirements, cylindrical LNG tanks typically occupy three times the volume of an equivalent amount of energy stored in the form of fuel oil.

The following images present some relevant examples of existing LNG fuelled ships and applications.

Image 15: LNG fuelled ultra large containership CMA CGM Jacques Saadé.

Source: CMA CGM/TOTAL

The 23,000 TEU capacity containership is the first of a new generation of large vessels using LNG as fuel, also innovative in the introduction of membrane containment system onboard ships other than LNG carriers. LNG bunkering of high LNG volumes at high transfer rates is made possible by ship-to-ship transfer. In the image the bunker vessel from TOTAL (MV Gas Agility), designed and put in service to assist specifically the CMA-CGM LNG fuelled containership fleet.

Image 16: NAUTICOR 7,500m3 LNG bunker vessel MV Kairos.

Source: Gasum Group. www.gasum.com

This ship is, to date, the largest in the sector, representing the growth in the need for LNG bunkering capacity. This ice-class bunker vessel also features a ballast-free design and an installed CNG tank to store vapor return gas produced during bunkering operations and received from supplied ships.

Image 17: AIDA Nova – first LNG fuelled cruise ship.

Source: Juanjo Martinez/Aida Cruises

Cruise ship with capacity for 5,200 passengers with an LNG capacity of 3,500m3 in Type C tanks located midship.

Image 18: MV Viking Grace – truck-to-ship LNG bunkering.

Source: Viking Line Abp

This RoPax has accumulated great experience in the use of this alternative fuels. The location of the tanks (aft, above deck) represents a conservative pre-IGF[79] approach, consuming typical accommodation/hotel space but aiming for reduction of safety.

Safety Concerns

The safety concept for the use of LNG as fuel onboard ships is based on the combination of strategies to ensure:

1) No loss of containment - should a loss of containment occur, the safety concept is based on the mitigation of ignition risk and protection of steel structures to avoid brittle cracking leading to structural failure.

2) No formation of explosive atmospheres (no NG-air mixtures) in piping or LNG fuel service equipment.

3) Avoidance of pressure build up at any point of the LNG fuel containment, preparation, and distribution system.

79 International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code)

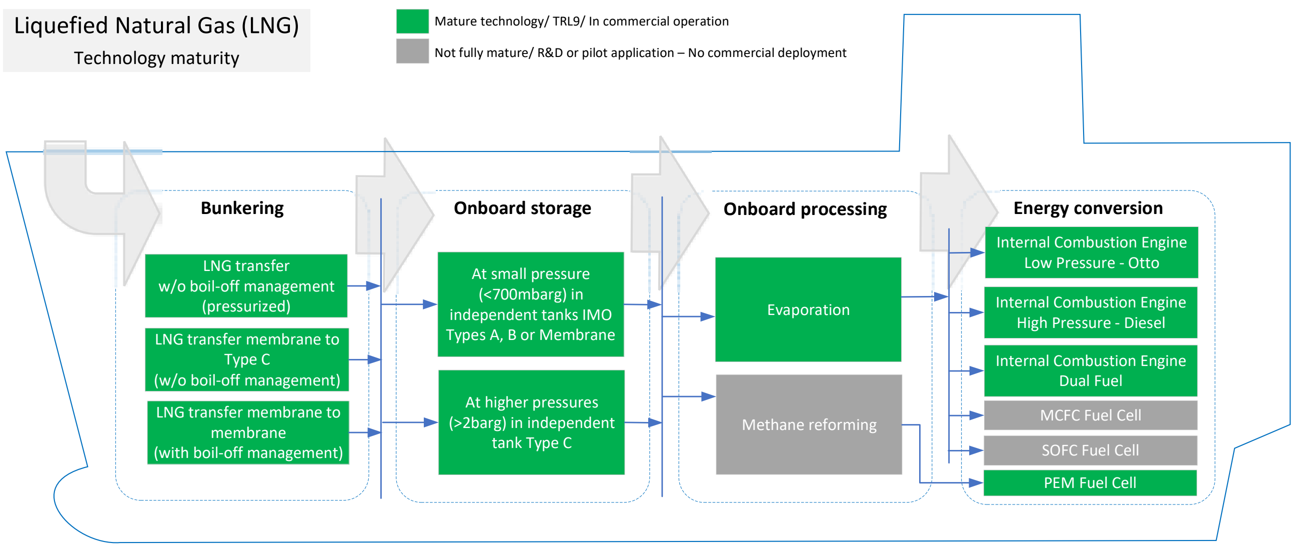
Technology

Significant technological development has taken place over the last 20 years in the context of LNG as fuel for maritime transport. Notwithstanding the long-standing experience with LNG as cargo, there was still a significant development curve with a view to integrate LNG systems into otherwise conventional ship designs and operating principles. LNG fuelled ships represent today more than the adoption of an alternative to oil fuelled ships; they represent a milestone of innovation which has become more pronounced since the adoption of the IMO Interim Guidelines for Ships with gas-fuelled installations, MSC.285(86), and culminating in the entry into force of the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) on 1 January 2017. The safety challenge has been addressed with the adoption of safety concepts already tested and put to proof in 'first-mover' ship installations.

Figure 126 illustrates the different technology blocks involved in a possible LNG fuelled installation on any ship type. The green and grey colour coding gives a qualitative indication of the maturity of the different technology blocks.

Table 39 provides a summary description of the present status of the different technology blocks, highlighting the main challenges involved in each of the identified blocks.

Figure 126: Technology blocks for the safe use of LNG as fuel.



Source: EMSA Services

Note: MCFC stands for molten carbonate fuel cells, SOFC stands for solid oxide fuel cells and PEM stands for proton exchange membrane.

Table 39: Summary description of the status of the main technology blocks for the use of LNG as fuel.

<table>
<tr>
<td>Bunkering</td>
<td>
LNG bunkering is today a mature, standardized operation which can take place in accordance with a variety of different arrangements: 1) Truck-to-Ship (TTS); 2) Port-to-Ship (PTS) or 3) Ship-to-Ship (STS), with the later gaining expression worldwide as the method with the best compromise between capacity and flexibility. With an excess of 1,000m3/h, STS bunkering has grown with a large number of bunker vessels being developed, in operation today close to the relevant ports visited and operated by LNG fuelled ships.
In assistance to safe LNG bunkering operations several standards and guidelines have been published which covered several aspects of interconnectivity and interoperability of LNG fuel transfer operations.
The key safety objectives in LNG Bunkering are:
1) Avoidance of leakages and formation of explosive atmospheres: To achieve this goal the LNG bunkering procedure is based on a well-defined sequence of events involving adequate LNG bunkering connection and hoses, inerting to displace air from inside the line prior to LNG transfer, initial cooling of the line to check for leakages and reduce thermal stresses and initial high boil-off generation, careful top-up, and final draining and inerting. The figure below presents the sequence of events during LNG Bunkering:

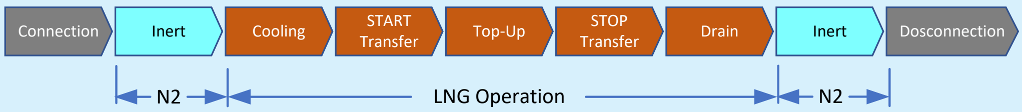


Figure A – LNG Bunkering process
Source: EMSA Services
2) Mitigation of Ignition risk: ensuring that, in the event of loss of containment in the bunkering line, the risk of ignition of a flammable vapour cloud release does not occur. For this purpose, during bunkering operations, a layered scheme of Hazardous Zone + Safety Zone are established. Inside the first only authorized and well-equipped personnel are authorized, together with the use of EX-proof material. In the second an effective access control should be exercised to avoid presence of potential hazards that have the potential to ignite an LNG dispersing vapour cloud, resulting from possible loss of containment during bunkering.
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<tr>
<td>Onboard storage</td>
<td>
LNG can be stored onboard in accordance with the relevant provisions of the IGF Code Sections, both for tank location and for containment system requirements.

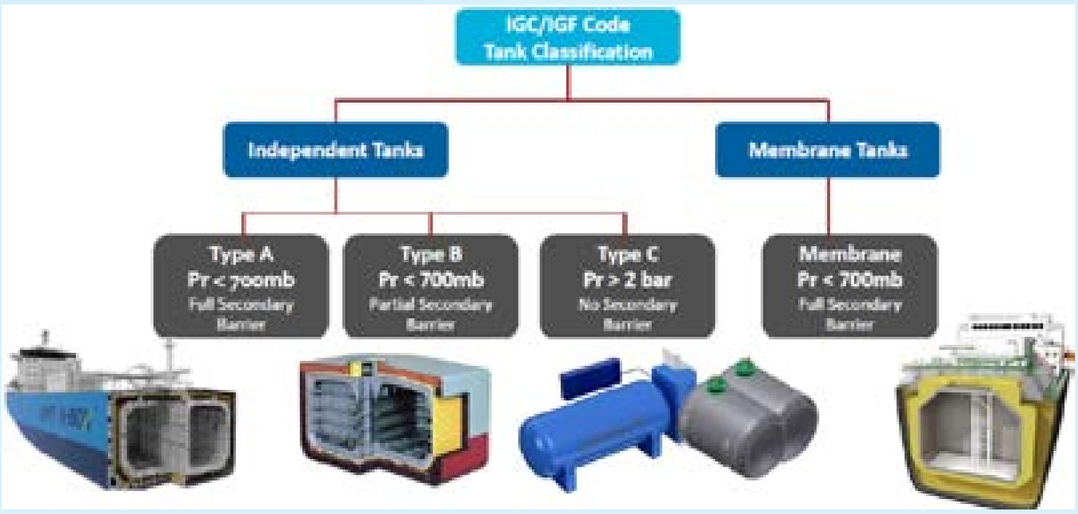

Figure B – LNG Storage – containment systems.
Source: [34]
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</tr>
</table>

Onboard Processing

Onboard processes associated to LNG preparation prior to use may include evaporation, expansion or even methane reforming for possible onboard hydrogen production.

Energy Conversion

Dual Fuel energy technology. Focus has been put on the identification of technology solutions which can mitigate the release of unburnt methane (methane slip). With Dual-Fuel 2-Stoke, High Pressure, engine technology currently holding the highest potential for possible to identify also other areas where further development is still needed on dual-fuel engine technology:

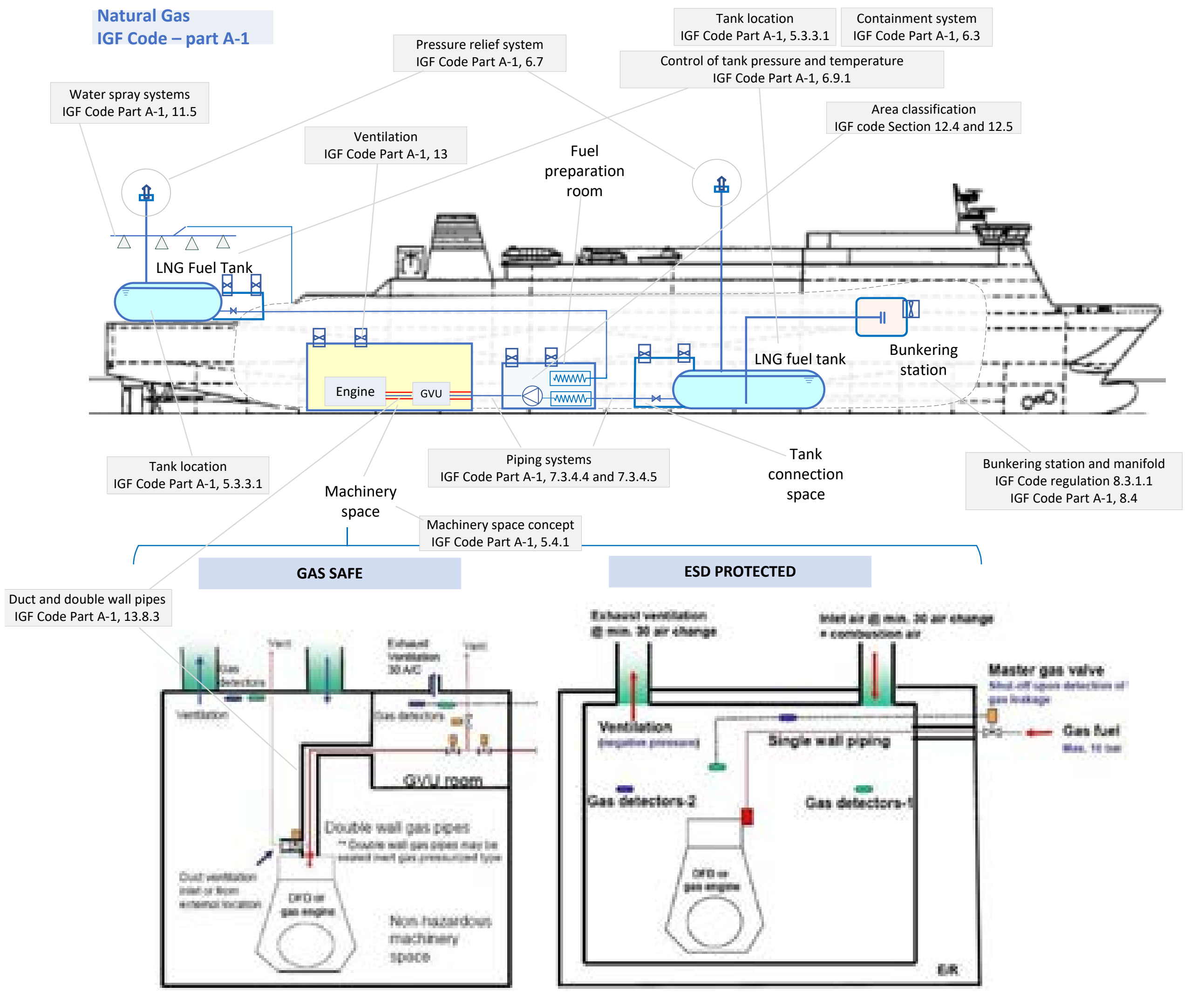
Energy Conversion Equipment	Operation	TRL	Efficiency	Safety Concerns
Dual-Fuel (DF)	Can operate on Gas and Liquid fuel Ignition by Micropilot fuel – typically 1-3% of the total fuel input At gas operation: Lean Burn – very lean mixture	9	47-50%	Internal combustion engines are a well-proven and mature technology. The addition of natural gas, either in dual-fuel or any other cycle arrangement, bring the added safety concerns of possible gas leakages on the fuel supply system. This can be at low or high pressure. To address this concern, two different machinery space concepts are defined: 1) Gas Safe and 2) ESD protected, as defined in the IGF Code/ Part A-1/5.4.1
Bi-Fuel (BF) Diesel cycle	Often converted to gas from corresponding diesel engine Can operate on Gas and Liquid fuel At gas operation: • Mixing of gas with intake combustion air – typically 15-50% of the total • fuel input is diesel • Lean Burn but not very lean mixture	9		
Spark-ignition Gas (SG) Otto cycle	Mono fuel Gas engine – Rich or Lean Burn – Ignition by spark plug – with very lean burn in a pre-chamber	9		
Gas-Diesel	Can operate on Gas and Liquid fuel At gas operation: Ignition by pilot fuel High pressure gas feed – typically pressure increase to 300 – 400 bar	9		
High-Temperature FC (MCFC, SOFC, HT-PEM))	High Temperature Fuel Cell can reform natural gas internally and use the resulting hydrogen as part of the electrical energy production process	7	60%	Safety concerns associated to High-Temperature operation and fuel reforming.
Low-Temperature FC (PEM)	Low temperature fuel cells, directly consuming hydrogen into electrochemical cell for electrical power production	9	40%	Safety concerns related to hydrogen storage and feeding process

Regulatory Development

The IGF Code Parts A-1, B-1 and C-1 contain all relevant provisions specific to the use of natural gas as fuel. In addition to the introduction on the code already provided in section 5.2.1.2, the diagram below includes a visual summary of the sections in the IGF Code relevant to LNG as fuel. The generic ship design presented is here only to provide an overview of the different functional groups typically present in an LNG fuelled ship design.

In addition to the IGF Code Part A, relevant standards have been published in the last 5 years which collectively contribute to the safe and sustainable deployment of LNG as fuel. Directive 2014/94/EU[80], currently under revision with a proposal to become an EU Regulation, has set the framework for enforcement of relevant standards for safety, compatibility, and interoperability. LNG bunkering operations (technical requirements and operation) are defined in ISO/TS 18683[81] an ISO 20519[82], while LNG bunkering connectors have just recently been standardised by ISO 21593:2019.

Figure 127: IGF Code – Diagram with application of the different LNG related Part A-1 provisions.



Source: EMSA Services in interpretation of the IGF Code

80 Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure

81 ISO/TS 18683 - Guidelines for systems and installations for supply of LNG as fuel to ships

82 ISO 20519 - Ships and marine technology — Specification for bunkering of gas fuelled ships

5.2.2.2 Hydrogen (H_2)

- **General**

Hydrogen (H_2) is a colourless, odourless, and non-toxic gas. For use on ships, it can either be stored as a cryogenic liquid, as compressed gas, or chemically bound.

The boiling point of hydrogen is very low: 20 Kelvin (−253°C) at 1 bar. It is possible to liquefy hydrogen at temperatures up to 33 Kelvin (−240°C) by increasing the pressure towards the 'critical pressure' for hydrogen, which is 13 bar. The energy density per mass (LHV of 120 MJ/kg) is approximately three times the energy density of HFO. The volumetric density of liquefied H_2 (LH_2) (71 kg/m^3) is only 7 per cent that of HFO. This results in approximately five times the volume compared to the same energy stored in the form of HFO. When stored as a compressed gas, its volume is roughly ten to 15 times (depending on the pressure [300 to 700 bar]) the volume of the same amount of energy when stored as HFO.

Hydrogen can be used in fuel cells to produce electrical power or, together with other fuels, in multi/dual-fuel internal combustion engine concepts.

The figures below present different examples where hydrogen as fuel is becoming a fuel solution.

Image 19: Hydrogen vessel Energy Observer.

Source: © Energy Observer Productions – Antoine Drancey.

An "ambassador" of hydrogen as fuel technology represents an expression of hydrogen technology integration, with onboard hydrogen production from electrolysis and subsequent storage in compressed hydrogen cylinders. Figure 128: Project for a hydrogen fuelled, 3.2MW fuel cell powered passenger ship, currently being designed by Havyard Design for the shipowner.

Figure 128: Project for a hydrogen fuelled, 3.2MW fuel cell powered passenger ship, currently being designed by Havyard Design for the shipowner.

Source: Havila Kystruten Operations AS

Image 20: MS Suiso Frontier – World's first LH_2 carrier.

Source: Kawasaki Heavy Industries, Ltd

First world LH_2 carrier, launched in 2019, with 1,250m^3 LH_2 cryogenic storage tank fitted in the end of 2020

Figure 129: HySeas III – the third development stage of EU funded project to deliver a ferry powered by hydrogen fuel cells.

Source: © HySeasIII

Safety Concerns

Hydrogen as fuel has seen its potential application in shipping deterred by three factors: low energy density; challenging onboard storage; and safety. While the first two factors are best addressed in the technology section, the part on safety is inevitably a key challenge based on the key hazardous properties of the fuel associated to its chemistry and to the fuel containment strategy adopted.

The key safety concerns relating to hydrogen as fuel are:

- **Flammability range and low ignition energy**. Compared with other flammable gases, it has a wider flammability limit (4-75% volume in air), and low ignition energy, leading to very high explosion risk in a large number of different hydrogen loss of containment scenarios. Not only the likelihood of having an explosive/flammable concentration is high, also the probability of ignition is significantly increased.

- **High flame velocity**. Its high flame velocity can result in detonation in confined spaces, with shockwave associated.

- **Low density and high diffusivity**. Hydrogen is a gaseous fuel much lighter than air. In reality, hydrogen has an even faster diffusivity potential (3.8 times faster than natural gas), which means that when released, it dilutes quickly into a non-flammable concentration. Though low density and high diffusivity of hydrogen may reduce the possibility of formation of a flammable atmosphere in open spaces, adequate ventilation is necessary for enclosed spaces where formation of hydrogen-oxygen/air mixture may occur.

- **Invisible flame** during combustion, leading to difficult identification of the real extent of the fire. Fire response/firefighting requires due consideration for this aspect, with fire responders having to be equipped with thermal imaging identification for adequate flame visualisation.

- **Permeability**. Given its minimal molecular size, hydrogen is able to permeate through containment materials, including carbon steel.

- **Containment hazards**. Given its molecular properties, hydrogen is typically stored at high pressures (up to 700 bar-g) or extremely low temperatures (-253°C, at ambient pressure) to achieve the necessary energy density. Depending on the containment strategies adopted, there may be safety specific aspects to consider:

Liquefied hydrogen (LH2)

- Liquefied hydrogen leakage (at near absolute zero temperature) can be catastrophic for unprotected steel structures (immediate loss of toughness and embrittlement of carbon steel);

- With large, unmitigated liquid hydrogen releases, hydrogen vapours can remain heavier than air for prolonged periods;

- Within the immediate vicinity of release, liquid hydrogen can liquefy/freeze air, resulting in O2 doping increasing its reactivity with hydrogen vapours.

Compressed hydrogen (CH2)

- Rupture of high-pressure hydrogen tanks releases a large amount of energy (not necessarily because of hydrogen but as a result of the containment pressures involved);

- High pressure releases (leakage, venting) can result in auto-ignition (spontaneous ignition);

- Ignition of high-pressure releases will result in jet fires.

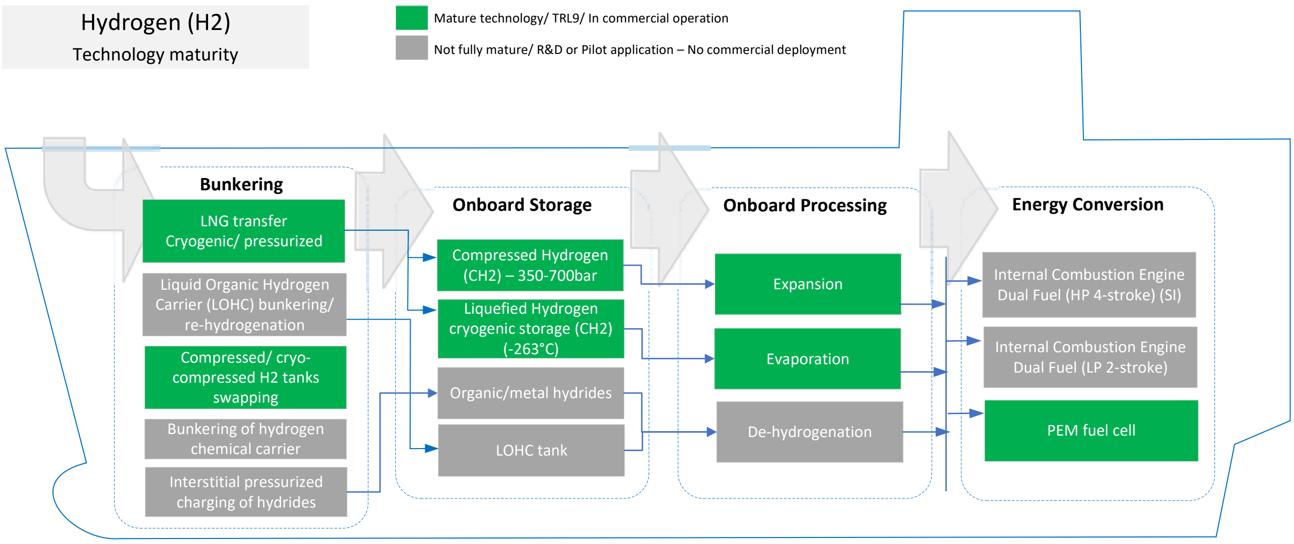
Technology

Hydrogen as fuel for maritime transport is not a mature technological framework. Several design challenges, stemming from low energy density, a challenging containment system and safety concept concerns, have posed several barriers to the uptake of hydrogen fuel as an energy carrier solution for shipping. R&D and dedicated financing have however pushed recently for the development of hydrogen-based solutions, with both applications of liquefied and compressed hydrogen storage, always involving the use of fuel cells for energy conversion.

As has been recognised in several design concepts and also in IMO MSC.420(97), the technology developed for LNG carriage represents an important step ahead in the facilitation of liquefied hydrogen solutions. The cryogenic nature of both fuels, the fact that they are both lighter than air in their gaseous form and the different technological options and safety concepts applied to the natural gas can all have conceptual relevance in the development of solutions for hydrogen fuel for shipping. Due consideration made to the intrinsic differences of hydrogen in comparison to natural gas, it is important to take the LNG as fuel experience as a facilitating block of hydrogen safety.

The figure below illustrates the different technology blocks involved on a generic possible hydrogen fuelled installation on any ship type. The green and grey colour coding gives a qualitative indication on the maturity of the different technology blocks.

Figure 130: Maturity diagram for hydrogen as fuel.



Source: EMSA Services

Table 40: Summary description of the technological maturity associated with the use of hydrogen as fuel.

<table>
<tr><td>Bunkering</td><td>
Bunkering rules for liquid hydrogen do not exist. Based on this, the ship side of the bunkering process will have to be approved following the alternative design approach as specified in IGF code. Current procedures for bunkering of LNG are based on cryogenic insulation to protect the ship steel from spills and leakages in the bunkering station and double piping when going inside the vessel. This, together with experiences for bunkering of liquid hydrogen onshore would form a knowledge basis for establishing the first requirements for bunkering of liquid hydrogen to a ship. It is uncertain to what degree the solutions developed for LNG will be feasible and applicable for liquid hydrogen. It is possible that N2 filling of voids/double pipes may be required or be necessary. A water curtain on the ship-side is required for bunkering of LNG according to IGF, and this is likely to be expected for LH as well.
Bunkering of chemical hydrogen carriers would have to take into consideration the specificities of the carrier itself. It is however expected that this approach could potentially have beneficial effect for the safety profile of the bunkering operation.
</td></tr>
<tr><td>Onboard Storage</td><td>
Storage: Hydrogen storage is today a significant area of discussion and research. An important fundamental note is that whilst hydrogen holds a high specific energy (MJ/Kg), its energy density (MJ/m3) is quite low. Thus, to carry a similar amount of energy onboard to that of hydrocarbons would require a very large tank volume. Compression and/or liquefaction are therefore the two strategies most commonly applied to achieve a satisfactory storage of energy for mobile applications. Research is ongoing in other areas and strategies for hydrogen storage, either chemically or physically. The tree diagram below includes the variety of possible onboard hydrogen storage media.

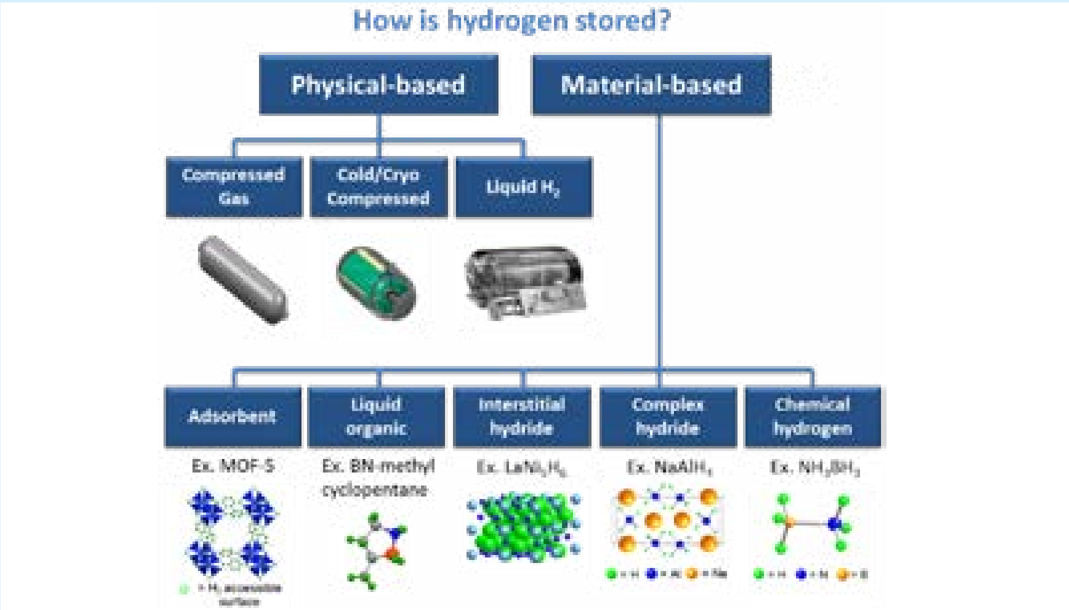


Figure A – Different possible hydrogen storage options.
Source: U.S. Department of Energy
</td></tr>
<tr><td>Onboard Processing</td><td>
Onboard processing will depend largely on the hydrogen fuel storage option adopted.
</td></tr>
<tr><td>Energy Conversion</td><td>
Power generation systems based on hydrogen may eventually be an alternative to today's fossil-fuel-based systems. While fuel cells are considered the key technology for hydrogen, other applications are also under consideration, including gas turbines or internal combustion engines in stand-alone operation or in arrangements incorporating fuel cells [14].
Hydrogen-fuelled internal combustion engines for marine applications are said to be less efficient than diesel engines. Hydrogen fuelled piston engines for ships are not available in the market. On land development is ongoing. Possibly larger-scale industrial and maritime applications combined with waste heat recovery solutions might be better suited for high-temperature technologies such as solid oxide fuel cells (SOFC) or even industrial systems using molten carbonate fuel cells (MCFC) [14].
Fuel cells combined with batteries (and possibly super capacitors) adding peak-shaving effects are a promising option. Even proton exchange membrane fuel cells (PEMFC), thanks to their flexible materials, could improve fuel cell lifetime significantly when protected against the harshest load gradients. SOFC must be applied in a hybrid environment using peak-shaving technology to be a realistic alternative for shipping [14].
Hydrogen as a fuel has been demonstrated in internal combustion engines, gas turbines, and fuel cells, all of which will play a role in marine power generation and propulsion systems.
</td></tr>
</table>

■ **Regulatory Development**

Hydrogen is a low-flashpoint fuel subject to the International Code for Safety of Ships using Gases or Other Low-flashpoint Fuels (IGF Code). There are however, currently, no specific prescriptive requirements for the use of hydrogen as fuel. For the time being, hydrogen as fuel solutions must follow the alternative design approach in accordance with SOLAS Regulation II-1/55 to demonstrate an equivalent level of safety.

IMO work on the Interim Guidelines for Safety of Ships using Fuel Cell Power Installations has been concluded at CCC7, with a view to be approved at MSC105 in 2022. With Fuel Cells being, by definition, hydrogen consumers, the finalization of these guidelines is an important mark in the regulatory framework for the use of hydrogen as an alternative fuel for shipping.

Resolution MSC.420(97), adopted in November 2016, Interim Recommendations for Carriage of Liquefied Hydrogen in Bulk, has been a recent IMO publication with important safety related elements and recommendation which are of great relevance also to the development of the framework for the safe use of hydrogen as fuel. MSC.420(97) is expected to play an important role not only in the preparation of future provisions for the IGC Code but also providing relevant elements for the safe use of hydrogen as fuel.

More recently, in MSC104, it has been agreed to task the IGF Working Group with the development of Interim Guidelines for the safe use of hydrogen as fuel. This is work expected to be already initiated in 2022.

5.2.2.3 Liquefied Petroleum Gas (LPG)

■ **General**

Liquefied petroleum gas (LPG) is by definition any mixture of propane and butane in liquid form. Specific mixtures of butane and propane are used to achieve desired saturation, pressure, and temperature characteristics.

Propane is gaseous under ambient conditions, with a boiling point of −42°C. It can be handled as a liquid by applying moderate pressure (8.4 bar at 20°C).

Butane can be found in two forms: n-butane or iso-butane, which have a boiling point of −0.5°C and −12°C, respectively. Since both isomers have higher boiling points than propane, they can be liquefied at lower pressure. Regarding land-based storage, propane tanks are equipped with safety valves to keep the pressure below 25 bar. LPG fuel tanks are larger than oil tanks due to the lower density of LPG.

The world's first two VLGCs powered by LPG were ordered in December 2017. A coastal passenger shipping company in the Republic of Korea has also conducted conceptual designs, in cooperation with shipyards, to operate the new coastal passenger ships that use LPG fuel in 2019 [15].

Despite the more convenient containment storage of LPG onboard, without the requirement of cryogenic liquefaction, LPG has limited application as fuel for ships other than LPG carriers. Provisions for the safe use of LPG as fuel are currently under development as part of the IGF Code development, with Interim Guidelines currently being drafted.

The images below present an existing LPG carrier, converted for the use of LPG as fuel.

Image 21: BW MV Gemini, 2020, after conversion to LPG as fuel.

Source: BW LPG

The conversion introduced 2 pressurized LPG tanks on main deck and included conversion of the main engine for LPG dual fuel operation.

Image 22: BW MV Gemini, LPG fuel tanks.

Source: BW LPG

Safety Concerns

The availability of representative Risk Assessments for the use of LPG as fuel is very limited. Reference is made to the Risk Assessment studies submitted to IMO CCC, just before the drafting of the Interim Guidelines for the Safety of Ships using LPG as fuel, from which the following can be extracted (Flammability and Explosion hazards similar to LNG and therefore not repeated here – only presented the LPG characteristic aspects).

- **LPG is heavier than air**. In general, LPG is heavier than air and may be present in liquid state at normal temperature. In particular, in order to reduce the risks associated with LPG fuel properties, LPG-fuelled ships should be given special consideration in comparison to the LNG-fuelled ships as follows, but not limited to:

1) arrangement of gas detectors and liquid detectors.

2) arrangement of equipment for use of liquid fuel.

3) arrangement of LPG engines and exhaust system due to low auto ignition temperature.

4) arrangement of mechanical ventilation system.

- **Auto-ignition temperature**. The auto-ignition temperature of LPG (490° C) is lower than that of LNG (580° C), which may require a lower surface temperature near electrical equipment. Compared to LNG, LPG has fewer challenges related to temperature because it is not cryogenically stored. But it has challenges related to higher density as a gas and a lower ignition range, with a lower flammability limit of about 2%.

- **LPG composition**. Since LPG composition may vary in the relative content of butane/propane, some safety characteristics, like the flammability range, may vary.

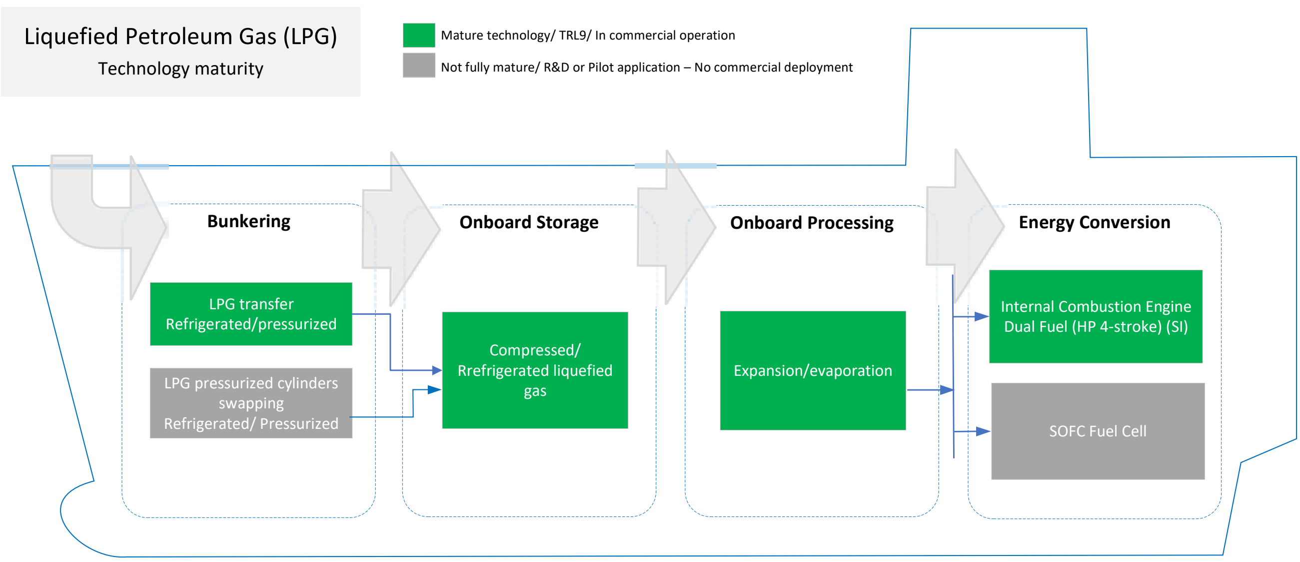
From a general perspective, in comparison to LNG, LPG has lesser concerns with respect to structural protection in case of a loss of containment. Without cryogenic storage temperatures, brittle fracture.

With temperature/pressure conditions for storage onboard similar to those applicable to Ammonia, LPG is also considered today as a technology with potential to facilitate the deployment of ammonia as fuel, irrespective of the other safety challenges associated to ammonia.

Technology

LPG as fuel for maritime transport is not widely applied and, apart from projects of LPG cargo as fuel, there are no other applications. The figure below, highlights the maturity owed to the experience with LPG cargo as fuel. Maturity is significantly reduced for applications other than LPG cargo as fuel, with no evidence of other ship types, operating or on order, using this fuel.

Figure 131: Maturity diagram for Liquefied Petroleum Gas (LPG) as fuel.



Source: EMSA Services

Table 41: Summary description of the technological maturity associated with the use of LPG as fuel.

Bunkering	LPG can be stored under pressure or refrigerated. It will not always be available in the temperature and pressure range a ship can handle. Therefore, the bunkering vessel and the ship to be bunkered must carry the necessary equipment and installations for safe bunkering. A pressurized LPG fuel tank is the preferred solution due to its simplicity, and because the vessel can bunker more easily using either pressurized tanks or semi-refrigerated tanks without major modifications.
Onboard Storage	The preferred way of storing LPG for use as propulsion fuel is in a pressurized tank at ambient temperature. Storage in a semi-refrigerated tank made of cheaper steel types than for LNG is also possible, but in order for such an arrangement to be sufficiently reliable, back-up systems must be in place to ensure low temperature in the tank. This makes pressurized tank storage a more reliable, affordable, and simple solution [16]
Onboard Processing	LPG requires Evaporation/Expansion process prior to use onboard.
Energy Conversion	There are three main options for using LPG as ship fuel: in a two-stroke diesel-cycle engine; in a four-stroke, lean-burn Otto-cycle engine; or in a gas turbine. Currently, only a single two-stroke diesel engine model is commercially available, the MAN ME-LGI series. In 2017, a Wärtsilä four-stroke engine was commissioned for stationary power generation (34SG series). This engine had to be derated to maintain a safe knock margin. An alternative technology offered by Wärtsilä consists in the installation of a gas reformer to turn LPG and steam into methane by mixing them with CO2 and hydrogen. This mixture can then be used in a regular gas or dual-fuel engine without derating [16].

Regulatory Development

LPG is a low-flashpoint fuel subject to IGF Code, even if for the meantime only the General Provisions of the Code apply, in the absence of LPG-specific provisions. For the time being, LPG as fuel solutions must follow the alternative design approach in accordance with SOLAS Regulation II-1/55 to demonstrate an equivalent level of safety

IMO work on the Interim Guidelines for Safety of Ships using LPG as fuel is currently underway, with an estimate for finalization at CCC9, in 2023.

5.2.2.4. Methanol (MeOH)

Methanol, with the chemical structure CH3OH, is the simplest alcohol with the lowest carbon content and highest hydrogen content of any liquid fuel. Methanol is a liquid between 176 and 338 Kelvin (−93°C to +65°C) at atmospheric pressure.

Due to its density and lower heating value (19.5 MJ/kg), methanol fuel tanks have a size approximately 2.5 larger than oil tanks for the same energy content. Methanol has a flashpoint of 11°C to 12°C and is considered a low-flashpoint fuel.

The pictures below illustrate two front-runner projects in the application of methanol as fuel, the Waterfront Methanol Tankers, and the STENA Germanica RoPax.

Image 23: Waterfront Shipping methanol fuelled tanker.

Source: Methanex Corpo ration

A series of methanol fuelled tankers have been put in service by this company in what can be characterized by the largest fleet application of methanol as fuel currently in operation.

Image 24: Methanol fuelled ship STENA Germanica.

Source: Stena AB

A 240 meter long, 51 000 GT RoPax, has undertaken retrofit conversion for the use of methanol as an alternative fuel under the project entitled "Methanol: The marine fuel of the future", a pilot action that was granted 50% support by the EC under the 2012 Trans-European transport network (TEN-T) multi-annual program.

Safety Concerns

Methanol as fuel for shipping has important safety concerns which are specific to alcohol fuels [17]:

- **Fire Safety**

  The following specific fire safety concerns can be highlighted for the use of methanol as fuel for shipping:

  - Flammability limits: 7 – 37 % methanol vapour concentration in air.
  - Flashpoint: 12°C.
  - Formation of explosive atmosphere inside the fuel tank – need to provide inerting to the fuel tanks.
  - Burn with clean flame (near invisible) requiring IR imagery support for effective firefighting/extinguishing. Installation of CCTV/IR is an important support safety instrument to mitigate the effect/escalation of methanol-based fires.

- **Material Compatibility**

  Methanol is more corrosive than ethanol; material compatibility issues of methanol fuels require modifications of engine fuel systems. Both elastomers (soft components used for seals and fuel lines) as well as metals, if not chosen properly, can be attacked by methanol [18].

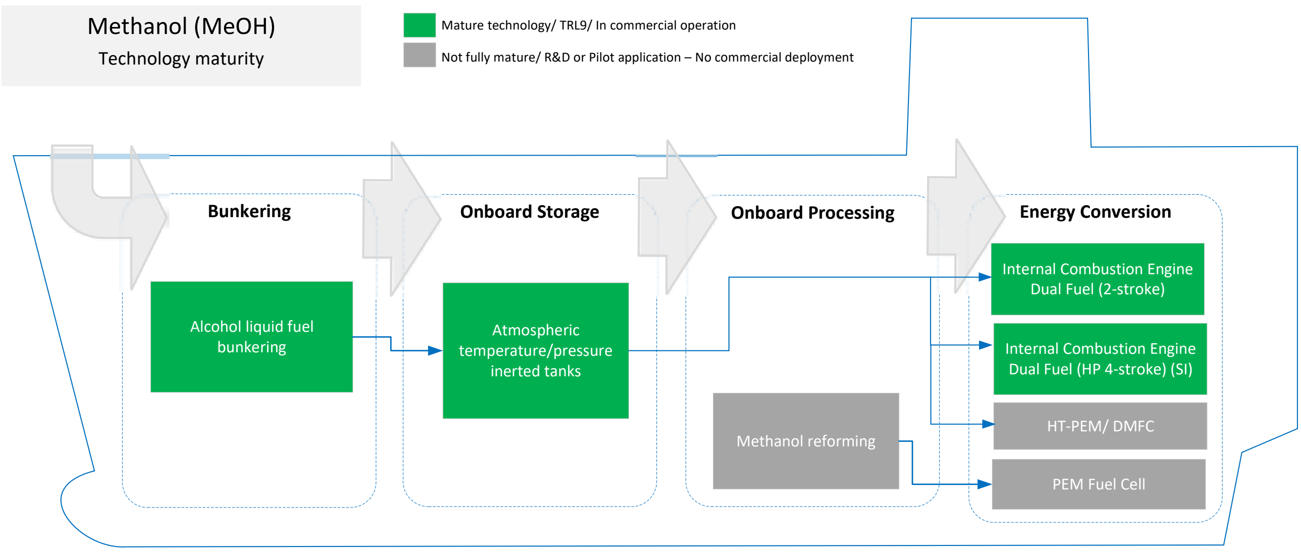
- **Toxicity**

  US OSHA[83] permissible exposure limit for general industry in air (40 h/week) is 1900 mg/m3 for ethanol, 900 mg/m3 for gasoline, and 260 mg/m3 for methanol. It is difficult to smell methanol in air at methanol concentrations less than 2,000 ppm (about 1500 mg/m3). Hence, the onboard fuel preparation, bunkering process, bunkering system and shore-side aspects related to fuel handling need to take this into special consideration.

Technology

Methanol as fuel is currently applied in a limited number of operating ships. Despite this, it is possible to confirm the technical maturity of the different technology blocks [17].

Figure 132: Maturity diagram for methanol as fuel.



Source: EMSA Services

83 Occupational Safety and Health Administration

Table 42: Summary description of the technological maturity associated with the sue of methanol as fuel.

Bunkering

Evidence in available literature of mature and proven technology for MeOH bunkering.

Current MeOH bunkering operations are limited to the small number of ships using methanol as fuel (1 RoPax + 4 chemical tankers). Arrangements for bunkering are customized and scalability is not yet prepared. Current bunkering infrastructure is dependent on specific supply contract

Table below is presented with the breakdown of the MeOH bunkering system [19] [17]:

System Component	TRL	Remarks
Mechanical ventilation and atmospheric control	9	If enclosed/ semi-enclosed bunkering station [19]
Control from safe location	9	
Pipes self-drained, arranged for inerting and gas freeing	9	
System for cargo and fuel segregation	9	Dependent on the ship type, relevant for chemical tankers [19]
Transfer coupling shall automatically close at disconnect	8	No standard exists for "dry-disconnect" even if technology is proven (aviation fuelling couplers") [19]
Monitoring and control systems – Emergency Shut-Down	7	No harmonized ESD for MeOH bunkering [19]

Onboard Storage

Due to its density and lower Energy Density (15.6 MJ/l), methanol requires approximately 2.5 times larger fuel tanks than MGO per energy unit. This value, considering containment system, is similar to that of LNG. There is however a shape factor with LNG type C tanks which make LNG containment systems more onerous in terms of internal volume requirements [20].

Storage of MeOH is done at atmospheric pressure and temperature and this is, indeed, the key advantage of MeOH as a quasi-"drop-in" fuel. The physical properties and chemical composition of MeOH lead however to the requirement for inerting of the fuel with a "nitrogen blanket". With low flashpoint (12ºC) and oxygen content in the molecule, the likelihood for explosive atmospheres to develop inside the fuel storage tank is high. Constant supply of inert gas needs therefore to be ensured. IMO Guidelines put a strong focus on this aspect [17].

Below, a simplified diagram illustrates the different blocks integrated in the Stena Germanica conversion for methanol fuel operation.

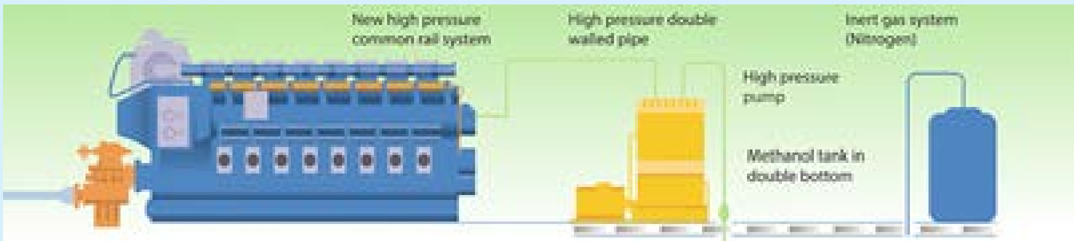


Figure A – Methanol fuel system – STENA Germanica.
Source: Stena AB

System component	TRL	Remarks
Arrangement for inerting and gas freeing, by nitrogen – constant atmosphere monitoring at cofferdam spaces.	8	Monitoring of Inert Gas blanketing is fundamental to ensure mitigation of explosion hazard inside the fuel tank.
Materials – Corrosion	8	There is still experience building up regarding the compatibility of certain materials, especially in high pressure fuel systems, pump seals, gaskets and other materials proven to be more sensitive to corrosivity and low lubricity of MeOH [19].
General structural arrangement for secondary barrier and cofferdam	9	
Filtering of Methanol	9	Especially for chemical tankers with Methanol fuel service tank.
Fire detection – IR CCTV	7	Visibility of MeOH flames is very
Fixed foam fire extinguishing system	9	For fuel tanks on weather deck

<table>
<tr><td>Onboard Processing</td><td colspan="3">No particular onboard processing is required, except if Methanol Reforming is used for the onboard production of hydrogen.</td></tr>
<tr><td rowspan="6">Energy Conversion</td><td colspan="3">There are two main options for using methanol as fuel in conventional ship engines: in a two-stroke diesel-cycle engine or in a four-stroke, lean-burn Otto-cycle engine. Only one single two-stroke diesel engine type is currently commercially available, the MAN ME-LGI series, which is now in operation on methanol tankers. Wärtsilä four-stroke engines are in operation on board the passenger ferry MV Stena Germanica. This engine, in contrast to the MAN ME-GI series, can inject liquid low flashpoint fuels such as MeOH. In order to use methanol in a dual-fuel combustion mode, the cylinder covers need to be equipped with fuel-booster injection valves that can inject liquid methanol into the cylinder at about 600 bar.</td></tr>
<tr><td>Energy Conversion Technology</td><td>Technology / system components</td><td>Remarks</td></tr>
<tr><td>Dual Fuel Internal Combustion Engine (DF ICE), HP

(2-stroke)</td><td>Dual fuel – Conventional fuel

together with low flashpoint liquids methanol, ethanol, LPG,

gasoline, or DME possible.</td><td>Technology is the most versatile for possible retrofit projects, making use of existing 2-stroke engine blocks.</td></tr>
<tr><td>ICE, 4-stroke (SI)</td><td>Lack of maturity in the 4-stroke technology, with no current maritime applications.</td><td>-</td></tr>
<tr><td>Fuel Cell – HT-PEM</td><td>High temperature PEM with possibility for internal reforming of MeOH.</td><td>Already some applications in pilot project (MV Viking Lady).

High potential for FC improved efficiency.</td></tr>
<tr><td>Fuel Cell – PEM</td><td>Needs external reforming and is very sensitive to hydrogen impurities.</td><td>Ideal application for lower power requirements and safety critical environment.</td></tr>
</table>

Regulatory Development

IMO finalised the interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel (MSC.1-Circ.1621), adopted at MSC102, in 2020. These guidelines allow experience to be gained with the application of the relevant provisions on the different areas covered.

With the approval/publication of the guidelines, ships installing ethyl/methyl alcohol fuel systems will need to individually demonstrate that their design meets the interim guideline requirements. Until now, the alternative design approach as outlined in IMO MSC.1/Circ.1455 (guidelines for the approval of alternatives and equivalence as provided for in various IMO instruments) has been the instrument to certify ships using alcohols as fuel.

Despite the good development with the publication of the Interim Guidelines, there are still relevant aspects which remain as gaps/challenges to be addressed from a regulatory perspective:

Fire detection and extinction

Current provisions of the IMO Guidelines for ships using alcohols as fuels do not cover sufficiently the aspects related to fire detection by visual aids such as IR imagery [21]. Due to the properties of a methyl alcohol fire, it is currently not known whether currently prescribed detection methods are effective. Equally, the extinction of a methanol fire may pose specific issues such as the ability of the person extinguishing a fire not being able to see the flame or the possibility that extinction may not be effective. Issues for specific fire suppression systems are as follows:

- Alcohol resistant foam: may not cover the edges of a fire and continue to burn.
- CO2: Re-ignition after space ventilation is distinctly possible if surfaces have not been cooled sufficiently.
- Water based systems: in order to use the dilution effect to make the material non-flammable large quantities are needed.

- **Vapour Detection**
  - Needed guidance on calibration of MeOH detectors,
  - Another gap related to vapour detection is the reliability of detection under high air flow conditions
- **Standardization/ Interoperability/ Interconnectivity**

  Missing standards on:

  1) Specification/Quality of MeOH as a marine fuel
  2) Standard specification for MeOH connectors
  3) Inert Gas generator quality and control systems

5.2.2.5 Ammonia

- **General**

Ammonia is a compound of nitrogen and hydrogen and at atmospheric temperature and pressure is a colourless gas with a characteristic pungent smell. At higher pressures ammonia becomes a liquid, making it easier to transport and store. It is a widely used and available chemical, notably used for fertilizer.

Ammonia has higher energy density by volume than hydrogen and can be liquefied at 8.6 bar at ambient temperature, which makes it easy to store on board the vessel. It is commonly stored at 17 bar to keep in a liquid state, even when the surrounding temperature increases.

The atomic composition of ammonia, with three hydrogen atoms, and with no carbon, has made ammonia a candidate fuel in a context of international goals for decarbonization of maritime transport.
The increasing attention of ammonia as a potential alternative fuel for shipping has recently culminated with several calls[84] to MSC104 and CCC7 (see following part on Regulatory Development).

Figure 133: MV Viking Energy/ShipFC EU funded ammonia fuelled project.

Source: ShipFC/Eidesvik Offshore ASA

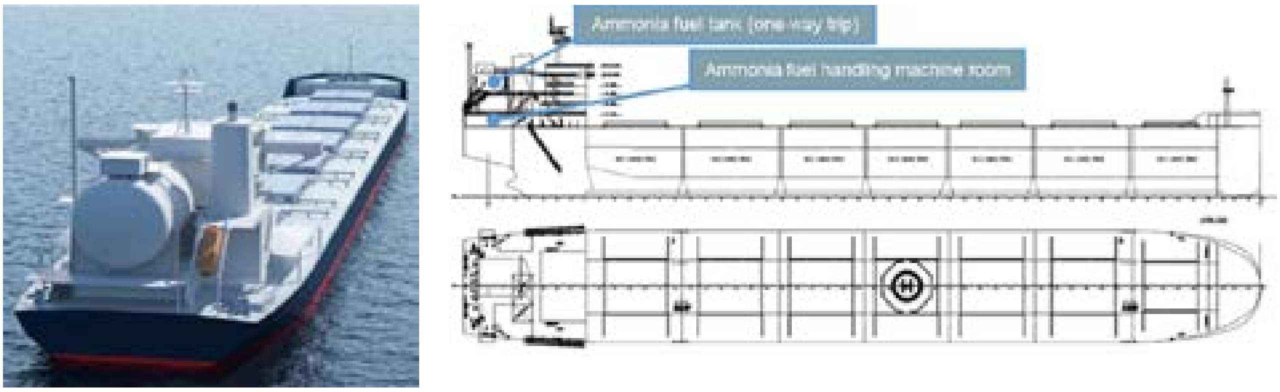
Application of a large direct ammonia fuel cell (DAFC) designed to deliver total electric power to shipboard systems. A significant part of the project is the scale up of a 100 kW fuel cell to 2 MW. First ammonia fuel cell to be deployed on a ship.

Figure 134: Renderisation of a Norwegian project for an ammonia fuelled bulk carrier.

Source: Viridis Bulk Carriers AS

84 Submissions to MSC104: MSC104/15/9, 10, 11

Figure 135: Renderisation of a project for an ammonia fuelled bulk carrier[85].



Source: Japan's Ministry of Land, Insfrastructure, Transport and Tourism, Roadmap for Zero Emissions of International Shipping, March 2020

Large, pressurized ammonia tank located just aft of the superstructure. Ship Design in IMO submission paper (MSC 104-15-10 – Hazard Identification of ships using ammonia as fuel. The specific case, for an ammonia fuelled bulk carrier, has been presented as a support case to promote the initiation of the drafting exercise of interim guidelines for the safety of ships using ammonia as fuel.

Safety Concerns

Ammonia has very particular safety considerations. The list below highlights the main aspects to take into account for the safe use of ammonia as alternative fuel onboard ships [22]:

- **Flammability**. Ammonia is a flammable gas. Ammonia flammability limits are: Lower flammable limit: 15% by volume; Upper flammable limit: 28% by volume in the air, it can be ignited easily and poses an explosion hazard. under certain conditions can be a fire and explosion risk and hence safety concepts need to consider both toxicity and fire/explosion risks. The autoignition of ammonia will occur at 650oC. Potential for boiling liquid expanding vapour explosion (BLEVE) if exposed to heat. At high temperatures, ammonia can decompose into a flammable gas, hydrogen, and toxic nitrogen dioxide.

  To fight ammonia fire, suitable media are water spray, alcohol-resistant foam, dry chemicals or carbon dioxide. When ammonia is released into the air, the best option is to spray it with water as ammonia can dissolved in water.

- **Toxicity to Humans**. In low concentrations, ammonia can be irritating to the eyes, lungs, and skin and at high concentrations or through direct contact it is immediately life threatening. Symptoms include difficulty breathing, chest pain, bronchospasms, and at its worst, pulmonary oedema, where fluid fills the lungs and can result in respiratory failure. Skin contact with high concentrations of anhydrous ammonia may cause severe chemical burns. Exposure to the eyes can cause pain and excessive tearing, in addition to injury to the corneas. Acute exposure to anhydrous ammonia in its liquid form can cause redness, swelling, ulcers on the skin, and frostbite. If it comes in contact with the eyes, it can cause pain, redness, swelling of the conjunctiva, damage to the iris and cornea, glaucoma, and cataracts.

  Repeated or prolonged exposure on the skin will cause dermatitis.

  Due to these toxicity issues, ammonia is therefore classified as a hazardous substance and exposure levels and time of exposure controlled through a number of national standards, typically setting Permissible Exposure Limits (PEL) of approximately 50 ppm, Recommended Exposure Limits (REL) of 25 ppm and identifying the Immediate Danger to Life or Health (IDLH) limit at 300 ppm.

- **Corrosivity**. Ammonia is incompatible with various industrial materials, and in the presence of moisture reacts with and corrodes copper, brass, zinc and various alloys forming a greenish/blue colour. Ammonia is an alkaline reducing agent and reacts with acids, halogens, and oxidizing agents.

- **Reactivity**. Can react violently with certain chemical and material if exposed.

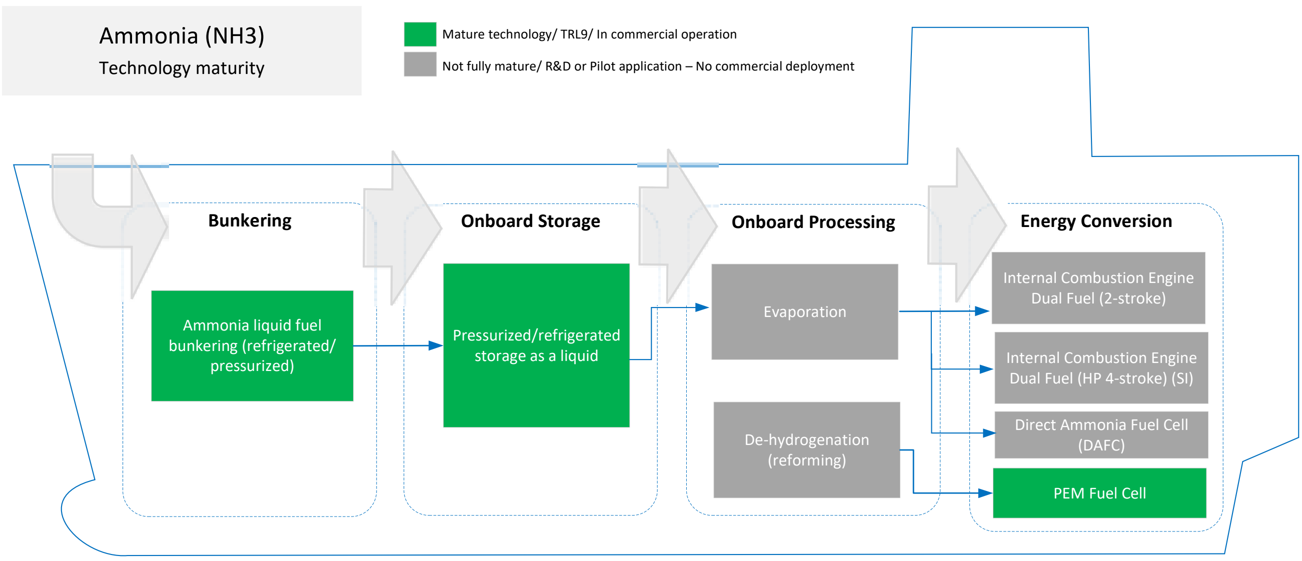
85 https://www.ammoniaenergy.org/articles/maritime-ammonia-ready-for-demonstration/

Despite being well known as a chemical substance, ammonia is only now receiving attention as a fuel. It is important to develop relevant hazardous scenarios where ammonia properties can be addressed with relevant safeguards designed and put in place with a view to achieve an equivalent safety design to existing conventional fuels. The entire safety concept for the safe use of ammonia is new and requires adaptation of the wider maritime community to the development of new processes and procedures with a view to mitigate the risk of potentially severe occupational accidents. The definition of relevant concepts such as “toxicity risk zones” will play an important role in the integration of safety in design.

Technology

The maturity of the technology framework for ammonia as fuel is very low. There is no commercially operating vessel using this alternative fuel. Despite this, several shipowners and shipping companies have brought to public recently their plans to adopt this alternative fuel in the short-to-medium term. With several technology blocks still with low maturity, it is expected that development and R&D will intensify over the next 5 to 10 years with a view to increasingly and safely deploy ammonia as fuel for maritime transport [22].

Figure 136: Maturity diagram for ammonia as fuel.



Source: EMSA Services

Table 43: Summary description of the technological maturity associated with the use of ammonia as fuel.

Bunkering	The lack of a bunkering infrastructure represents a barrier for using ammonia as an alternative marine fuel and is likely to remain a barrier for a long time while the technology is further investigated and developed.
Onboard Storage	It has higher energy density by volume than hydrogen and can be liquefied at 8.6 bar at ambient temperature, which makes it easy to store on board the vessel. It is commonly stored at 17 bar to keep in a liquid state, even when the surrounding temperature increases [20]. The storage of ammonia onboard is considered feasible in any containment system otherwise designed and prepared to store LPG. With similar refrigeration/pressurization, ammonia is considered, from a physical point of view, as a less challenging gaseous fuel to contain. From a toxicity risk mitigation perspective, the storage of ammonia fuel will have to consider the relevant safeguard measures with respect to venting, tank connections and fuel preparation.
Onboard Processing	Evaporation/ Expansion are the key onboard processes to condition the fuel prior to its use.
Energy Conversion	The EU-funded project ShipFC, involving retrofitting of the Viking Energy, an offshore support vessel, with a 2-MW fuel cell using ammonia, is scheduled for completion in 2023, the project will test the feasibility of using sustainably sourced, ammonia in a SOFC system on a commercial ship. The use of Fuel Cell technology for ammonia as fuel requires either external reforming, for onboard production of hydrogen, or internal reforming in FC technologies such as Direct Ammonia FC or SOFC. However, it appears that the ICE can be considered as best option as it has high efficiency and is sufficiently practical. However, in the future further development of fuel cell technology might change this evaluation [23]. Reviewing the ammonia powered option of the ICE with the conventional HFO option the technical performance is similar on power density, load response, part load performance, coping with marine environment and system efficiency [23]. The engine manufacturer MAN recently introduced the ME-LGIM engine, which was designed to operate on a DF combustion mode with methanol and diesel. The same engine can be used with ammonia instead of methanol with slight modifications to the fuel-delivery system to supply ammonia at 70 bar and inject it into the cylinder at 600–700 bar. Experimental studies have shown that combustion with ammonia results in similar or lower NOx formation than diesel, and two to six times lower CO_2. However, it can result in some ammonia slip if it is injected into the cylinder during the exhaust valve event. The high-pressure direct-injection systems used in DF engines, such as the MAN ME-LGIM, can inject fuel late in the compression stroke to avoid ammonia slip. Wärtsilä has already successfully tested an Otto cycle an engine running on a fuel mix containing 70% ammonia, and they target to the testing of engines on 90-95% ammonia using the diesel cycles. At time of writing no ammonia-powered demonstration vessel has sailed yet, but several consortia have already initiated projects that should lead to ammonia-powered vessel demonstrations by 2023/2024 (see Table below). [22]

Company / project	Engine	Ship	Type of pilot	Start year	Remarks
Wärtsilä, Knutsen, Repsol, Sustainable Energy Catapult Centre.	Four-stroke combustion engine	Unknown	Test	2021	Source: [22]. Long-term and full-scale testing.
Wärtsilä, Samsung Heavy Industries [86]	Four-stroke auxiliary engines	Newbuilds	Development programme	2023	Agreements signed in 2021.
MAN, Samsung Heavy Industries [87]	Two-stroke engine	Oil tanker	Demonstration project	2024	
Equinor, Eidesvik, Prototech [88] (ShipFC project)	Fuel cell system	Offshore supply vessel	Demonstration project	2024	The Viking Energy, use of both LNG and ammonia, 2 MW fuel cell.
ShipFC project.	Solid oxide fuel cell system.	Commercial ship	Test	unknown	Source: [22]

86 https://www.wartsila.com/media/news/22-09-2021-wartsila-and-shi-agree-to-collaborate-on-ammonia-fuelled-engines-for-future-newbuilds-2978445

87 https://www.ammoniaenergy.org/articles/the-maritime-sectors-ammonia-learning-curve-moving-from-scenario-analysis-to-product-development/

88 https://www.bbc.com/news/business-54511743

Regulatory Development

Despite the low maturity of ammonia as fuel, the attention given at international level to this potential alternative fuel for shipping has led to significant pressure for regulatory development.

One of the key questions recently addressed is related to which should be the adequate instrument to host the provisions for the safe use of ammonia as fuel: should ammonia as fuel be under the IGF Code?

The goal and functional requirement-based structure of the IGF Code previously highlighted, together with the clear path to approval of fuels not directly covered by the prescribed requirements using the 'Alternative Design' process, means the IGF Code has the right framework for approval of all gases and low flashpoint fuels.

The protective tank location criteria, cryogenic and pressurized fuel containment and distribution requirements, the double barrier concept for fuel supply piping, the use of ventilation and gas detection methods to detect leaks and mitigate them increasing to LEL (Lower Explosive Limit), hazardous area classification, together with requirements for training, PPE and operational measures, is a strong set of safety concepts that are very transferrable to other gases. In the case of ammonia, this suite of requirements can be applied to reduce the likelihood and mitigate accidental releases based on toxicity levels, i.e., ppm levels, rather than the percent (%) levels required for fire and explosion protection with methane.

The IGF Code can be underlined as the most appropriate IMO instrument to deal with ammonia as a fuel until such time as IMO develops non-mandatory guidelines or amends SOLAS instruments to cover application.

Ammonia can sometimes be quoted as having a relatively high flash point of approximately 132C. However, many property data tables do not quote flashpoints for gases because the flashpoint testing is applicable to closed cup liquid hydrocarbon testing, and the flammability range, autoignition temperature and ignition energy level are more relevant to determining the fire and explosion risk of a particular gas, and hence determine the appropriate safety mitigation.

This flashpoint characteristic of ammonia has been the core argument of a submission to IMO by Japan, Singapore, ICS and Intercargo in their paper MSC 104/15/9. In that document a new output is proposed and the question on flashpoint of ammonia, and applicability under the IGF Code is raised. Toxicity and corrosivity are raised as the main safety risks and the paper provides an update of R&D activities in progress. The paper invites the MSC to add the development of non-mandatory guidelines for ships using ammonia as fuel to the CCC agenda to commence at CCC 8.

In preparation for the CCC 7 session in September 2021, the EU Member States submitted paper CCC 7/3/9 commenting on the report of the IGF Code correspondence group report. This paper also recognised the need to prioritize the IGF Code activities, if necessary, by allocation of more resources, and highlighted the need to urgently develop requirements for hydrogen and ammonia. The paper proposed that hydrogen and ammonia are separate contenders for zero and low carbon future fuels and the requirements could be developed in parallel. The paper suggests the development of separate guidelines for hydrogen and ammonia to be added to the Terms of Reference for the IGF Code work and correspondence group. The authors of this paper clearly believe the development of IMO's ammonia as fuel guidelines should fall under the scope of the IGF Code.

Both proposals mentioned above, following deliberations at MSC104, have given the start signal for the IGF Code Working Group to initiate work on development of interim guidelines for the safe use of ammonia as fuel. This is work expected to take place in parallel with the work on safety provisions for the use of hydrogen as fuel.

5.2.2.6 Biofuels

Biofuels are included in the present report in the strict scope of "drop-in" liquid biofuels used in replacement of existing oil-based diesel distillates. These are fuels often treated as pure and simple replacement products for oil fuels, but it is important to carefully consider their characteristics with a view to identify potential challenges with safety impact in their use as alternative fuels.

The table below identifies the potential of different biofuel/biodiesel products, with the indication of their potential to replace existing oil fuels and/or to blend with existing oil fuels.

The key safety concerns associated with the use of biofuel products replacing oil diesel are [24]:

- **Fire Safety**

  Fuel similar fire hazard characteristics between FMAE, HVO and SVO when compared with MDO.

  Fire Hazards may however have to be considered as a consequence of possible material incompatibility or degradation of any components throughout the fuel supply system.

Biodiesels contain no hazardous materials and is generally regarded as safe. A number of studies have found that biodiesel biodegrades much more rapidly than conventional diesel. Users in environmentally sensitive areas such as wetlands, marine environments, and national parks have taken advantage of this property by replacing toxic petroleum diesel with biodiesel [25].

Like any fuel, biodiesel will burn; thus, certain fire safety precautions must be taken as described in this section. Of much greater concern are biodiesel blends that may contain kerosene or petroleum diesel. Kerosene is highly flammable with a flash point of 38°C to 72°C (100°F to 162°F). Diesel fuel is generally considered flammable—its flash point is 52°C to 9°C (126°F to 204°F). The flash point of biodiesel is required to be greater than 93°C (200°F), so is considerably less dangerous. However, biodiesel blends will have flash points in between diesel and biodiesel. The U.S. Department of Transportation considers a blend flammable, and the Resource Conservation & Recovery Act of 1976 considers it to be ignitable if the flash point is lower than 60°C (140°F) or combustible if the flash point is 60°C to 93°C (140° to 200°F) [25].

Table 44: Potential for blending/drop-in of different biofuels.

	FAME (Fatty Acid Methyl Ester)	HVO (Hydrogenated Vegetable Oil)	SVO ((Straight Vegetable Oil)
Potential for Blending/ Drop-in	**LOW** According to ISO8217:2017[89] maximum blending of 7%. Maximum blending % to mitigate potential risk of hygroscopic-based safety/compatibility issues with engine operation. **Maximum blending: 7%**	**HIGH** Due to molecular compatibility with fossil and FT diesel, HVO biodiesel can be blended in any %. Typical designation for HVO biodiesel gives indication. **Maximum blending: 100%.**	**LOW** It is unlikely that vegetable oil could be blended with HFO. Risk of emulsions is high with strong hygroscopic potential attracting water to the fuel would have high safety/ operation implications. **Maximum blending: N/A – Not blendable with oil products – but can replace HFO in existing installations.**

89 ISO 8217:2017 - Petroleum products - Fuels (class F) - Specifications of marine fuels.

- **Material Compatibility**

FAME biodiesel is an ester, which may cause problems in some motor engines. This is why the use of traditional biodiesel is still limited to a maximum concentration of 7% in Europe (based on EN 590 diesel standard), and up to 20% in other parts of the world, varying from country to country and state to state. Any higher concentrations can cause problems, such as damage to the rubber and plastics parts in the fuels system or carbon build-up in the engine. Traditional biodiesel can also absorb water, which may result in microbial growth in the fuel tank during storage.

Unlike gasoline, petroleum diesel and biodiesel may freeze or gel at common winter temperatures; however, biodiesel's cloud point (the temperature at which crystals begin to form) can be significantly higher than that of petroleum diesel. If the fuel begins to gel, it can clog filters and eventually become so thick that it cannot be pumped from the fuel tank to the engine.

Soy biodiesel, for example, has a cloud point of 0°C (32°F). In contrast, different petroleum diesels have a wide range of cloud points. Petroleum diesel cloud points can be as low as -45°C (-49°F) or can be higher, such as -7°C (19°F), depending on time of year and region of the country. Blending of biodiesel can raise the cloud point above that of the original diesel fuel, depending on the starting cloud point of the diesel fuel. For example, a recent study showed that when soy biodiesel was blended into a specially formulated cold weather diesel fuel (cloud point of -38°C [-36°F]) to make a B20 blend, the cloud point of that blend was -20°C (-4°F). In very cold climates, this cloud point may not be adequate for wintertime use. To accommodate biodiesel in cold climates, low-cloud point petroleum diesel or low-temperature flow additives, or both, are necessary. Another option is to reduce the percentage of biodiesel in the blend. Generally speaking, with the same biodiesel and diesel fuel, a B10 will have better cold weather operability properties than a B20.

- **Corrosion**

This is most critical for biodiesel in higher concentration (B80-B100). Some types of hoses and gaskets could degrade, leading to loss of integrity and interaction with some metallic material such as copper, brass, lead, tin, zinc, etc. It could also result in an increased formation of deposits. Hence, it is important to verify that these components in the fuel system are endurable and can be used together with biofuel.

- **Microbial Growth**

Bacteria and mould may grow if condensed water accumulates in biodiesel fuel. Microbial growth leads to excessive formation of sludge, clogged filters and piping. Frequent draining of tanks and the application of biocide in the fuel may reduce or mitigate microbial growth.

- **Oxygen degradation**

Biodiesel can degrade over time, forming contaminants of polymers, and other insoluble. Deposits in piping and engines could form, compromising operational performance. In advanced stages, this could lead to increased fuel acidity, which could result in corrosion in the fuel system and accumulation of deposits in pumps and injectors. It is therefore recommended not to bunker the fuel for long-term storage before use, but to treat the fuel as fresh goods and to use it within a relatively short period of time. Adding antioxidants to the fuel at an early stage may improve the ability of a somewhat longer time of storage without degradation.

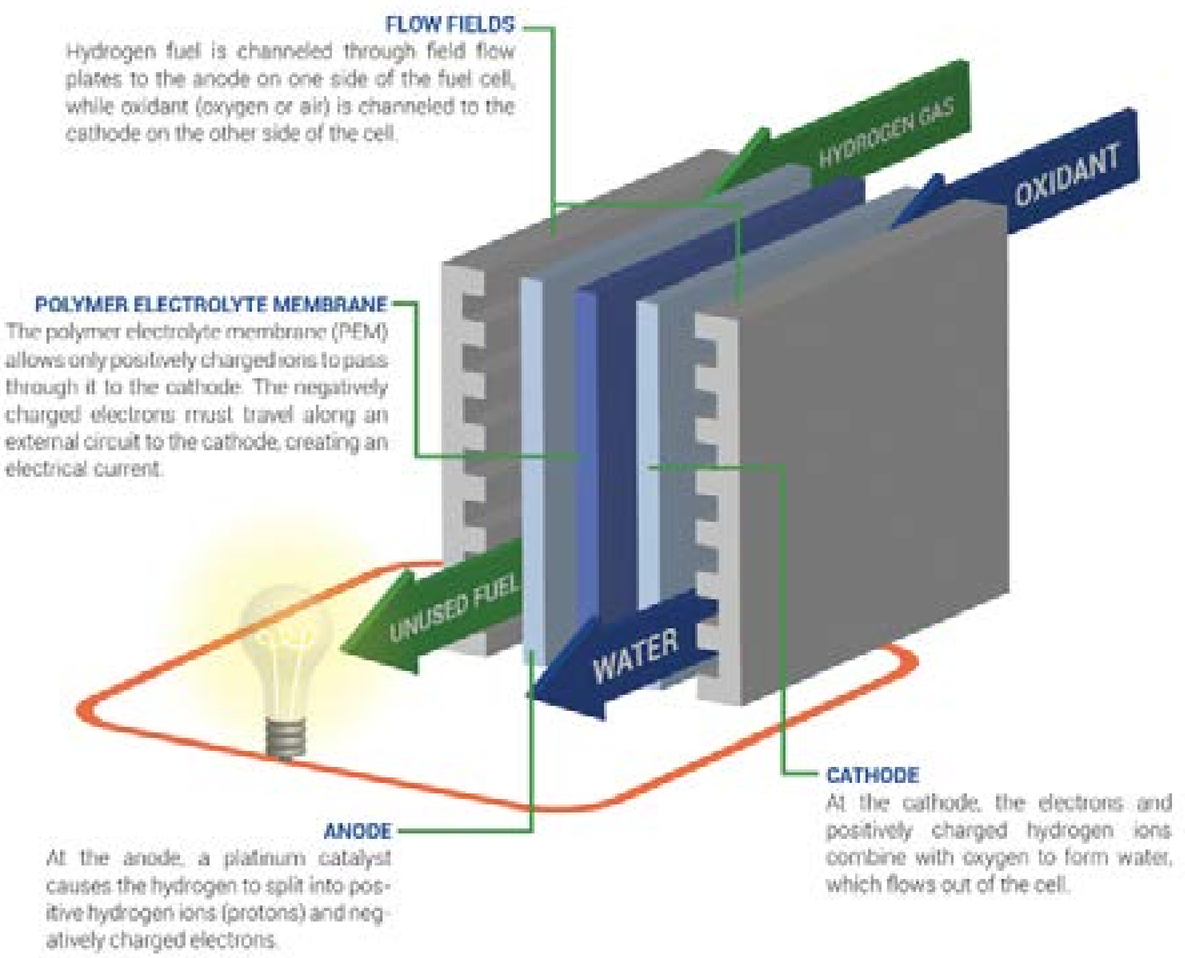
- **Conversion**

Biodiesel has shown to have a solvent property, so when switching from diesel to biofuel it is expected that deposits in the fuel system will be flushed, clogging fuel filters. It is recommended to flush the system and/or to monitor filters during this period.

5.2.3 Fuel cells

Fuel cells are a prime mover energy conversion equipment that transform the electrochemical potential energy from hydrogen into electrical energy, which can either be consumed directly or, as in most cases, indirectly from storage in batteries. There is the possibility to have different technical arrangements where fuels other than hydrogen (e.g., LNG or methanol) are directly fed into the fuel cells and, following a transformation process, can be used as chemical carriers for hydrogen. In any case, hydrogen safety has to be considered due to possible leakages from piping, fixture, and the cell itself [26].

Figure 137: Basic fuel cell elements and operating principle.



Source: Setra Systems

Hydrogen as fuel, reacting with oxygen to produce electricity and water.

The use of fuel cells onboard ships has, so far, been limited to a modular application with rated outputs below MW. The concept has matured from a technology perspective and fuel cells are currently being developed for use in multi-MW applications. Due to the low power density of fuel cell systems, scaling the technology beyond 1MW represents a significant step difficult to meet by any modularisation approach. Ship design applications are under development which will increase the attractiveness of the fuel cell option as an energy conversion technology [26].

Figure 138: Viking Lady embarking fuel cell power module in the context of the FellowSHIP project.

Source: Eidesvik Offshore ASA

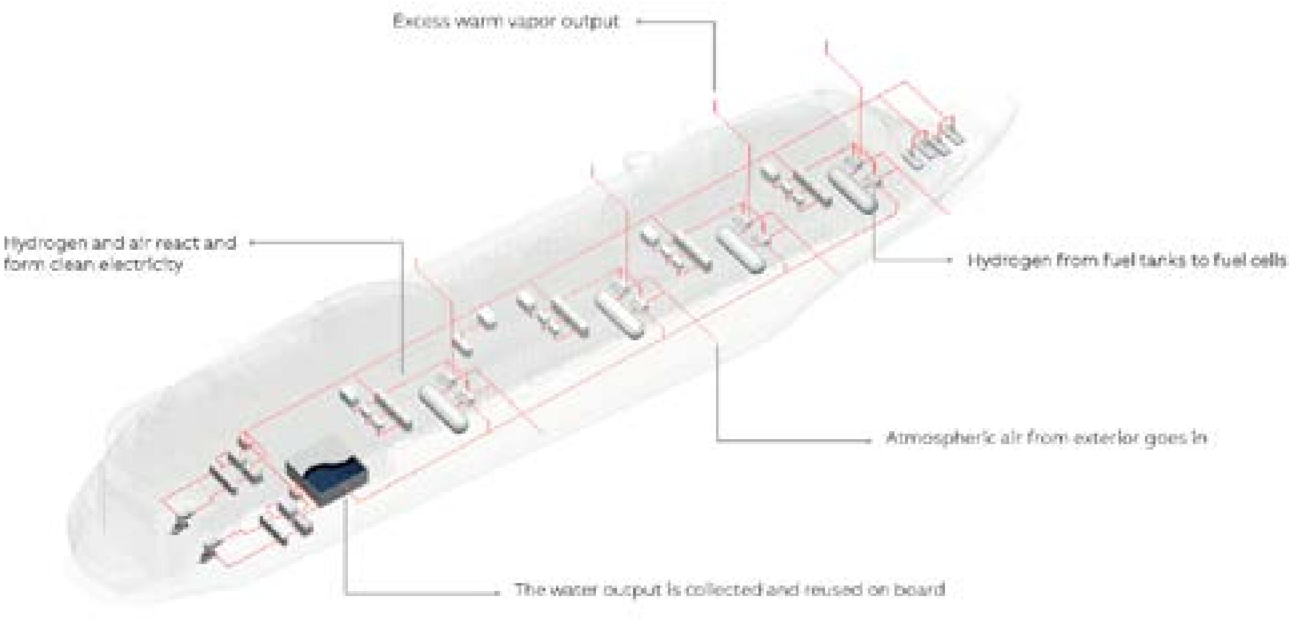
The project is based on the use of LNG as fuel on a Fuel cell power installation.

Figure 139: Prototype solid oxide fuel cell unit for ThyssenKrupp.

Source: Sunfire GmbH (2015)

Project MultiSchIBZ - aiming to develop and demonstrate a solid oxide fuel cell (SOFC) suitable for maritime use by 2020-2022.

Figure 140: Illustration of a modular power supply system developed for marine use.



Source: ABB

The system is based on PEM fuel cell technology, applicable to high and low voltage, as well as AC and DC power systems, and can be used in combination with batteries or engines. The system can be fully hydrogen-electric or integrated as part of a hybrid power system. The options for ship design provided by possible grid distributed energy systems onboard is increase.

Technology

Fuel cells are a technology which has today derived into several sub-technology categories. A recent EMSA study on fuel cell technology [26], identified and assessed these sub-technologies using chemical, design, and operating criteria. The study details all the analysis on the potential for the different technologies.

The study allowed to identify three technologies with the highest potential: Proton Exchange Membrane (PEM), High Temperature Proton Exchange Membrane (HT-PEM) and Solid Oxide Fuels Cells (SOFC). These technologies are further described in the table below. It should be noted that HT-PEM and SOFC operate at high temperatures which provides for improved efficiency but raises additional safety concerns with respect to the associated higher fire risk due the temperature and potentially accelerated degradation of the fuel cell stack materials.

From a safety perspective, the potential hazardous and the specific risks to mitigate for each technology are detailed in EMSA study on fuel cell technology [26].

Table 45: Most promising fuel cell technologies for applications in maritime transport [26].

Technology	TRL	Note/ Reference	R&D needs for TRL increase
PEM (Proton Exchange Membrane)	9	PEM fuel cell technology is the most mature fuel cell technology used in mobile applications, remarkably for road applications.	• Catalyst chemistry and cost reduction materials. • Water and air management • Efficiency improvement • CO poisoning prevention
HT-PEM (High Temperature Proton Exchange Membrane)	7/8	HT-PEM are currently applied in stationary applications. With higher operating temperatures and elimination of the water management issues, HT-PEM presents the potential for improved efficiency and tolerability to hydrogen impurities.	• HT membrane • Heat activation and heat waste management • Structural solution and integration for mobility. • Hazardous Area Certification of Fuel Cell Stack – High Temperature stack not considered in current version of FC Guidelines.
SOFC (Solid Oxide Fuels Cells)	7	With PEM, Solid Oxide Fuels Cells (SOFC) represent the largest number of applied FC technologies. Their application is currently object of the ShipFC Eu co-funded project, with use of ammonia as fuel, onboard an OSV, with an objective for a scale-up to 2MW SOFC power installation.	• Advanced materials • Temperature management (ideal 500degC for trade-off materials VS performance). • Heat activation and heat waste management necessary for efficiency improvement. • Hazardous Area Certification of Fuel Cell Stack – High Temperature stack not considered in current version of FC Guidelines.

Regulatory framework

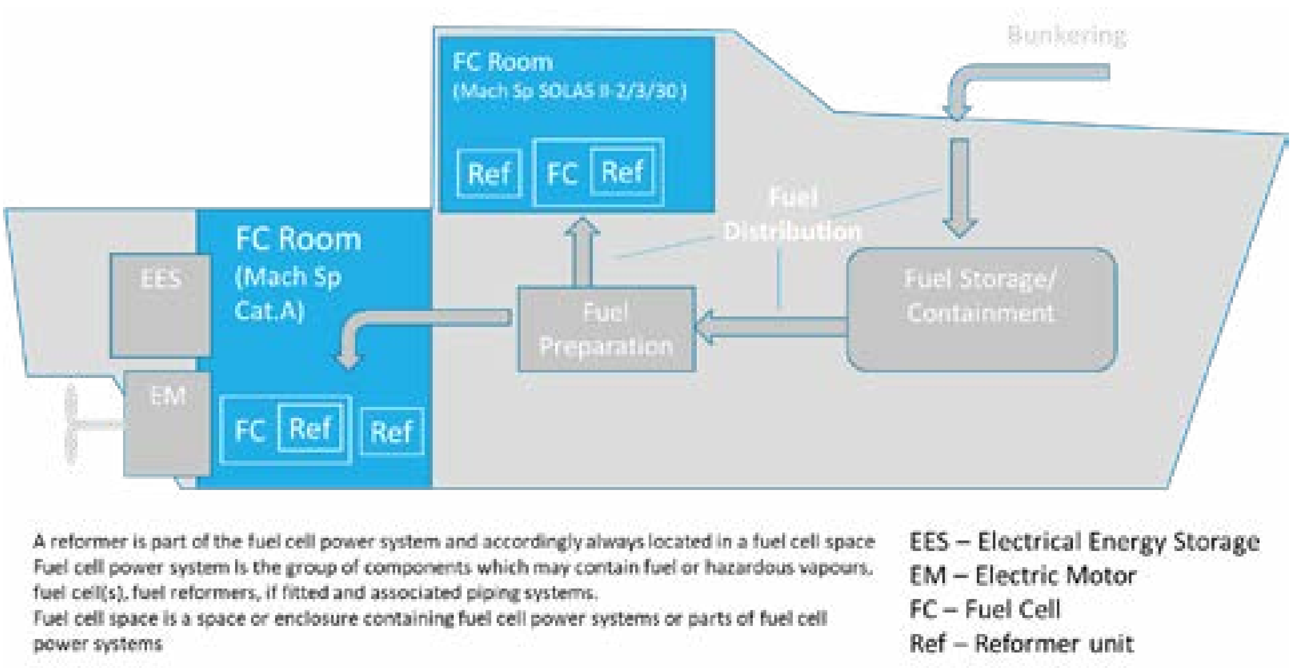
The IMO Interim Guidelines for the Safety of Ships using Fuel Cell Power Installations were finalised at IMO CCC7, in 2021 and are expected to be adopted at MSC105, in 2022.

The guidelines will assist ship designers and operators with important safety provisions related with the installation of fuel cell powering systems to ensure an equivalent level of safety and reliability to conventional oil-fuelled machinery installations, regardless of the specific fuel cell type and fuel, but do not include provisions regarding the fuel reforming, i.e., those using fuels other than hydrogen and transforming them as hydrogen carriers.

Depending on the fuel used, other regulations (e.g., IGF Code, part A) and provisions (e.g., Interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel) are applicable in addition to these Interim Guidelines.

The figure below highlights in blue the areas covered under the IMO Fuel Cell Guidelines, essentially focusing on the fuel cell installation, irrespective of the fuel system adopted for each ship.

Figure 141: Scope of the IMO Interim Guidelines for the safety of ships using fuel cell power installations.



Source: EMSA Services

5.2.4 Electrification

5.2.4.1 Electrification in the maritime transport sector

The use of electricity onboard ships is primarily driven by operational, design and sustainability aspects and has several applications in the maritime transport sector. From an operational perspective, electrical propulsion systems present opportunities in terms of propeller speed variation, stationary positioning systems, manoeuvring and onboard comfort, avoiding the complexity of a traditional propulsion system involving shafts, gearboxes with associated vibration and maintenance. It provides flexibility to ship designers for the internal arrangement as there is no need to align energy converters with the propulsion units.

There are several solutions in the market from the pure electric to the hybrid/electric and hybrid plug-in model. The implementation is growing at fast pace, with more than 500 ships currently operating with some electrical energy storage systems as primary energy sources. However, the current low energy density of battery systems leads to applications on ships that are either involved in short-distance routes or engaged in services which do not require high autonomy. For deep-sea shipping, engaged in longer routes, hybrid options which include other renewable and low carbon energy sources, are being considered as a valid option towards GHG reduction.

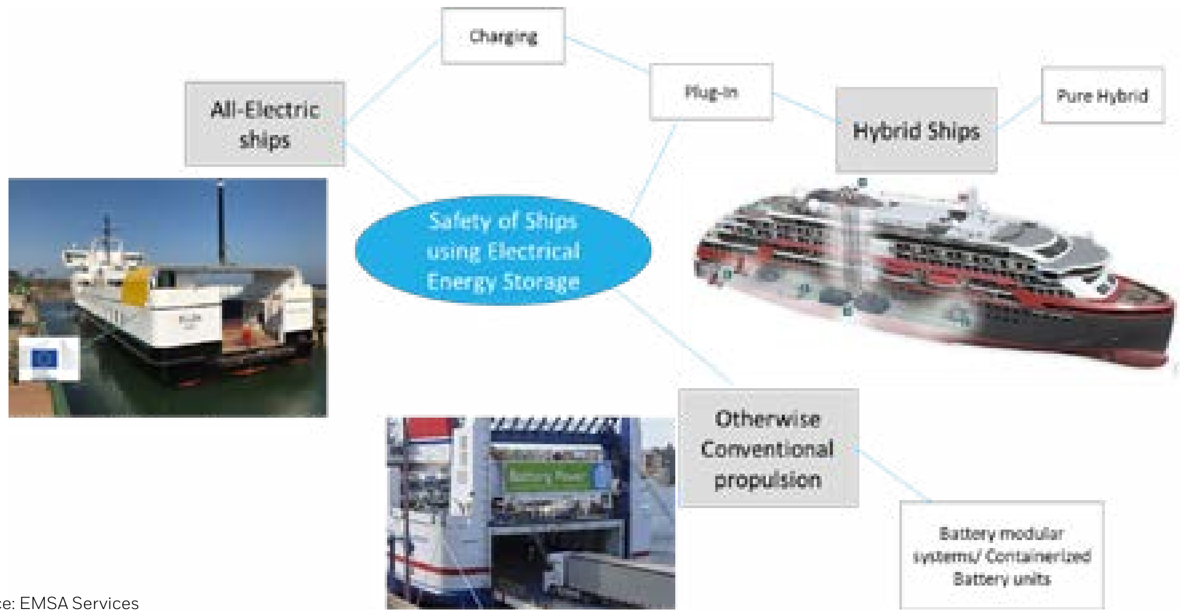
Inland waterway transport, in comparison to its maritime counterpart, presents increased opportunities for the use of electricity. Using well defined inland waterway routes, with regular port calls along the way, inland waterway vessels are today adopting electrification solutions such as hybridization and all-electric concepts, based on the possibility to recharge frequently along regular trading routes. Battery swapping and other modular relevant concepts have been developing in a way that reveals how modularization and simplified retrofitting may assist in the transformation of this sector.

Operation of electric power-driven ships requires shore-side/port infrastructure not only for supply of shore power but also for charging secondary battery groups onboard. Interconnectivity and interoperability are key challenges to address for shore-side electricity connection. Another important challenge for port electrical capacity development are constraints from transmission and distribution grid due to the need to feed significant electrical power capacity into ports to address the power demand from ships at berth.

5.2.4.2 Electrical Energy Storage – Battery Technology and Applications

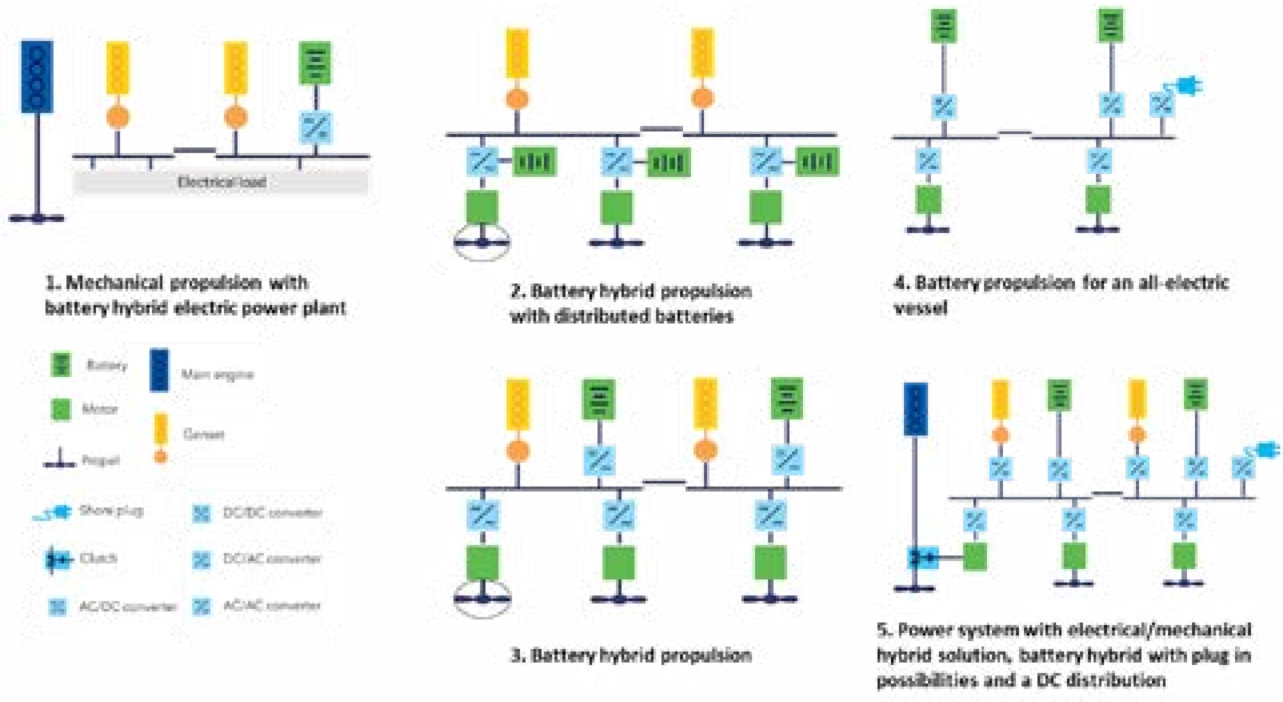
The use of Electrical Energy Storage in shipping may take place in different configurations and practical solutions. The diagram below illustrates the different possibilities for battery technology integration onboard ships, in all-electric ships, hybrid-electric and as distributed electrical energy supply on otherwise conventional ships.

Figure 142: Different possible applications of battery systems in maritime transport.



Source: EMSA Services

Figure 143: Integration of electrical energy storage into different powertrain configurations.

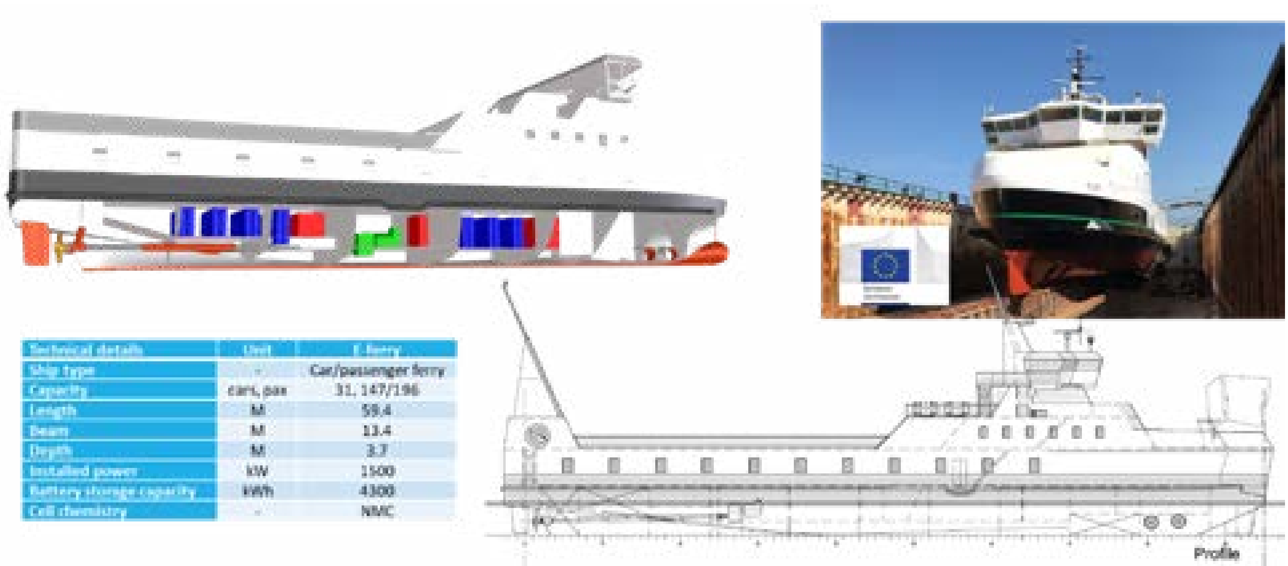


Source: [27]

Battery systems can be integrated in a variety of different ways, as a function of different operational requirements.

The EMSA Study on Electrical Energy Storage lists relevant projects where all-electric or hybrid applications have been deployed, in the large majority of the cases in a context of EU co-funded projects. The E-Ferry, below, (MV Ellen), started operation in the summer of 2019.

Figure 144: EU co-funded project for an all-electric ferry – MV Ellen.



Technical details	Unit	E-ferry
Ship type	-	Car/passenger ferry
Capacity	cars, pax	31, 147/196
Length	M	59.4
Beam	M	13.4
Depth	M	3.7
Installed power	kW	1500
Battery storage capacity	kWh	4300
Cell chemistry	-	NMC

Source: DG RTD

The above-mentioned study includes a wide range of battery technologies/chemistries with identified advantages and disadvantages in applications onboard ships and those with a higher potential for maritime applications. Currently, the most popular technology is that of lithium-ion (Li-ion).

Safety Aspects

From a safety perspective, the electrification of maritime transport brings important challenges, including:

- Large Li-ion Battery applications – Thermal Runaway Events, Gas release, Occupational Safety.
- Electrical Safety aspects, in particular with respect to Shock and Arcing hazards.
- Installation of DC energy systems (batteries, fuel cells) into otherwise AC onboard grid, leading to the necessary installation of solid-state converters (Inverter/Rectifier).
- Safety Culture challenge with need to define well the relevant competencies for crew and personnel involved in operation and maintenance of electrical energy and grid distributed systems.

The different failure modes are presented as follows, together with specific battery technology considerations with impact on Safety. Operational safety risks of lithium-ion batteries are also listed, detailing the different conditions with critical safety impact. Finally, special relevance is given to the Fire Safety concept for this type of installations.

- **Failure Modes**

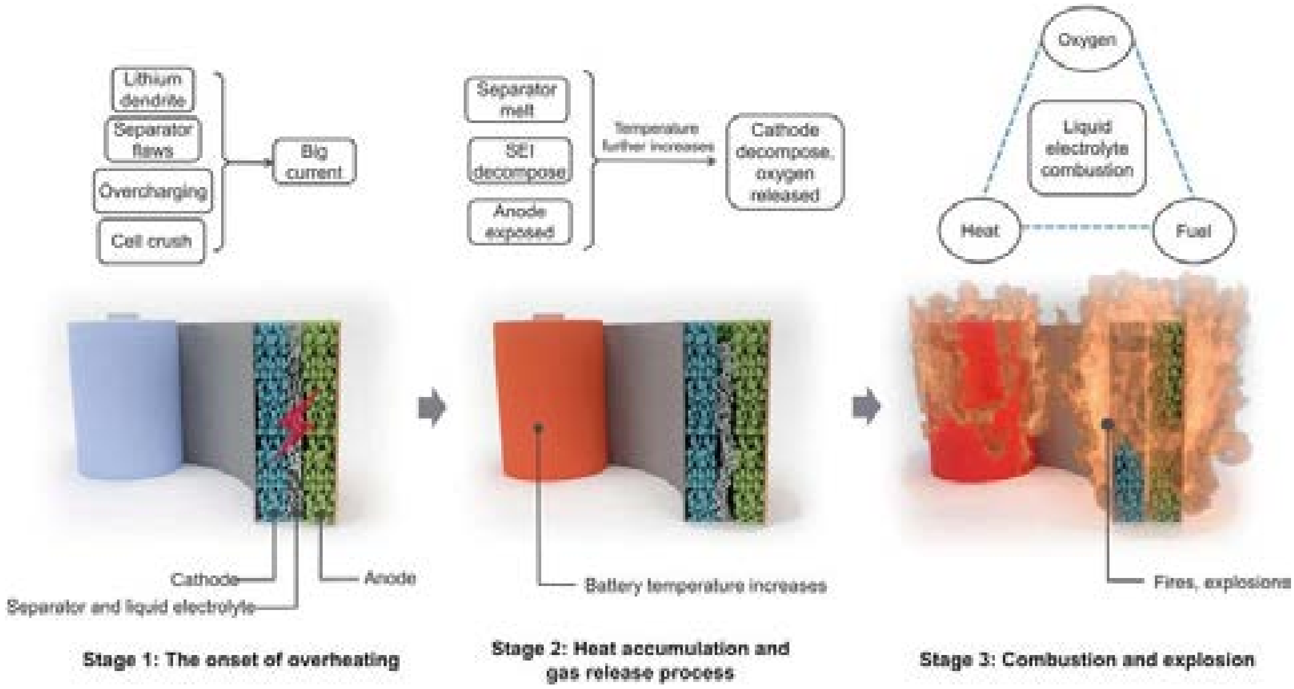
Safety concerns regarding lithium-ion batteries come from two sources – one is the presence of flammable, unstable electrolyte, and the second is the presence of metal electrodes that can burn and often release oxygen. Ignition and likelihood of a safety event is largely linked to the flammable electrolyte, while the high temperature and difficult to extinguish nature of the fire is largely linked to the second aspect. Based on these components, there are two primary failure modes or effects that can result from lithium-ion battery abuse: cascading thermal runaway and the release of toxic and flammable gasses. This section will provide an account of main abuse mechanisms that pose risks with respect to lithium-ion battery safety, as well as description of these main effects and consequences that can results from such incidents [28].

1. **Thermal runaway & propagation**

   Thermal runaway is the exothermic reaction that occurs when a lithium-ion battery starts to burn. The thermal event often starts from an abuse mechanism that causes sufficient internal temperature rise to ignite the electrolyte within a given cell. This fire then poses significant risk of igniting the metallic electrodes that are contained within the battery cell, thus producing a high temperature metal (Class D) fire. Additionally, these metals may contain oxygen, which is thus released as it burns. Not all lithium-ion batteries contain oxygen within the electrodes but all lithium-ion batteries on the market today contain electrolyte that can ignite and cause this thermal runaway scenario.

   A maritime battery system is typically made up of thousands of cells. Thus, the failure and total heat release of a single cell is a relatively minor threat. The greater threat comes from that thermal event producing sufficient heat that it propagates to other cells, causing them to go into thermal runaway. As this cascade through the battery, heat produced increases exponentially and the risk is developed of a fire in which the entire battery is involved. Thus, battery modules and systems must be engineered to protect against propagation based on the cell that is used, and these cascading protections are the key feature regarding system design for safety.

Figure 145: Li-ion battery fire safety – the 3 stages of thermal runaway.



Source: [29]

2. Electrolyte off gas

The electrolyte that is contained within a given cell consists of an organic solvent, typically variants of ethyl carbonates. This means that they are flammable, and additionally, this means the gasses that are produced during a failure scenario are also flammable and can present an explosion risk. These gasses also typically contain other species which are toxic – such as HCl and HF. These aspects of battery off gas thus require consideration regarding ignition sources and ventilation within both the battery module and battery room.

- **Battery technology considerations**

In addition to general safety aspects of lithium-ion batteries, there can also be significant differences between specific systems. These variations consist of the chemistry of the battery cells themselves, the design of the module (assembly of multiple battery cells) and the control system internal to the battery known as Battery Management System (BMS).

Table 46: Considerations regarding battery technology systems.

Battery Technology Element	Description
Battery Management System - BMS	The battery is only as strong as its weakest link (cell). All batteries within the system will degrade at slightly different rates. A BMS system should minimise those variations keeping batteries in balance. In addition, the BMS is responsible for calculating current limits, State of Charge (SoC), and State of Health (SoH). The BMS is also vital in preventing the converter overcharging the battery system. Such failures may cause more than one cell or module to fail simultaneously. Note that the most probable scenario for such failures is that any fire or off-gassing will start at the weakest cell or module, before spreading to the rest of the system.
Battery cell and chemistry considerations	A battery system is built up of tens of thousands of cells. In the case that one cells fails in some sort of thermal event, it should not propagate to other cells around it. Limiting the size of the cells limits the heat produced. A larger cell will contain a larger amount of energy and thus produce more heat when it burns. Larger cells have advantages regarding energy content and density of a system, but the potential heat released should be also considered. Chemistry is also an important factor. Most lithium-ion batteries in use are of a Lithium Cobalt Oxide (LCO), Nickel Cobalt Manganese (NCM) or Lithium Manganese Oxide (LMO) type. These chemistries present similarities in terms of having layered metal oxides and thus producing oxygen during thermal runaway events. Thus, these chemistries will tend to burn more violently and with greater amount of heat released. Iron Phosphate (LFP) batteries, on the other hand, do not contain oxygen in the internal metal structures and thus do not produce as much heat in the case of a thermal failure. Additionally, Lithium Titanate Oxide (LTO) batteries will tend to produce less heat during a thermal failure scenario.
Module Design	The module is the level at which key detections are made – multiple sensors for voltage, temperature, and current will be placed in the module. The higher number of sensors, the better the visibility the control system has into the battery and thus the ability to detect an event as soon as possible. Many systems have voltage sensors on every cell, which is highly advantageous. Many will also have multiple temperature sensors placed strategically, as well as current sensors. An increased amount of sensors will typically accompany increased system cost. Modules also contains the systems responsible for thermal management of the battery. Batteries are typically either air-cooled or liquid cooled. The cooling system will help ensuring a more balanced operation and degradation of the cells.

- **Operational safety risks of lithium-ion batteries**

The following are the main ways in which a lithium-ion battery can be misused and increase the risk of producing a failure scenario. Many of these risks come from undesired electrical operation, and thus the control system – Battery Management System, BMS – plays a key role. The electrical architecture and system protections are also very relevant. These factors are described in the following table with a cell perspective. However, these are also present at module and rack level with potentially worst consequences for the ship [27].

Table 47: Operational safety risks of lithium-ion batteries.

Operational Safety Risk	Description
Overcharge	Overcharging a lithium-ion battery is one the most likely scenarios and with the worst consequences. Overcharging a battery means charging it to a point where its voltage is greater than it is rated to be at. When a battery is overcharged, internal temperature rises, and the electrolyte is at significant risk of breaking down into gaseous constituents. Both circumstances lead to risk of igniting the electrolyte in liquid or gaseous form. The overcharging can happen due to incorrect communication of the state of charge (SOC) from the battery management system (BMS) to the converter or the Power Management System, imbalance between cells or a short circuit producing an excessive charge current.
Overdischarge	Overdischarge represents a scenario where the battery voltage has dropped below manufacturer recommended limits. This can lead to decomposition of the electrodes within the battery which then poses a risk of short circuiting – and thus of heating electrolyte and causing a fire. Also, like overcharge, the BMS has a prime role in protecting against overdischarge.
Overcurrent	Overcurrent comes from charging or discharging the battery at a too high-power rate. This can cause excessive temperature generation thus leading to electrolyte ignition. In addition, this can lead to incorrect voltage management, and thus accidental overcharging or overdischarging. The converter connected to the battery should be equipped with an overcurrent protection with limits set by the BMS. In severe cases, the excessive current may be of a fault or short circuit type, and thus out of control; passive electrical protections such as fuses and breakers are key to prevent this failure.
Overheating	Thermal management of a battery system is essential. Excessive temperatures will accelerate degradation and lead to an accident. If ambient temperature is too high, then the battery may increase its internal temperature beyond acceptable limits. Acceptable upper temperature limits are often near 45°C.
Excessive cold	Operating a battery in temperatures below its rated range will increase internal resistance, decrease efficiency and can also lead to an accident through lithium plating on the anode or formation of dendrites – thus resulting in an internal short circuit and rapid heating of the electrolyte. Lower temperature thresholds range widely between different cell chemistries, and manufacturer recommendations should be followed closely, but it can be considered generally inadvisable to operate below 10°C.
External short circuit	An external short circuit poses the same risk as many other failure modes described in this section. If the battery is rapidly charged or discharged, the electrolyte in a cell may heat to the point of ignition and pose a threat of thermal runaway and/or flammable or toxic off-gas release. As mentioned before, passive electrical protections such as fuses, and breakers are the key to prevent this failure.
Mechanical damage	If a cell is mechanically damaged, a risk is posed of the electrodes coming into contact and short circuiting as well as many other electrical components. This short-circuiting thus produces the same failure mode of heating the electrolyte to the point of ignition.
External fire	An external fire poses the threat of involving the battery system and thus direct overheating and combustion of all battery materials. An external fire might also heat up the battery space, such that the ambient temperature exceeds the acceptable limit of safe battery operation. Proper fire segregation of the battery room and a fire extinguishing system that removes the heat from the battery space is then important.
Internal defect	An internal defect represents perhaps the largest threat to a lithium-ion battery system because it is something that cannot be detected by the battery BMS. Most all other failures will result in indications from voltage or temperature sensors that will be detected and accounted for by the BMS. An internal defect may produce an internal short circuit without warning. This can the result of poor-quality control from manufacturing. Although many cell producers maintain a high degree of quality control, the large number of cells required for an installation makes more difficult its detection. An internal defect is a significant risk and the main reason that off-gas and thermal runaway must be considered and protected against in even the most highly controlled and monitored systems.

- **Fire Safety Concept**

The Fire Safety Concept for large battery installations onboard ships has been a recent area of ongoing investigation. A recent Technical Reference[90] was published in 2019. Its scope is limited to Lithium-ion - Nickel manganese cobalt oxide (Li-NMC) and Lithium iron phosphate (LFP) technologies, the most common at this moment.

Battery fires have specific characteristics when compared to more conventional energy and power systems. The temperatures achieved in the fires are considerably higher with production of toxic and explosive gases. The report provides important considerations regarding gas detection, fire extinguishment systems, battery room ventilation systems, toxicity, off-gas detection and thermal runaway identification.

In terms of ventilation systems, which are critical to avoid accumulation of explosive gases, the report concludes that ventilation alone will not adequately mitigate gas accumulation if a significant portion of the battery system ignites. In addition, it stresses that battery design must have preventive safety barriers to avoid propagation to other battery layers. Finally, it underlines the importance of early fire and gas detection, meaning that the gas sensor should be located as close to the battery as possible.

- **Regulatory Development**

No international regulations or guidelines concerning risk management of battery storage and installations for electric propulsion have yet been developed by IMO. There is only a general reference (SOLAS II-1/40.2):

> *The Administration shall take appropriate steps to ensure uniformity in the implementation and application of the provisions of this part in respect of electrical installations.**
>
> * Refer to the recommendations published by the IEC (International Electrotechnical Commission) and, in particular, publication IEC 60092 – Electrical installations in ships.

Furthermore, regulation 45 "Precautions against shock, fire and other hazards of electrical origin" states the following related to batteries:

> *"9.1. Accumulator batteries shall be suitably housed, and compartments used primarily for their accommodation shall be properly constructed and efficiently ventilated."*

However, several flag States and classification societies have published relevant guidelines regarding battery storage for electric propulsion, trying to address the growing interest in the adoption of electric and hybrid-electric arrangements.

IEC Standards provide for relevant standardization of the Li-ion battery and for general electrical safety aspects. It is however important to address the necessary development of safety provisions for ships using battery systems.

5.2.4.3 Shore Side Electricity

Shore Side Electricity (SSE) is increasingly an alternative energy/power option for ships at berth. Disconnecting onboard generators and receiving electrical power from shore or charging onboard batteries from shore-side battery charging installations are some of the possible options that are today available. Some key aspects of the infrastructure, equipment and operational concepts have an important role in the safety of SSE installations. Aspects such as interconnectivity and interoperability, electrical safety risk management, selectivity and electrical protections are some of the relevant elements to consider.

The different SSE technical options include:

- **Onshore Power Supply (OPS)**: supply of electrical power across the ship-shore interface, in AC or DC, HV or LV, directly to the ship's main distribution switchboard, in replacement of onboard electrical power generation.
- **Shore-side Battery Charging (SBC)**: supply of electrical power across the ship-shore interface, in AC or DC, HV or LV, with the objective of charging Electrical Energy Storage (EES) units onboard, involving power and battery management ship-shore interconnectivity.
- **Battery Swapping (BS)**: swapping of modular Electrical Energy Storage (EES) systems/units between ship and shore, where a charged modular unit is embarked and connected onboard, in replacement of an identical/compatible unit to be charged at shoreside.

90 Technical Reference for Li-ion Battery Explosion Risk and Fire Suppression by DNV-GL [32]

- **Shore-side Power Banking (SPB)**: use of electrical energy storage/battery bank systems to provide energy for SSE services, when used as a main power source. Power Banking can be either 1) from shore-to-ship, with EES ashore and otherwise standard OPS/SBC connection or 2) via embarkation and onboard connection of modular EES.

- **Power Generation (PG)** is the combination of distributed and microgeneration power solutions arranged in such a manner that are used in direct supply of electricity to SSE services.

Figure 146 presents the highlights for each of the previous shore-side electricity options.

Figure 146: Shore-side electricity options.

Onshore Power Supply (OPS) • Key technology to mitigate ship's emissions at berth. • Availability of OPS is increasing as part of ports sustainability initiatives. • Supply of high voltage electricity is a key enabler for OPS of higher power demanding ships. • Feasibility of OPS projects requires involvement from many stakeholders. • Architecture of OPS systems is increasingly automated to allow for efficient operation.	• More ports are today offering OPS services, allowing ships to reduce emissions at berth, with benefits for local air quality, reduction of GHG emissions and noise. • Ships at berth have significantly different operating profiles, imposing different requirements for power supply. • High voltage supply (>1 kV AC) enables more efficient connection. • Matching AC frequency 50/60 Hz is still an important aspect to consider for transoceanic ships. • Standardisation achieved by complete IEC/IEEE 8005 series. • IMO Interim Guidelines for Safe OPS operation have been finalised.	
Shore-side Battery Charging (SBC) • Shore-side battery charging has developed at the pace of increasing numbers in hybrid/electric ships • Charging from port-side infrastructure, through onshore transformers, is key.	• Growing number of electric/hybrid ships has driven the development of shore-side battery charging options, typically automated and associated with dedicated mooring systems. • SBC with shore-side transformer saves significant space onboard the receiving ship. • Typical specification in the order of multi-MWh charger for fast charging during short periods at berth.	
SBC Battery Swapping (SBC-BS) • Battery swapping may allow electric/plug-in vessels to have reduced turnaround times at berth, without having to "wait-to-charge". • Modularity and standardisation are key aspects to ensure.	• Battery swapping provide for flexibility, reduced charging periods at berth and operational gains for waterborne trade in fixed routes. • High demand for standardised solutions and to mitigate the risk of multiple proprietary solutions. • Ship-shore interface infrastructure to be designed for swift and safe handling of battery module units.	
Shore-side Power Banks (SPB) • Power banks, or shore-side Electrical Energy Storage (ESS) units are technology enablers for the storage of on-site renewable electricity. • Batteries are the central technology in power bank stations.	• Power banks are used in many applications, for temporary storage of renewable electricity production. • Important technology enabler for implementation of solar/wind projects in the port area. • Current battery technology has low energy density, leading to a large footprint area per installed MWh energy unit.	
Port Generator • Electricity supply where SSE infrastructure is not yet in place can be provided by port generators. • For actual environmental gains, electricity production should be based on cleaners low-to-zero carbon fuels.	• Port Generators may be shore or waterborne, either in containerized units or power barge units. • Solution already deployed and implemented in practical commercial applications. • Allows for flexibility, with electricity production possible in different port locations. • Actual environmental benefits depend on fuel used for power generation.	

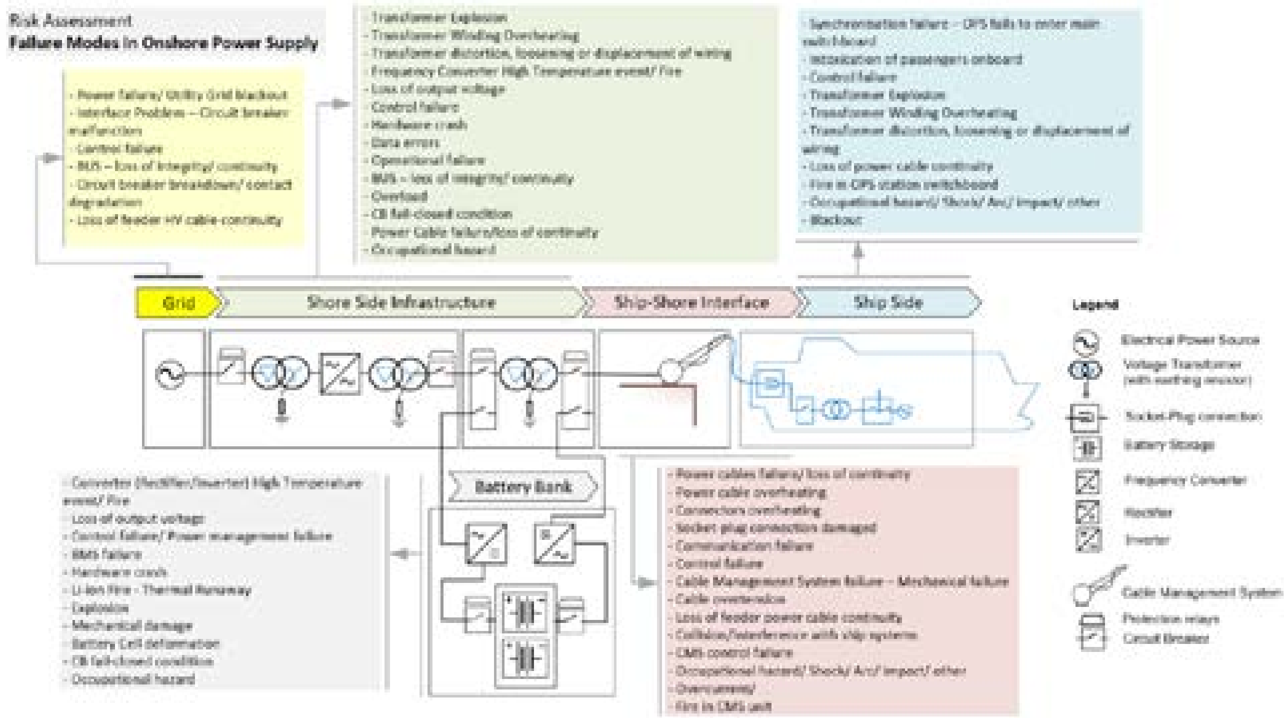
Source: German News Agency, Cavotec SA, Wärtsilä Corporation, Stena Line, Becker Marine Systems.

Safety Challenges

There are different safety challenges involved in SSE. The figure in the diagram below illustrates the different possible failure modes that can occur.

Relevant safeguards to mitigate risk involve a mix of procedures, safety equipment, electrical protection strategies and devices, grounding, training, among other aspects.

Figure 147: Possible failure modes in shore-side electricity arrangements.



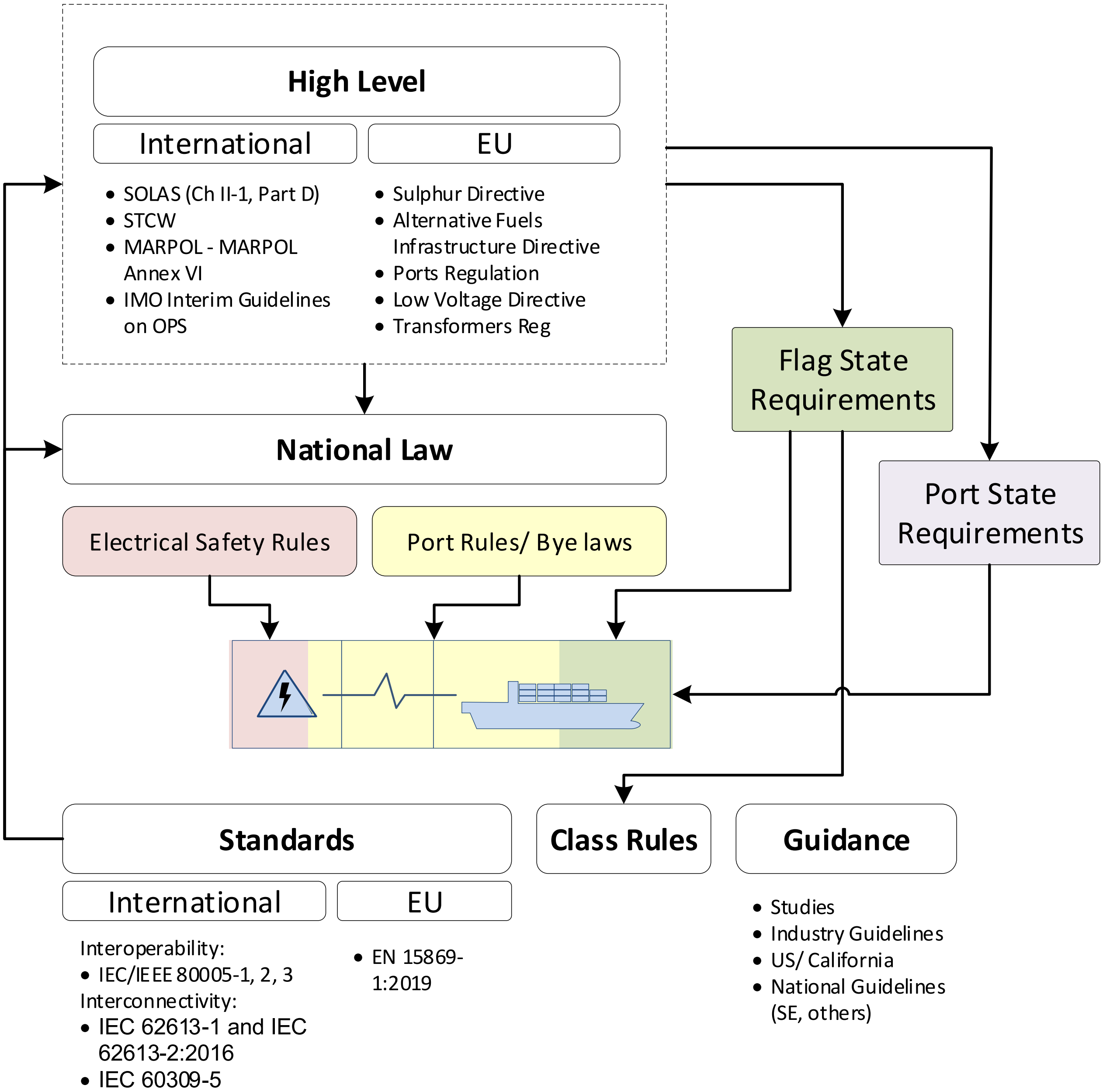
Source: EMSA Services

Regulatory Development

The Regulatory Framework construction for SSE is presented in the figure to the right. Since both sides of the Ship-Shore interface are implied the key challenge is to ensure interconnectivity and interoperability over the interface. This requires significant effort for harmonisation and integration of international recognised standards with local/ port/national frameworks.

Table 48 presents the level of completeness of the SSE regulatory framework, including already the IMO Interim Guidelines for Ships using OPS, expected to be adopted.

Figure 148: Shore-side electricity regulatory framework – different dimensions.



Source: EMSA Services

Table 48: Shore-side electricity regulatory framework – identifying the gaps.

SSE Mode		Interconnectivity	Interoperability	Data Communication	Automation	International/ EU Regulatory
OPS (Onshore Power Supply)	HVSC	IEC 62613-2:2016	IEC/IEEE 80005-1	IEC/IEEE 80005-1 (7.8) IEC/IEEE 80005-2 (normative requirements currently exist only for cruise ships).	Missing	IMO OPS Guidelines EU AFID.
	LVSC	IEC 60309-5	IEC/IEEE 80005-3 (under development/ finalization).	IEC/IEEE 80005-2	Missing	Missing
	LVSC – IW	EN 15869-2:2019 (up 125A) EN 16840: 2017 (above 250A)		Possible application of IEC/ IEEE 80005-2.	Missing	CCNR CESNI – ES-TRIN2019.
SBC (Shore-side Battery Charging)	SBC-AC As OPS – ship-side charging.	IEC 60309-5/ IEC 62613-2 AC connection	IEC/IEEE 80005 series As OPS – ship-side charging.	Possibility for future development for IEC/IEEE 80005-2 or ISO15118.	Missing	Missing
	SBC-DC	Not yet standardized.	Not yet standardized.		Missing	Missing

Source: EMSA Services

5.3 Transportation of alternative fuelled vehicles onboard ships

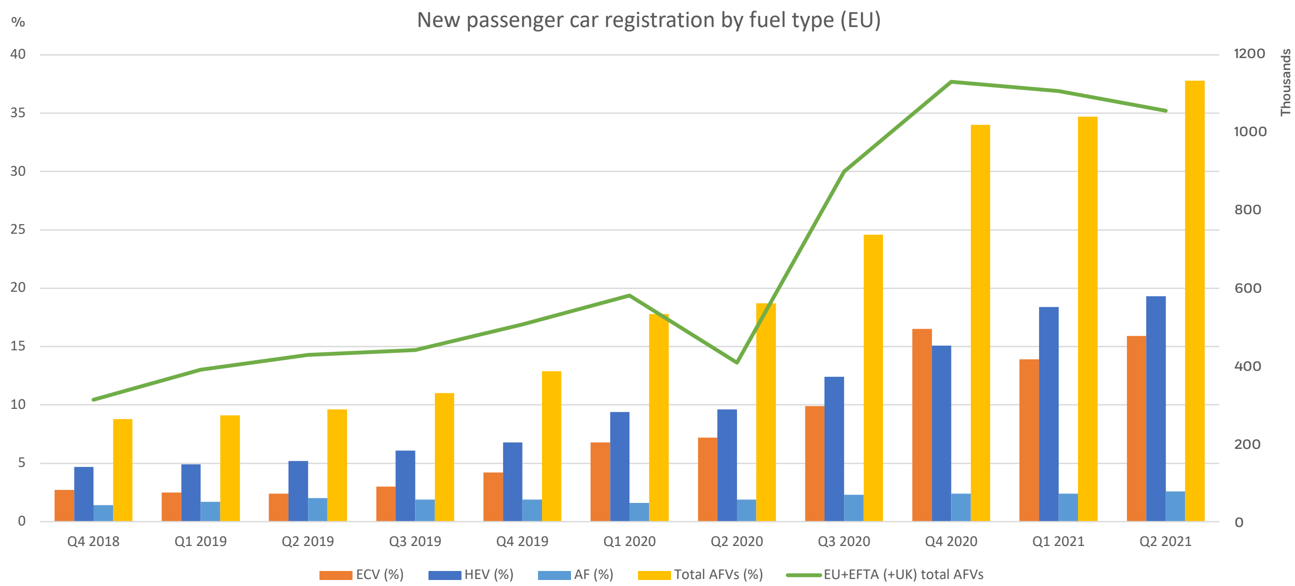
Emission targets are not limited to maritime transport; land transport, including trucks and cars, will have to evolve as well. Accordingly, the ships dedicated to carry these new vehicles will have to be adapted to these emerging safety challenges.

This topic has become a serious safety concern given the enormous growth in the fleet size of alternative fuelled vehicles (AFV) combined with the high uncertainty of the fire characteristics and potential fire risks of these vehicles. Passenger car registration data in the EU per new fuel type, i.e., Electrically Charged Vehicles (ECV) which include both battery electric and plug in hybrids, Hybrid Electric Vehicles (HEV) and other Alternative Fuels (AF), shows that there has been a significant increase in the EU of new AFV. The figure below shows an increase of the proportions of these vehicles from almost 9% to 38% within a 2.5-year range. It is also interesting to observe that the percentage increase in new AFV persisted even with the drop in car sales in Q2 of 2020 due to the COVID-19 pandemic.

This means that, at a steadily increasing rate, both passenger and cargo ships will need to transport AFV onboard.

Different safety related risks are associated with AFV onboard ships. For example, HEV, typically equipped with a Nickel Metal Hydride (NiMH) battery, which is considered a non-dangerous good, does not have particularly different fire characteristics to conventional vehicles. The list below provides more information on the hazards from the carriage of AFV, but it should be noted that the risks presented form a list of possible events without ranking their severity or probability of occurrence. It is expected that incidents related to new risks of AFV will have a significantly low probability of occurrence due to the built-in safety barriers of these vehicles.

Figure 149: New passenger car registration by fuel type in the EU, Q4/2018 - Q2/2021.



Source: European Automobile Manufacturers' Association (ACEA)

The following list contains energy carrier specific events and hazards [30]:

- Liquid fuels (diesel, gasoline or ethanol):
    - Fuel tank integrity loss increase in fire size. Pool fires (consider alcohol and other than gasoline/diesel)
- Liquefied fuels (LPG, LNG, liquefied dimethyl ether (DME)):
    - Venting of boil-off gas.
    - Jet flames from pressure release valve activations
    - Gas tank integrity loss
        - Increase fire size and fire propagation
        - BLEVE (boiling liquid expanding vapor explosion)
        - Pressure vessel explosion
        - Fire ball
    - Gas leak
        - Gas explosion under the following conditions
            - There are thermal effects (flash fire) if there is ignition of flammable gas cloud in unconfined and non-congested space; or
            - There are pressure effects (VCE = Vapour Cloud Explosion) if there is ignition of flammable gas cloud in confined and congested space
- Compressed gas (CNG/CBG):
    - Jet flames from PRD activations
    - Gas tank integrity loss
        - Severe increase in fire size and propagation
        - Pressure vessel explosion
        - Fire ball
    - Gas leak
        - Gas explosion (if gas can be accumulated for a while before being ignited)
- Batteries (Lithium-Ion) (thermal runaway):
    - Increase in fire size and propagation
    - Small jet flames
    - Toxic gases
    - Gas explosion (if the released gas can be accumulated for a while before being ignited)
    - Long lasting re-ignition risk (can ignite or re-ignite weeks, or maybe months after the provoking incident)
    - Difficult to stop/extinguish
- Fuel cells (compressed hydrogen):
    - Much higher tank pressure than CNG which may lead to leaks, which lead to accumulation of flammable or even explosive hydrogen air mixtures.
    - Rupture of pressure tank can cause very high concentrations of hydrogen in the vicinity of the car. In open spaces, this will cause a combustible mix to form for a short period. Enclosed spaces could accumulate enough hydrogen-air mixture for a large explosion.

From the above list it becomes clear that additional precautions are needed onboard ships to tackle these potential hazards. EMSA published high-level guidelines to assist relevant authorities and stakeholders in ensuring that the carriage of Alternatively Fuelled Vehicles (AFV) onboard ships is conducted safely and with due regard for protection of the environment. The main challenges and some interim mitigation measures from a ship perspective are:

- How to reduce ignition probability as far as practicable?
  - In case charging of ECV is allowed (only for the case of ro-ro passenger ships), ensure that a number of safety barriers are put in place to reduce the probability of any electrical faults, overcharging, etc.
  - On vehicle carriers and ro-ro cargo ships (PCTC) particular attention should be given to the maximum State of Charge values recommended by car manufacturers when loading ECV
  - Damaged ECVs should only be carried if their battery has been removed.
  - AFV should be easily identifiable, so that in case of a fire incident even in adjacent non-AFV the crew can take appropriate measures
  - AFV should generally be free from any leakages of fuel/gases
- How to rapidly detect the onset of fire in/close to an AFV?
  - Direct access to AFV needs to be considered
  - Portable gas detectors and thermal cameras to be used by fire patrols
  - Drivers of ECV should inform the crew in case they are aware of anything unusual about their vehicle.
- How to perform fire suppression and extinguishment of AFV?
  - There should be a ship specific emergency response procedure taking various elements into account.
  - Regular fire drills should include scenarios involving AFV
  - Firefighting suits and equipment should be updated taking into consideration AFV fire needs

The above list only includes interim measures, as there is currently significant ongoing research tackling relevant issues, such as the charging of ECV, fixed detection systems, fixed extinguishing systems, automatic identification of the fuel type of vehicles and personal protective equipment. In particular, the EU funded LASH FIRE project (https://lashfire.eu/) is planned to provide relevant deliverables within the course of 2022 and 2023.

Another issue to consider is that ro-ro ships will carry AFV and traditional vehicles with internal combustion engines at the same time, for a number of years to come. In addition, there are hybrid cars which incorporate both technologies at once. The associated risks and the associated fire safety techniques are different and, accordingly, there might be a need to differentiate both types of vehicles in their location onboard. While in long voyages the vehicle owners should probably be asked to indicate the type of vehicles in advance, for short voyages the crew should be able to distinguish them visually. This system could also avoid mistakes and misdeclarations. However, currently there is no way by which these types of vehicles can be distinguished visually.

The carriage of AFV presents various safety challenges and it is essential to perform their transport at a high safety standard to move towards sustainable transport.

5.4 E-certification

Nowadays, the issuance of certificates and statutory documents in electronic form is a reality, and is expected to continue to increase within the shipping sector. The development of electronic certificates presents a number of challenges and opportunities. One example of a challenge relates to the enforcement of e-certificates, given that paper statutory certificates may not be found on board. On the other hand, one of the opportunities presented is the timely delivery of e-certificates to shipping companies and another the strengthening of the validation mechanisms of statutory certificates. Through this, there is reduced potential for forgery in contrast with the traditional paper format.

From an enforcement point of view, the IMO has issued guidance on how the electronic certificates can be used and validated by inspection authorities (FAL.5/Circ.39/Rev.2). Further to this, the digitisation of the content of statutory certificates facilitates the transfer of information between Flag Administrations and RO, and, in what is relevant for PSC authorities, also paves the way for having statutory information integrated into the THETIS inspection database. The availability of the full content of statutory certificates in the THETIS inspection database would facilitate the work of the PSC inspector by allowing the relevant documentation to be checked prior to the visit to the ship. In this way, the duration of the on-board document checking would be considerably reduced, allowing efforts to be concentrated on the operational part of the inspection. The reduction of inspection time would also equally benefit shipping companies and crew members all round.

From the perspective of the work of the Member States in their capacity as flag state, the adoption of e-certificates also reduces the administrative burden on the issuance and timely delivery of certificates to shipping companies. It is also an occasion to support the transition of the EU maritime sector to a paperless environment and towards better tracking of certificate issuance.

EMSA, as the hosting institution of the THETIS inspection database, has initiated technical developments foreseeing the integration of electronic statutory certificates into THETIS and established pilot-projects in this sense. One EU RO has successfully uploaded the full content of one type of statutory certificate (IOPP) into THETIS. It is expected that similar initiatives will be pursued soon with interested flag administrations and RO. Through these bilateral initiatives, EMSA will progressively evaluate and develop the technical means in place to be in a position to receive e-certificate information for the benefit of enforcement authorities in the future.

6. Looking ahead

An analysis of the previous sections leads to the conclusion that the next few years will be eventful in the maritime safety field. There are challenges and opportunities in practically all of the areas analysed that will have to be tackled effectively and in a cooperative manner by the maritime community as a whole.

6.1 Human element

- The human element is crucial in maritime safety. However, it has been noted that the seafarer group is ageing, especially in many traditional maritime EU countries. The lack of attractiveness of the profession for young people is at the root of the problem. Accordingly, ships flagged in EU Member States need to bring in seafarers from other non-European countries to crew their ships. The data included in the STCW information system shows that in total, there are around 330,000 masters and officers available to crew EU ships.

- It is worth mentioning that efforts are being made to increase the attractiveness of seafaring to young people. ECSA and ETF agreed to work together in this topic through a joint project: Contributing to an Attractive, Smart and Sustainable Working Environment in the Shipping Sector (WESS) which is expected to be concluded during 2022.

- Being a seafarer is a high-pressure profession, as just one mistake can lead to a catastrophic event with serious environmental and financial consequences and with possible legal ramifications. The risk of such an event occurring can be minimised through proper training and qualifications. The EU has a centralised assessment system where EMSA audits the education systems of non-EU states so that their certificates can be recognised by the EU[91]. Decision-makers should be aware of the need to maintain enough resources for conducting this assessment activity to ensure that there are enough and well-qualified seafarers available to crew European Member State-flagged ships.

- The working environment of seafarers is not an easy one; the hardships go beyond the storms, the high waves and the bad weather conditions endured. The long days at sea, the intense activity in port and the limited social interaction, the fatigue, are all factors that make life at sea more demanding. Efforts to improve the working conditions of seafarers, like the MLC Convention, are steps in the right direction. However, the figures from the PSC inspections demonstrate that there is still a long way to go (see section 2.1.3). Around 25% of the deficiencies found are related to the human element, most of them within MLC Title 4 which deals with healthcare, safety protection and accident prevention of seafarers. One out of every six inspections show deficiencies in this field.

91 EMSA inspections: http://emsa.europa.eu/inspections.html

Source: piola666/E+/Getty Images

- The introduction of Maritime Autonomous Surface Ships (MASS) will have important implications for seafarers. There will be a transfer of human intervention from the ship to onshore control stations, further reducing the crew onboard and potentially increasing fatigue.

- This transfer of seafarers to shore stations will reduce the accidents caused by the crew onboard but will not eradicate human error totally. The human element will still be present in different roles, like carrying out remote supervision, verification, monitoring or even programming. Accordingly, the risk does not disappear but will take different forms which should be considered in the Safety Management Systems.

- The operations onboard MASS will be different from those of traditional ships. The higher level of automation will require the implementation of new procedures where technology will be more present. This will require new qualifications for the crew onboard but also for those who will have to control MASS operations from shore-based stations.

- MASS will also bring opportunities to seafarers. The transfer to shore stations will improve working conditions by reducing the exposure to hazardous environments and to the long periods of time in partial social isolation.

- Although the EMSA Annual Overview of Marine Casualties and Incidents highlights that a high percentage of maritime accidents are attributed to human error, the number of accidents avoided by seafarers is not measured and so not reflected in the reports. This reflection should be always considered when analysing maritime safety.

- This profession has no borders and, accordingly, it should be regulated at international level. The upcoming revision of the STCW Convention brings new opportunities for improvement and rationalisation.

- The COVID-19 pandemic – with seafarers uncapable to leave or join ships, in some cases, with infected fellow crew members and passengers unable to disembark and receive proper healthcare – has demonstrated the vulnerability of the social conditions of the profession. Lessons learnt should be considered at international level to take appropriate preventive measures for the future.

- To assist Member States in the process of issuing certificates to seafarers, EMSA is developing the EU Seafarers Certification Platform, a new digital tool to complement the STCW Information System database, also managed by EMSA. In this way, there will be more reliable data to carry out an analysis of the seafarers available and their qualifications.

6.2 Ship Safety

- Passenger ship operations present several challenges. There are more than one thousand of this type of ship under EU Member States flags and an even higher number operating in EU waters, and a large number are aging. In fact, passenger ships have the highest average age of all ship types: 28 years, double that of oil tankers. In general, safety standards are not applied retroactively and, accordingly, each ship fulfils the standards applicable at the date of construction. Therefore, passenger ships fulfilling the latest safety standards compete with older ships with a lower safety level on the same routes. For example, the damage stability standards for passenger ships have been updated several times in the last sixty years. They are usually referred to with the word SOLAS followed by the year when they entered into force, the main ones being SOLAS 60, SOLAS 74, SOLAS 90, SOLAS 2009 and SOLAS 2020. The analysis of the EU MS fleet shows that nowadays 40% of the passenger ships in operation were built at the time of SOLAS 60 and SOLAS 74 (see section 2.2.2). While recognising the importance of the time needed to recover the significant investment to build a passenger ship, imposing the immediate retroactivity would not be reasonable.

- The cycle to develop new safety standards can take more than a decade from the moment the problem is officially recognised until the associated standards come into force. And from there on, another decade or more can pass until the new requirements have a real impact on the fleet, as they usually apply only to new ships. This is illustrated in the case of fires on RoPax. It was demonstrated that there was a need to act in 2015, but it is likely that the new standards developed to minimise the problem will only become mandatory in 2026. This delay has been worsened with the COVID-19 pandemic, creating a bottleneck for important unaddressed safety topics.

- Fire safety on RoPax is one of the main areas where continuous effort is required by industry and administrations. In this regard, old RoPax should have been upgraded to the latest fire safety standards in 2010. However, the EMSA inspection campaign demonstrated that, unfortunately, this has not always been the case. Although EMSA carried out follow-up visits to ensure that the corrective actions stemming from the inspection campaign had been implemented, recent cases demonstrate that the retroactive fire safety requirements are not properly applied yet in all RoPax. Accordingly, the European Commission has requested to renew the inspection campaign so that an appropriate safety level is ensured.
- RoPax are also subject to a new safety challenge: alternative fuelled vehicles (AFV), the numbers of which are increasing across the EU, especially in the case of electric cars. The new risks arising from carrying this type of vehicle onboard is to be addressed. IMO has opened a new agenda item and EMSA, at the request of the European Commission, and in cooperation with a group of experts, developed high level guidelines which should be complemented with the results of the EU-funded project LASH FIRE.

Source: Monty Rakusen/ImageSource/Getty Images

- Finally, the interface between the ro-ro industry and road transport is still a challenge. There are no harmonised standards in terms of vehicle identification. For example, refrigerated trucks cause the highest proportion of fires on board ships and yet when they board a ship, operators have no means of verifying whether or not the vehicle has been inspected to ensure if fulfils the relevant safety standards, etc. All vehicles are accepted without question as it is not possible to filter them based on safety criteria. A similar challenge will occur with AFV, as they present a different set of risks to those related with internal traditional combustion engines, and cannot be externally distinguished, including if they are hybrid vehicles.

- The lack of harmonisation of fire protection standards for materials other than steel is another challenge. Whereas it is common to build large passenger ships of steel, small ones are built using aluminium, glass reinforced plastic (GRP) and wood. These ships are, in general, outside the scope of Directive 2009/45/EC which only covers ships above 24 m in length. However, in the domestic EU Member State- fleet, there are more than 1,000 passenger ships made of wood and 600 made of GRP already in operation with less than 24 m in length. The study launched by the European Commission which, among other issues, includes this element, could be the beginning of a harmonisation process to bring further opportunities to enhance safety and the internal market.

- Offshore wind farms are being installed in many EU sea areas. With this activity, there was a need to transfer personnel to build and maintain these installations offshore and, accordingly, a new type of ship has appeared in the market designed to carry industrial personnel. The IMO is in the process of developing a new Code for these ships operating on international voyages which is expected to enter into force on 1 July 2024. However, this Code does not include ships operating domestically.

- Containerships should also be subject to special safety attention in the short and mid-term. Three of the main concerns identified are cargo fires, loss of containers and cargo handling. The IMO has opened new outputs on this topic and EMSA has launched a study dedicated to tackle the cargo fires problem: CARGOSAFE.

- Fishing vessels have been analysed throughout this report. There are around 75,000 fishing vessels in the EU, 3% above 24 m in length, 6% between 15 m and 24 m, and the remaining 91% below 15 m in length. On the one hand, the EMCIP database shows that the highest number of SAR operations activated in the EU correspond to fishing vessels, twice as many as those of cargo vessels and four times more than passenger ships. Regarding accidents, the analysis in 2.2.3.3 confirms that their vulnerability is higher than any other ship type. The frequency of accidents is not high compared to other ship types, probably due to under reporting, but their consequences are worse than for other ship types: the proportion of very serious and serious accidents and the number of ship losses is much higher than for any other ship category.

- There is no international convention in force dealing with fishing vessel safety. At EU level, Directive 97/70/EC establishes the safety standards for ships above 24 m in length, i.e., the scope includes 3% of the EU fishing vessels fleet. The European Commission is currently in the process of reviewing several directives in which fishing vessels are considered: the one dealing with safety standards (Directive 97/70/EC), accident investigation (Directive 2009/18/EC) and port state control (Directive 2009/16/EC). In addition, IMO is reviewing the STCW-F Convention, which deals with the training and qualifications of fishermen, which is only ratified by 10 EU Member States. These revisions, and the promotion of the Cape Town Agreement, constitute a good opportunity to improve the safety of these vessels.

- With digitalisation, new opportunities arise from the issuance of electronic certificates of ships (e-certificates). If statutory e-certificates were fully integrated into THETIS, PSC inspectors would spend less time checking papers on board and could focus on the condition of the ship. The introduction of electronic certificates will also lead to a decrease in the forgery of paper documents. EMSA has carried out a pilot project with a recognised organisation with very good results. This opportunity should be further developed.

- The increased use of systems on board ships that rely on digitalisation, integration and automation have an associated cyber risk that may reflect on the safety of the ship and people on board. In general, cyber security addresses the protection of digital services from intentional attacks. However, there are threats to the digital services on board ships which can affect its safety coming from unintentional benign actions. For example, a failure occurring during software maintenance and patching, wrong software operation, etc. The IMO has required ships to take cyber risks management into consideration within the Safety Management System according to the ISM Code. Therefore, addressing these risks is not only advisable but mandatory. The IMO and industry have developed guidelines to support the risk assessment. In this respect, it is worth mentioning the IACS project aimed at delivering cyber resilient ships. This project is based on the publication of 12 Recommendations on Cyber Safety, nine of which are already published.

- Autonomous ships not only bring new opportunities to industry but also challenges. These are not limited to the regulatory field, but also include the technological field. For example, the decision systems that will replace the critical decision-making of the crew in avoiding collisions while complying with COLREG and reacting and avoiding bad weather conditions. In addition, the cyber security risks are more critical in MASS than in traditional ships as their safety depends on information technology while making use of complex communication systems.

- In addition, until a regulatory framework is developed, the initial MASS projects will have to follow the Alternative Design approach, i.e., they will have to be approved on a case-by-case basis with tailor-made risk assessments. This will make the inspection of these ships more difficult as they do not correspond to a category for which standards exist.

- The automation of ships will not happen immediately. It will follow a gradual approach. This means that, during the first years of operation, remotely controlled highly autonomous ships will sail on the same routes and call at the same ports as traditionally manned ships. This was also the case when steam propelled ships operated simultaneously with sailing ships. Difficult-to-predict challenges may arise in terms of surveys, manoeuvres at sea and in port, qualifications, etc.

- The mutual recognition agreement with the USA has allowed EU equipment manufacturers to access the US market while at the same time ensuring harmonised safety with an important flag state. The extension of this agreement to cover more items of equipment and the potential new agreements with other states, e.g., Canada, might bring new opportunities to the EU marine equipment industry.

- The new MED portal mobile applications and the strengthening of the unique identification numbers for each product might improve the lack of enthusiasm shown until now in embracing the e-tag application for marine equipment. The possibility to scan e-tags with a simple mobile phone might bring new opportunities to industry and administrations, especially to market surveillance authorities. In addition, the e-tag will minimise the possibility of installing non-compliant equipment on board. It is also worth mentioning that ISO has developed a standard to code MED e-tags which will facilitate its implementation.

6.3 Information exchange

- The exchange of information between Member States contributes to the maintenance of an appropriate safety level. For example, the implementation in 2023 of the requirement to report information relating to persons onboard to the National Single Window instead of to individual company systems, will facilitate SAR operations.

- The main challenge ahead is to continue improving the quality of the information exchanged via SafeSeaNet, and in particular to continue with the effort to reduce the number of mis-declared hazmat cargoes. This can only be achieved with the continuous support and engagement of national administrations and the shipping industry, particularly with more support from technology and awareness campaigns with the actors involved in (correctly) declaring the transportation of dangerous and polluting goods.

- To this end, EMSA makes available a Central Hazmat Database, in agreement with the IMO, offering a single location for all relevant actors from national authorities and industry to consult the substances classified under the IBC, IGC, IMSBC, IMDG codes and MARPOL Annex 1. During 2022, EMSA will also release a pilot project to electronically validate hazmat declarations and inform the users about possible errors with the declaration (wrong classification, missing details, etc.).

- In the coming years, the achievement of an actual European Maritime Single Window environment will lay the foundation for more accurate data exchanged between shipping actors, accompanied by a reduction of the administrative burden currently associated with reporting obligations. This will make it possible to improve the quality of the exchanged information and its timeliness and availability.

- New technologies and services are also being explored based on exchanged notifications and position reports. The further optimisation of digital data communications through the use of the VHF Data Exchange System (VDES), and new sources of information, such as satellite images, may complement existing land-based SAR services detecting e.g., EPIRB or man overboard alerts sent as AIS notifications which trigger alerts to maritime or SAR authorities.

6.4 Implementation of legislation

- The inspection regimes, including that of flag state, port state and the special EU survey system for RoPax and HSC engaged on regular voyages are at the cornerstone of the EU maritime safety policy. The effort made by all PSC inspectors in the EU is remarkable, from the smallest port to the gigantic terminals. The number of inspections carried out every year is above 14,000. To this number, the several thousands of flag inspections and those of the special regime for RoPax and HSC should be added. This effort deserves recognition as it creates an essential safety net to EU maritime transport. Sufficient resources and proper training programmes should be provided to ensure that the inspection effort is, at least, maintained.

- The efforts that go into EMSA's visits to Member States which serve to verify the implementation of EU legislation should not be disregarded. This exercise is far more than a mere 'control check'. It provides maritime administrations with the opportunity of becoming more efficient by learning from the best practices already in place in other Member States as well as of improving the safety performance. The horizontal analysis of a whole cycle of visits provides administrations with a safety benchmark against which they can compare their own operations. It also provides the EU legislator with first-hand feedback on the real issues being experienced when implementing EU law.

- Flag States are delegating more and more competencies, especially in the execution of statutory surveys, to recognised organisations. This means that part of the knowledge and experience of EU Flag States is being lost. This tendency reinforces the importance of at least retaining centralised EU expertise to ensure proper implementation of the international regulations. Sufficient resources should be kept for this important task. Similarly, the oversight of recognised organisations by EU Member States is also critical to ensure that the level of maritime safety is kept at an appropriate level. The IMO audits of flag states (IMSAS) show that with respect to the delegation of authority to RO, the most recurrent findings are related to weaknesses in the administration's oversight programme. Accordingly, it should be considered whether this activity should be strengthened.

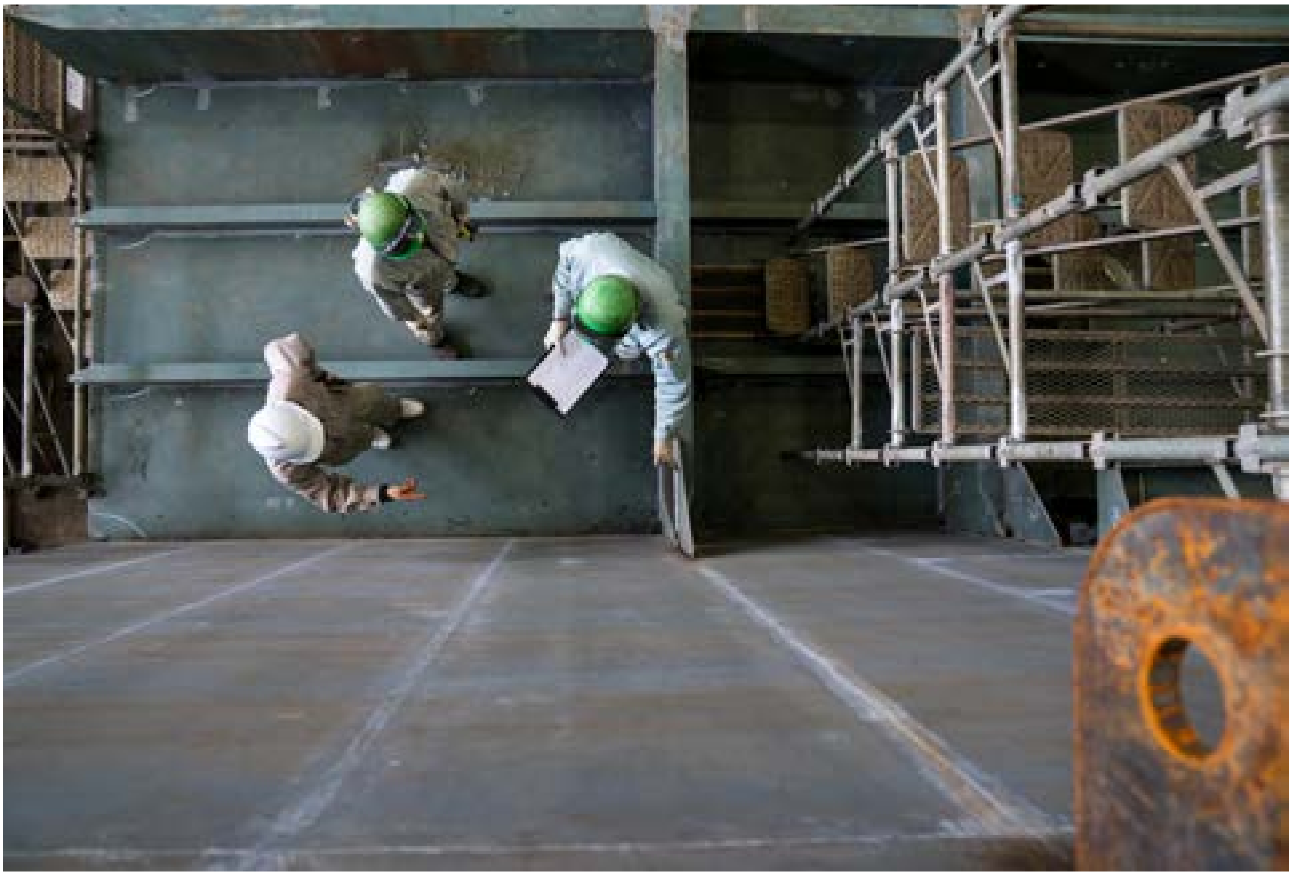
- Beyond the EU, a number of recognised organisations appear to be subject only to oversight by the respective recognising Flag State. According to a submission to the IMO from the Paris and Tokyo MoU, it could be concluded that this oversight is not effectively carried out by a number of flag states, resulting in certain instances of underperforming by organisations carrying out statutory survey and certification, with the subsequent consequence of having lower safety standards in practice. These ships can sail to/from EU ports, although they are still subject to PSC inspections.

- Non-SOLAS ships brought under EU MS flags should be subject to the safety standards applicable to new ships and not to old ones corresponding to the keel laying date. Throughout EMSA inspections, it was noted that this has not always been the case and has led to low-standard ships, a situation which should be avoided.

- During the COVID-19 pandemic, remote surveys were carried out for the first time with the aim of minimising the effect of a lack of physical inspections on safety. Some flag states have advocated for a continuation of this practice as it can save significant costs. However, there has been no harmonisation of the procedures. The EU submitted a proposal to IMO to limit the use of remote surveys to exceptional circumstances and subject to a subsequent physical check to ensure no decrease in safety level.

- The specific nature of fishing operations, working conditions and vessel design are factors that have not allowed to fully include fishing vessels in the scope of the various regulatory safety instruments implemented for conventional vessels. Fishing vessels under IMO and EU legislation are currently not included in the scope of Directive 2009/16/EC on Port State Control for example. With Port State Control cooperation under Memoranda of Understanding, the benefits of a harmonised port state control system have been demonstrated for conventional vessels. Therefore, the development of a port state control scheme for fishing vessels is an approach to be seriously considered. The integration of fishing vessels or establishment of a separate PSC MoU for fishing vessels is a topic that was raised by the Paris and Tokyo MoU and is currently being discussed by the Paris MoU through a dedicated task force to examine the most appropriate way of addressing the issue.

- The revision of the Flag State Directive (2009/21/EC) and Port State Directive (2009/16/EC) might bring new opportunities to increase the effectiveness and efficiency of these key instruments to ensure the proper implementation of safety legislation.



Source: Trevor Williams/DigitalVision/Getty Images

6.5 After the accident

- The possibilities offered by Places of Refuge in the event of an accident are a highly valuable resource to authorities, even though this naturally remains a sensitive topic. Improvisation should not be an option when dealing with accidents. This is why two very useful tools in this respect are the EU Operational Guidelines for Places of Refuge and the associated regular tabletop exercises.

- Digitalisation brings further opportunities to support decision makers in case of accidents. 24/7 emergency information services are available on the market, which in certain cases have the ability to remotely simulate the effect of the accident on a ship's structural strength, stability, etc.

- The COVID-19 pandemic demonstrated that the Place of Refuge concept, as currently defined, does not accommodate for a humanitarian health-related crisis of this nature. Appropriate consideration should be given to resolve this.

- Advanced technologies, like RPAS and satellite-based Earth Observation services, can bring new opportunities to make SAR more effective. EMSA already provides these services for other purposes and could be adapted to cover SAR operations more specifically.

- SAR procedures, including exercises and evacuation methods, should be updated as necessary to ensure that suitable measures are in place to tackle a potential mass evacuation taking into account current and future passenger ship sizes. This is even more relevant in remote areas, such as the polar regions.

- SAR co-operation plans (SARCP) for passenger ships in domestic voyages are not mandatory. These ships can carry thousands of passengers. The possibility should be considered to exchange best practices in this field.

- With regard to accident investigation, EMSA is exploring the option of providing operational support for the investigation of very serious and serious marine casualties using remotely operated underwater vehicles.

- Lastly, it is important that accident investigators are kept up to date with the impact of new technologies on safety. This will be necessary for the accident investigation process, particularly for incidents involving autonomous ships, alternative fuels transported as cargo or for propulsion, and ship electrification.

6.6 Decarbonisation

- Efforts to reach emission targets as part of the European Green Deal should go hand-in-hand with those to keep ships safe, especially given that the use of new fuels and power technologies come with associated safety risks. This report has addressed in depth the specific safety challenges associated with the use of alternative fuels – including LNG, hydrogen, LPG, methanol, ammonia and biofuels – and fuel cells onboard ships.

- Electrification in shipping is also considered in detail. The two sides of the problem need to be analysed: on the one hand, the safety risks due to the installation of high-capacity batteries onboard ships; and, on the other, the risks coming from the interface between onshore charging stations and the ship itself.

- EMSA, at the request of the European Commission, is developing Shore-Side Electricity Guidelines addressing mainly the port side. In addition, the Agency will start a new initiative looking at the safety implications of installing electrical energy storage (e.g., batteries) as primary energy sources onboard ships.

- Investments in new skills are critical to ensure that workers are prepared and protected in the process of introducing new fuels and their handling procedures. Seafarers will need to have the right skills to handle new, complex, hybrid and zero emission systems. Any gaps in this area could pose serious health and safety risks and hamper the energy transition.

7. Concluding remarks

The value of this report lies in bringing together in the one place the main challenges and opportunities facing maritime safety, thereby giving policymakers, regulators, industry, authorities or any other interested party the possibility of gaining an overall perspective on maritime safety.

While there is no such thing as perfect safety, all-in-all, the EU can be said to have a robust maritime safety system. Still, there is no room for complacency. Resources must continue to be made available and efforts undertaken in this respect. Accident statistics remind us that it does not matter how strong safety standards are, how complete inspections efforts are or how well-trained seafarers are, accidents still happen and in large numbers. The sea is a challenging environment which does not forgive any matter overlooked. The laws of physics are constantly at work, with the ship's centre of gravity always a concern and fire only needs three friends - fuel, oxygen and temperature – to have a devasting effect on the ship.

As can be seen in this report, the EU's maritime transport sector is still healthy. Nevertheless, certain signs of stagnation have been observed, not only in terms of shipbuilding but also in terms of the fleet itself. The growth pace of the fleet registered by companies based in EU Member States is lower than that of the world fleet. EU Member State flags are also delegating more and more their surveying responsibilities to recognised organisations. This means a gradual transfer of knowledge and experience from public administrations to private entities. While not a cause for concern in itself, this does imply a need for increased monitoring of these entities, not only at EU level but also worldwide, as any ship can call at an EU port.

Given the number of challenges and opportunities that lie ahead, the cooperation of industry and public administrations is required. Acting in isolation will not achieve effective solutions to the issues raised in relation to the human element, ship safety, information exchange and implementation.

In spite of all the prevention measures in place, it is fundamental to have a safety net to respond to incidents. The places of refuge concept and search and rescue services, under the competence of the EU Member States, are fundamental pillars of incident response management.

Accident investigation analysis affords insights, the value of which is difficult to quantify. In this respect, the European Maritime Casualty Information Platform (EMCIP) is likely to be the most complete database of its kind in existence. Given the number of ships in the EU Member States fleet and the number of port calls, authorities should not undervalue the time and effort dedicated to this activity. Information can save lives.

Finally, the future is practically the present. Autonomous shipping, together with the use of alternative fuels to minimise harmful air emissions, might well revolutionise the maritime world as it is currently stands. In the next 10 to 15 years, there might be a change similar to when steam replaced sails. The implications both technologies will have are difficult to fully predict, but there will probably be a gradual shift of maritime personnel from sea to shore, and the subsequent need to train current and new maritime professionals in these technological changes. The EMSA Academy can be one of the institutions to accompany maritime staff in this change.

To address all these challenges in the EU, EMSA will continue being a reliable partner with which to work. The Agency will continue investing in knowledge and technology to ensure that the EU maritime safety landscape not only maintains its high level of standards but also seeks to improve and make it more efficient.

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List of abbreviations

A

AI	Accident Investigation
AIB	Accident Investigation Body

B

BIMCO	Baltic and International Maritime Council

C

CDI	Chemical Distribution Institute

D

DG MARE	Directorate-General for Maritime Affairs and Fisheries

E

EC	European Commission
EMSA	European Maritime Safety Agency
EMTER	European Maritime Transport Environmental Report
EU	European Union
EU MS Flag	Refers to a flag of any EU Member State, Iceland and/or Norway
EU RO	Refers to any Recognised Organisation (RO) by the European Union

F

FAL	IMO Facilitation Committee
FAO	Food and Agriculture Organization
FSA	Formal Safety Assessment

G

GBS	Goal-based standards
GISIS	Global Integrated Shipping Information System

H

HSC	High Speed passenger Craft, unless otherwise specified

I

IACS	International Association of Classification Societies
ILO	International Labour Organization
IMO	International Maritime Organization
ISM	International Safety Management Code
IUMI	International Union of Marine Insurance

L

LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas

M

MASS	Maritime Autonomous Surface Ships
MED	Marine Equipment Directive
MS	Member States
MSA	Market Surveillance Authorities
MSC	Maritime Safety Committee

O

OCIMF	Oil Companies International Marine Forum

P

Paris MoU	Paris Memorandum of Understanding on Port State Control
PCF	The Permanent Cooperation Framework for the Investigation of Accidents in the Maritime Transport Sector
PSC	Port State Control

R

RO	Recognised Organisation
RoPax	Roll-on/roll-off cargo and Passenger ship
Ro-Ro	Roll-on/Roll-off cargo ship

S

SAR	Search and Rescue

V

VTS	Vessel Traffic Service

W

WSC	World Shipping Council

List of EU Recognised Organisations

ABS	American Bureau of Shipping
BV	Bureau Veritas SA – Registre international de classification de navires et d'aéronefs
CCS	China Classification Society
CRS	Croatian Register of Shipping
DNV	Det Norske Veritas and legacy companies.
IRCLASS	Indian Register of Shipping
KR	Korean Register of Shipping
LR	Lloyd's Register
ClassNK	Nippon Kaiji Kyokai General Incorporated Foundation
PRS	Polish Register of Shipping (Polski Rejestr Statków)
RINA	RINA Services S.p.A - Registro Italiano Navale
RS	Russian Maritime Register of Shipping

List of project and study acronyms

AEGIS "Accelerating EU-US Dialogue for Research and Innovation in Cybersecurity and Privacy", a Horizon 2020 project in a consortium made of top EU and US experts in policy, research, academia and the industry.

CARGOSAFE "Study Investigating Cost Efficient Measures for Reducing the Risk from Cargo Fires on Container Vessels", launched by EMSA.

Equasis "Electronic Quality Shipping Information System", online worldwide database giving details on port state control inspections, ship-related information from classification societies and P&I (Insurance) ship specific data.

EMCIP The European Casualty Information Platform

FIRESAFE I and II "Fire safety in ro-ro passenger ships", commissioned by EMSA, have been the basis of the IMO work on reviewing and updating the fire safety standards of ro-ro passenger ships.

H2H "Hull to Hull" project,

HUMANE "Human Maritime Autonomy Enable", a shared cost project by the Western Norway University of Applied Sciences.

LASH FIRE "Legislative Assessment for Safety Hazards of Fire and Innovations in Ro-ro ship Environment", funded by Horizon 2020

MOSES "AutoMated Vessels and Supply Chain Optimisation for Sustainable Short Sea Shipping"

MUNIN "Maritime Unmanned Navigation through Intelligence in Networks", project co-funded by the EC under its Seventh Framework Programme.

PREPaRE SHIPS "Predicted Positioning Based on the European Global Navigation Satellite System (EGNSS) for Ships" project, funded by the European GNSS Agency.

RBAT MASS "A Functional, Study Developing a Risk-Based Assessment Tool for MASS", commissioned by EMSA.

SafeSeaNet (SSN) The European Union's Maritime Information and Exchange System managed by EMSA

SAFEMASS Study of the risk and regulatory issues of specific cases of MASS, conducted by DNV, commissioned by EMSA.

SAFEMODE "Strengthening synergies between Aviation and maritime in the area of human Factors towards achieving a more Efficient and resilient MODE of transportation", conducted by DeepBlue, commissioned by the EC.

SFI AUTOSHIP "Autonomous ships for safe and sustainable operations"

STEERSAFE Steering and Manoeuvrability Study, conducted by DNV, commissioned by EMSA.

THETIS "The Hybrid European Targeting and Information System"

THETIS-EU The branch of the main THETIS system which provides solely for inspections under EU legislation other than the PSC directive.

EMSAFE – ANNEXES

List of Annexes

Annex 1 European policies and their focus

Directive/Regulation	Policy objectives and targets	Domain
Directive 2008/106/EC	Transposes the STCW Convention (education, training and certification of seafarers).	Human element
Regulation (EC) No 336/2206	On the implementation of the ISM Code within the EU.	Human element
Directive 2009/13/EC	Implementing the Agreement concluded by the European Community Shipowners' Associations (ECSA) and the European Transport Workers' Federation (ETF) on the Maritime Labour Convention, 2006, and amending Directive 1999/63/EC.	Human element
Directive 2013/54/EU	Concerning certain flag State responsibilities for compliance and enforcement of the Maritime Labour Convention, 2006.	Human element
Directive 2009/45/EC	Safety rules and standards for passenger ships.	Ship safety standards
Directive 2003/25/EC	Specific stability requirements for ro-ro passenger ships.	Ship safety standards
Directive 98/41/EC	Registration of passengers	Ship safety standards
Regulation (EU) No 530/2012	The accelerated phasing-in o double hull or equivalent design requirements for single hull oil tankers.	Ship safety standards
Directive 2001/96/EC	Requirements and procedures for the safe loading and unloading of bulk carriers.	Ship safety standards
Directive 97/70/EC	Safety regime for fishing vessels of 24 metres in length and over.	Ship safety standards
Directive 93/103/EC	Minimum safety and health requirements for work on board fishing vessels.	Ship safety standards
Directive 20014/90/EU	Marine Equipment Directive	Marine equipment
Regulation (EU) 2021/1158	Design, construction, performance requirements and testing standards for marine equipment.	Marine equipment
Regulation (EU) 2018/608	Technical criteria for electronic tags for marine equipment.	Marine equipment
Regulation (EU) 2018/414	The identification of specific items of marine equipment which can benefit from electronic tagging.	Marine equipment
Directive 2002/59/EC	Establishes a vessel traffic monitoring and information system with a view to enhancing the safety and efficiency of maritime traffic, improving the response of authorities to incidents, accidents or potentially dangerous situations at sea, including search and rescue operations, and contributing to a better prevention and detection of pollution by ships.	Traffic monitoring and information systems

Directive 2010/65/EU	To simplify and harmonise the administrative procedures applied to maritime transport by making the electronic transmission of information standard and by rationalising reporting formalities, for ships arriving in and ships departing from ports situated in Member States.	Traffic monitoring and information systems
Regulation 2019/1239 repealing Directive 2010/65/EU	It introduces an interoperable environment with harmonised interfaces, to simplify reporting obligations for ships arriving at, staying in and departing from EU ports. It also aims to improve the European maritime transport sector's competitiveness and efficiency by reducing administrative burden, introducing a simplified digital information system to harmonise the existing national systems and reduce the need for paperwork.	Traffic monitoring and information systems
Directive 2009/21/EC	Flag State Directive.	Flag state and ROs
Directive 2009/15/EC	Common rules and standards for ship inspection and survey organisations and for the relevant activities of maritime administrations.	Flag state and ROs
Reg. 391/2009	Common rules and standards for ship inspection and survey organisations.	Flag state and ROs
Regulation (EU) 2019/492	Amending Regulation (EC) No 391/2009 with regard to the withdrawal of the United Kingdom from the Union	Flag state and ROs
Reg. 788/2014	Laying down detailed rules for the imposition of fines and periodic penalty payments and the withdrawal of recognition of ship inspection and survey organisations pursuant to Articles 6 and 7 of Regulation (EC) No 391/2009 of the European Parliament and of the Council.	Flag state and ROs
Reg. 336/2006	Implementation of the International Safety Management Code within the Community	Flag state and ROs
Directive 2009/16/EC	Port State Control regime at EU level.	Port State Control
Directive (EU) 2017/2110	A system of inspections for the safe operation of ro-ro passenger ships and high-speed passenger craft in regular service.	Passenger ship safety
EU Operational Guidelines on Places of Refuge	Provides guidance for competent authorities and the main parties involved in managing a request for a place of refuge from a ship in need of assistance.	Places of refuge
Directive 98/41/EC	Provision of number of people onboard passenger ships and their personal information, facilitating the management of SAR operations.	SAR
Regulation (EU) No. 656/2014	Rules for surveillance of the external sea borders in the context of operational cooperation.	SAR
Directive 2009/18/EC	Fundamental principles governing the investigation of accidents in the Maritime transport sector in EU.	Accident investigation
Regulation 1286/2011	Adopts a common methodology for investigating marine casualties and incidents developed pursuant to Article 5(4) of Directive 2009/18/EC.	Accident investigation
Regulation 651/2011	Adopts the rules of procedure of the permanent cooperation framework (PCF) established by Member States in cooperation with the Commission pursuant to Article 10 of Directive 2009/18/EC.	Accident investigation

Annex 2

EU fleet per flag

Table A2. 1: Number of ships per EU MS flag excluding fishing vessels – Size of fleet in 2020 and evolution over the past 5 years.

Country	2020	2016-2020
Belgium	210	180 – 210
Bulgaria	51	55 – 51
Croatia	331	277 – 331
Cyprus	1,023	1001 – 1023
Denmark	755	677 – 755
Estonia	61	63 – 61
Finland	251	249 – 251
France	509	470 – 509
Germany	548	582 – 548
Greece	1,151	1209 – 1151
Ireland	99	74 – 99
Italy	1,200	1342 – 1200
Latvia	65	58 – 65
Lithuania	53	48 – 53
Luxembourg	156	161 – 156
Malta	2,099	2144 – 2099
Netherlands	1,124	1158 – 1124
Poland	110	113 – 110
Portugal	716	472 – 716
Romania	78	67 – 78
Slovenia	7	5 – 7
Spain	522	459 – 522
Sweden	354	324 – 354
Iceland	36	1 – 36
Norway	1,589	1474 – 1589

Table A2. 2: Total number of fishing vessels by EU country and by size (excluding Norway and Iceland).

Country	No. of vessels	<15 m	15-24 m	>24 m
Belgium	64	2	30	32
Bulgaria	1,828	1,770	47	11
Croatia	7,543	7,247	191	105
Cyprus	806	782	18	6
Denmark	2,036	1,792	178	66
Estonia	1,831	1,798	8	25
Finland	3,142	3,104	19	19
France	6,240	5,560	487	193
Germany	1,292	1,054	189	49
Greece	14,634	14,089	370	173
Ireland	2,033	1,820	100	113
Italy	12,154	10,696	1,139	319
Latvia	663	606	11	46
Lithuania	139	104	4	31
Malta	883	834	40	9
Netherlands	834	374	209	251
Poland	823	697	77	49
Portugal	7,715	7,254	287	174
Romania	175	170	1	4
Slovenia	136	130	6	0
Spain	8,839	7,156	996	687
Sweden	1,136	1,037	68	31
Norway	5,857			
Iceland	1,561			

Table A2. 3: Number of fishing vessels by age of each EU country (excluding Norway and Iceland).

Country	<5 years	5-14 years	15-25 years	>25 years
Belgium	0	3	18	43
Bulgaria	77	434	547	770
Croatia	70	617	808	6,038
Cyprus	10	55	257	484
Denmark	75	181	238	1,542
Estonia	108	343	483	897
Finland	134	485	585	1,938
France	293	916	1,599	3,432
Germany	35	101	262	894
Greece	108	1,351	3,487	9,688
Ireland	54	218	576	1,185
Italy	143	1,075	1,930	9,006
Latvia	5	12	91	555
Lithuania	10	10	14	105
Malta	15	91	307	470
Netherlands	33	87	195	514
Poland	2	137	142	542
Portugal	156	758	2,127	4,673
Romania	26	57	33	59
Slovenia	0	0	0	136
Spain	189	842	2,759	5,047
Sweden	21	63	137	915

Detailed characteristics of the fleet of each EU MS flag in 2020, excluding fishing vessels.

Belgium

There are 210 ships registered with the flag of Belgium corresponding to 2% of the total EU MS fleet.

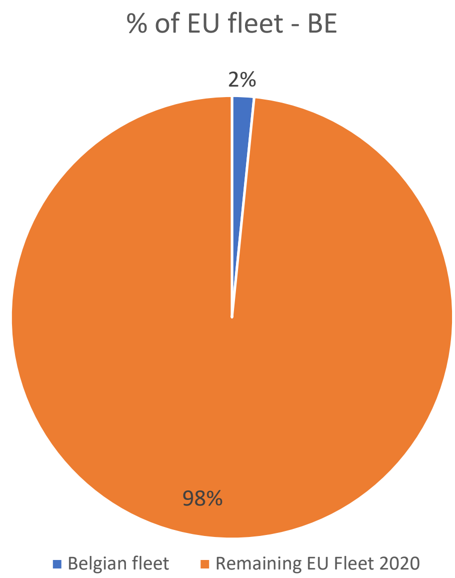
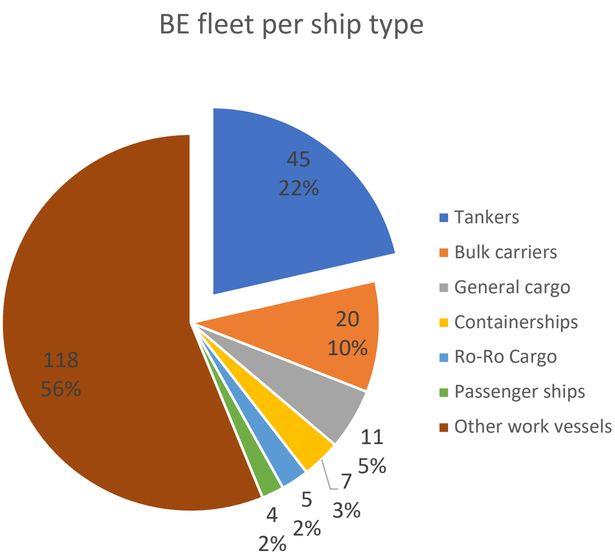
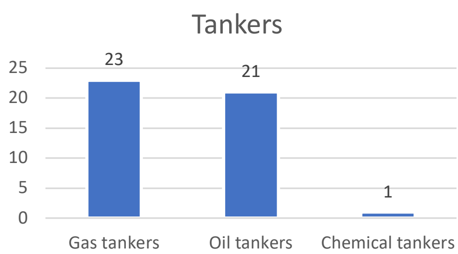


Figure A2. 1: Share of the flag of Belgium in EU MS fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Belgium are other work vessels, tankers and bulk carriers.

Out of the 45 tankers, the majority are either gas or oil tankers. There are no Ro-Pax nor HSC part of the Belgian fleet.





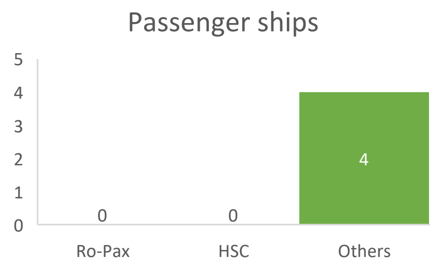
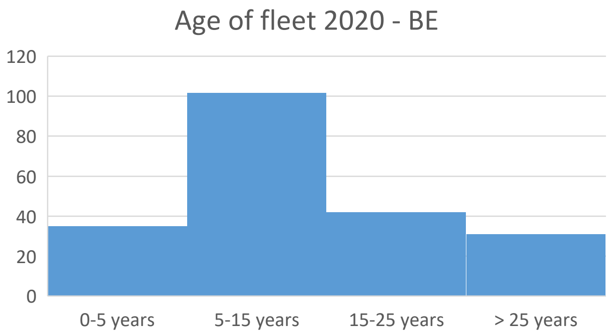


Figure A2. 2: Belgian fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Belgium is in the figures below.



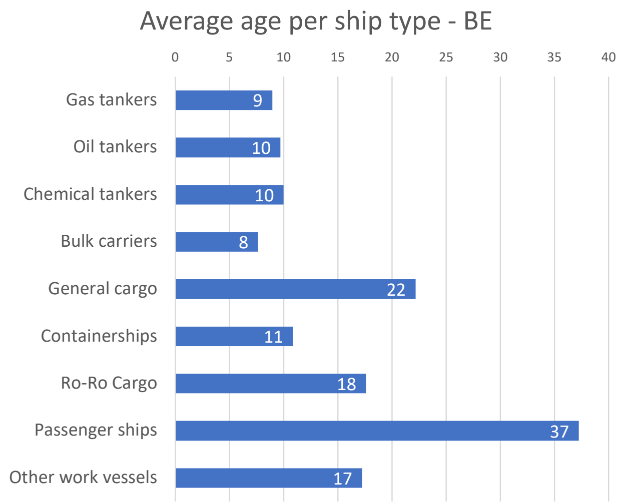


Figure A2. 3: Age of fleet with the flag of Belgium. Overall and average age per ship type.

The percentage of the ships other than fishing vessels with the flag of Belgium that belongs to shipowners registered in the country is shown below.

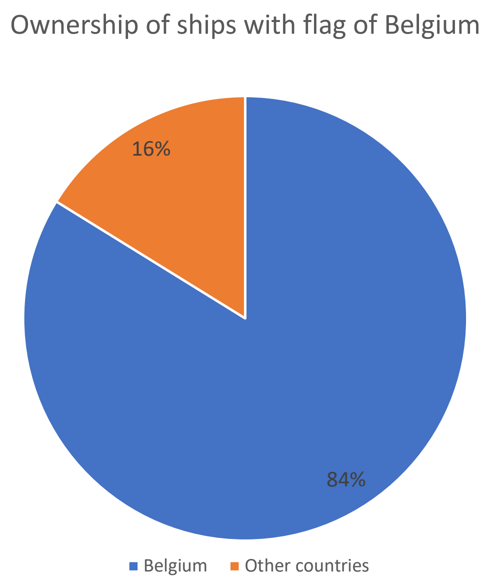
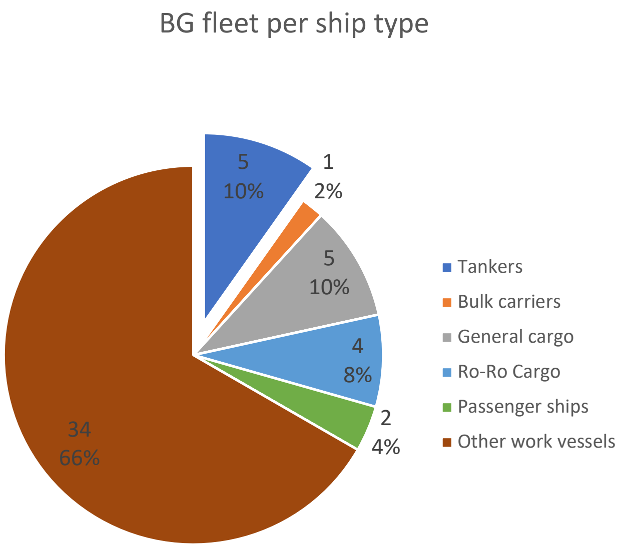
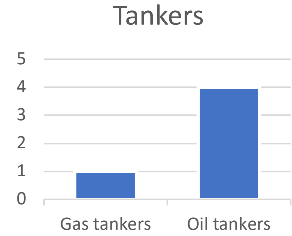


Figure A2. 4: Percentage of Belgian fleet owned by the shipowners of Belgium.

Bulgaria

There are 51 ships registered with the flag of Bulgaria. The division of those per ship type is shown below. Most ships flying the flag of Bulgaria are other work vessels. The fleet includes 5 tankers and 2 passenger ships being one Ro-Pax and one HSC.





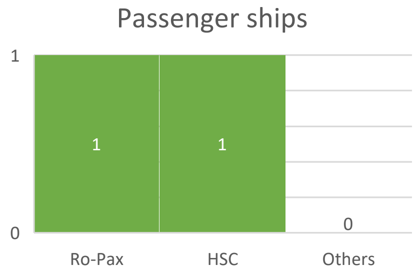
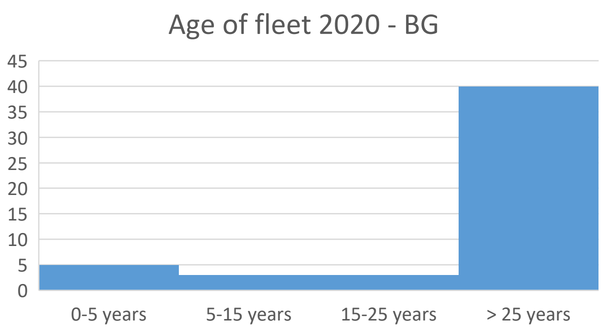


Figure A2. 5: Bulgarian fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Bulgaria is below.



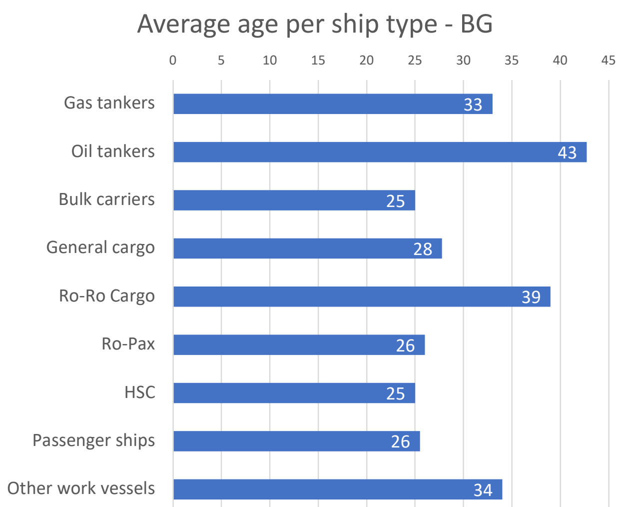


Figure A2. 6: Age of fleet with the flag of Bulgaria. Overall and average age per ship type.

All ships with the Bulgarian flag belong to shipowners based in Bulgaria.

Croatia

There are 331 ships registered with the flag of Croatia corresponding to 3% of the total EU MS fleet.

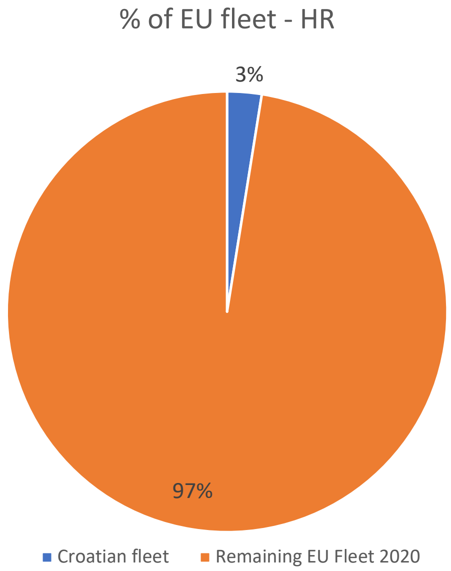


Figure A2. 7: Share of the flag of Croatia in EU MS fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Croatia are passenger ships, followed by other work vessels and tankers out of which the majority is chemical tankers. There are 51 Ro-Pax and 8 HSC ships part of the Croatian fleet.

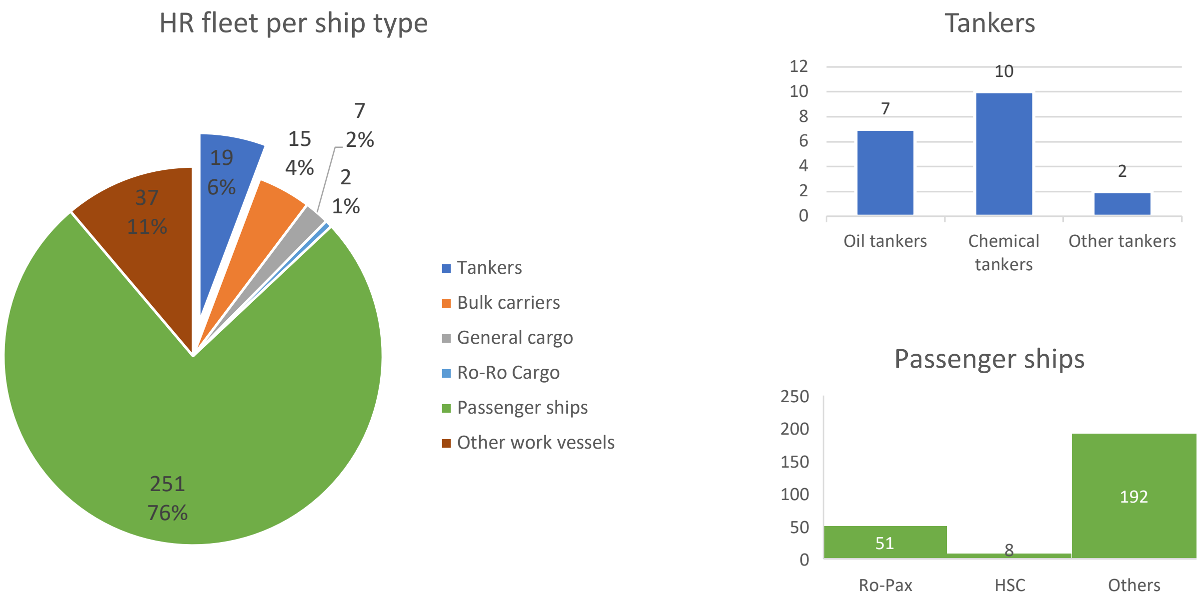


Figure A2. 8: Croatian fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The passenger ships of Croatia correspond to 10% of the total EU MS fleet of that ship type in number of ships.

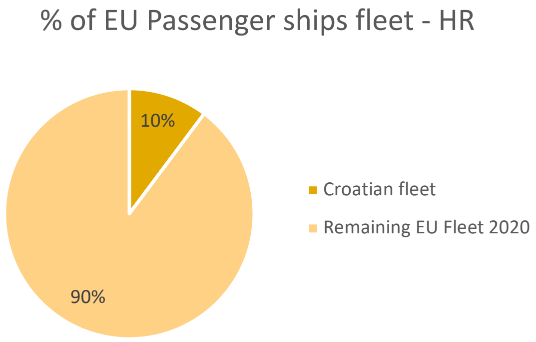
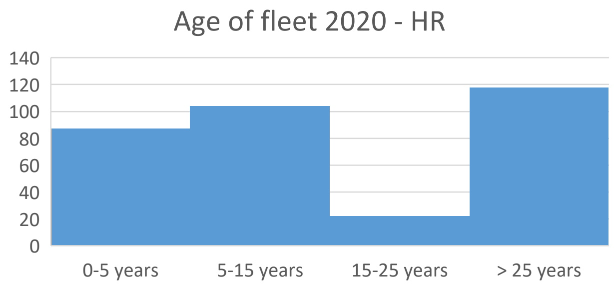


Figure A2. 9: Share of the flag of Croatia in the EU MS Passenger ships fleet.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Croatia is below.



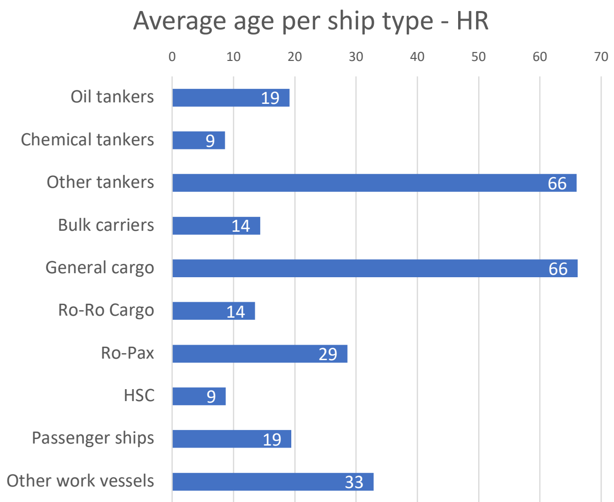


Figure A2. 10: Age of fleet with the flag of Croatia. Overall and average age per ship type.

The percentage of ships with the flag of Croatia that belongs to shipowners registered in the country is shown below.

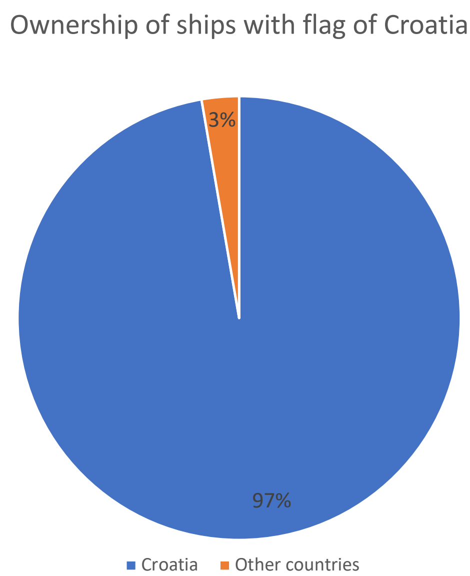


Figure A2. 11: Percentage of Croatian fleet owned by the shipowners of Croatia.

Cyprus

There are 1023 ships registered with the flag of Cyprus corresponding to 8% of the EU MS Fleet.

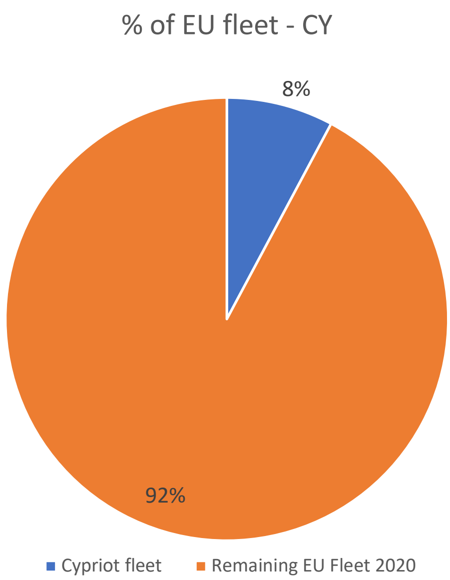


Figure A2. 12: Share of the flag of Cyprus in EU MS fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Cyprus are bulk carriers (26%) followed by general cargo vessels (18%), containerships (18%) and other work vessels (17%). There are 83 passenger ships including 58 Ro-Pax and 20 HSC ships part of the Cypriot fleet.

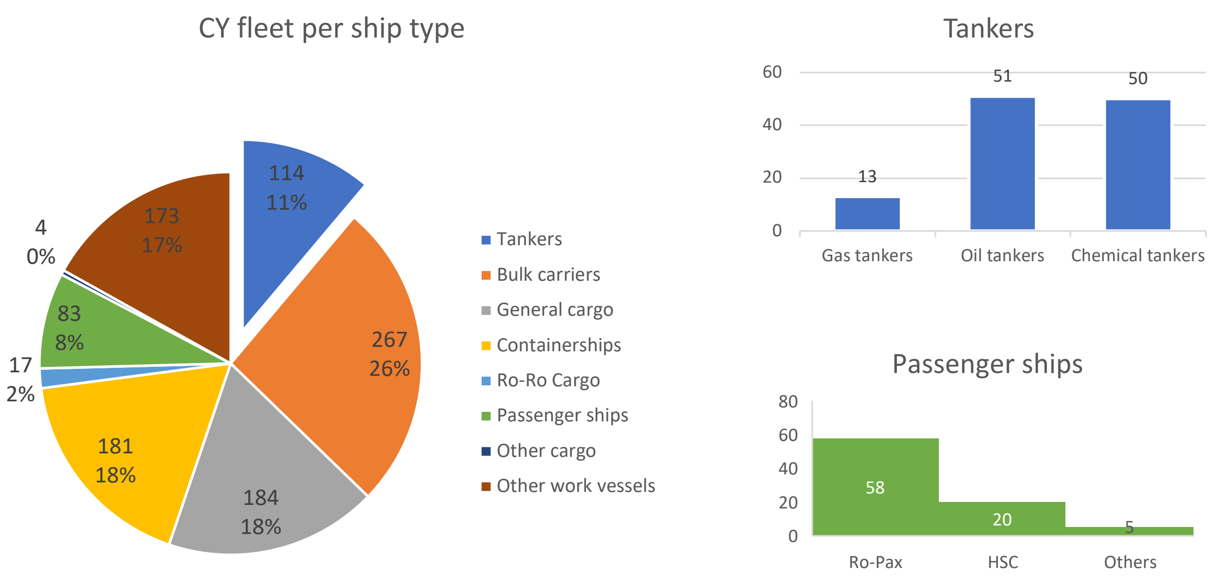


Figure A2. 13: Cypriot fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The bulk carriers of Cyprus correspond to 21% of the EU MS fleet of that ship type in terms of number of ships and there are also significant shares of the fleets of general cargo ships and containerships flying that flag.

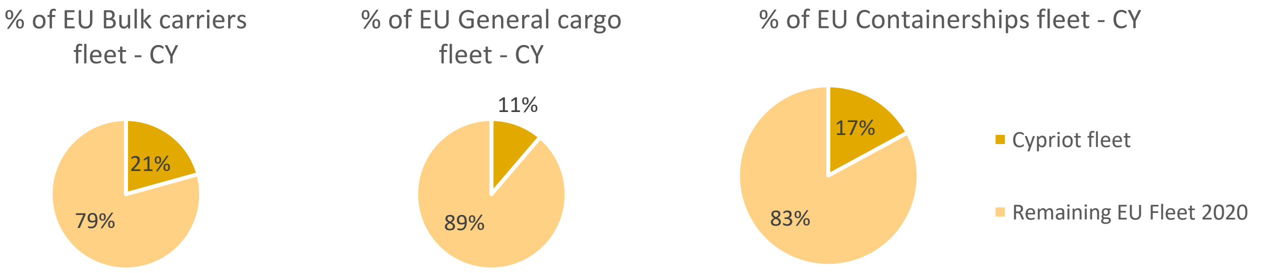
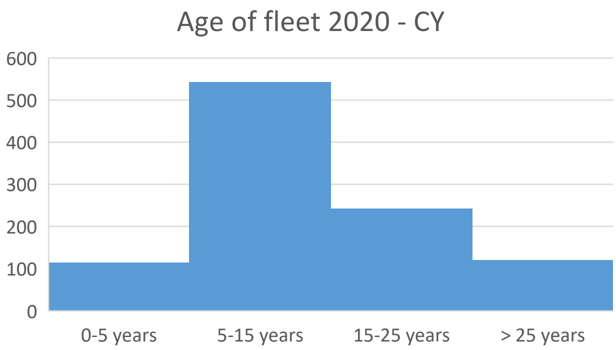


Figure A2. 14: Share of the flag of Cyprus in the EU MS bulk carriers, general cargo vessels and containerships fleets.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Cyprus is below.



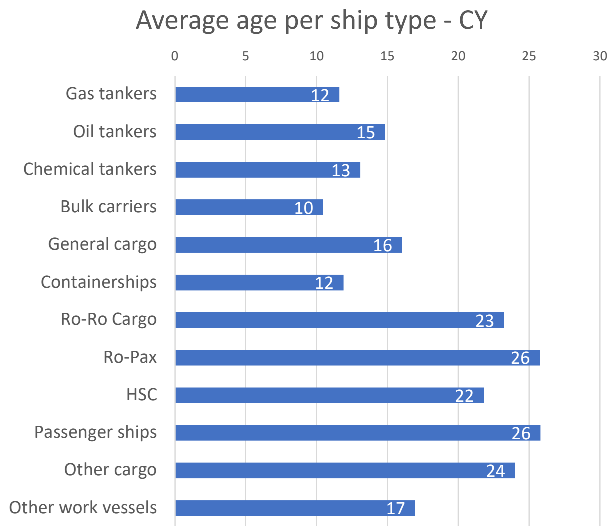
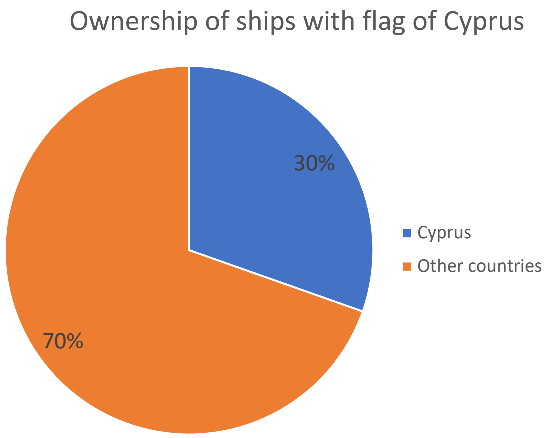


Figure A2. 15: Age of fleet with the flag of Cyprus. Overall and average age per ship type.

The percentage of ships with the flag of Cyprus that belongs to shipowners registered in the country is shown below. That percentage has been steadily growing in the past 5 years. In addition, 11% of the ships with the flag of Cyprus belongs to shipowners outside the EU.



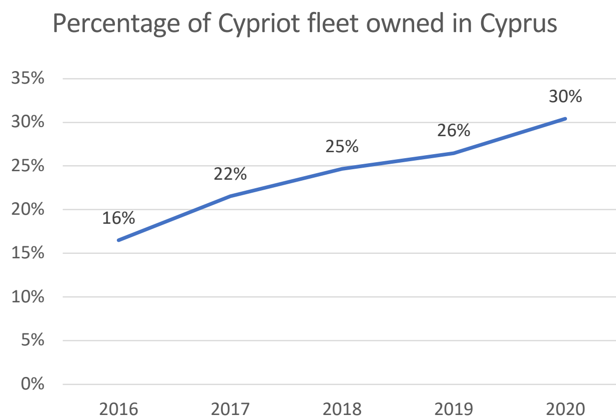
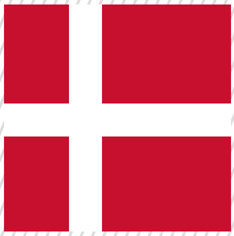


Figure A2. 16: Percentage of Cypriot fleet owned by the shipowners of Cyprus. Evolution over the past 5 years.

Denmark



There are 755 ships registered with the flag of Denmark corresponding to 6% of the total EU MS fleet.

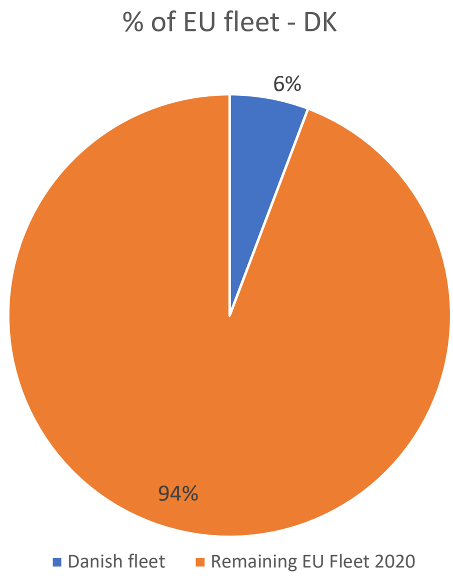


Figure A2. 17: Share of the flag of Denmark in EU MS fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Denmark are other work vessels (32%) followed by tankers (27%) and containerships (19%). There are 97 passenger ships including 64 Ro-Pax and 5 HSC ships part of the Danish fleet.

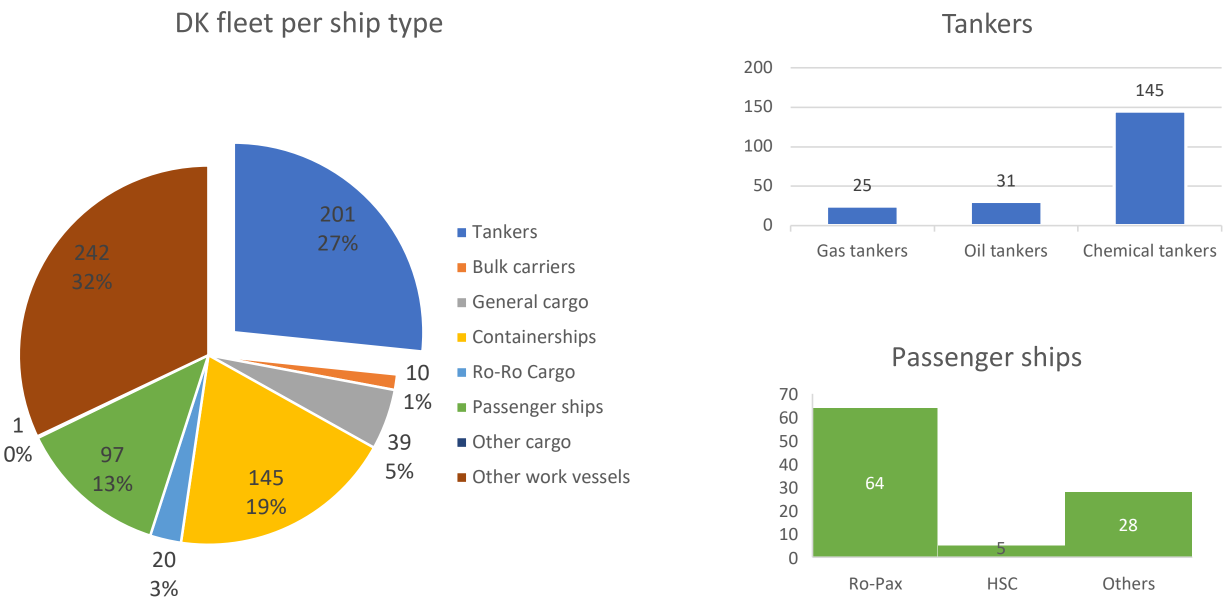


Figure A2. 18: Danish fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The chemical tankers of Denmark correspond to 14% of the EU MS fleet of that ship type in terms of number of ships and there is also a similar share of the fleet of containerships flying that flag.

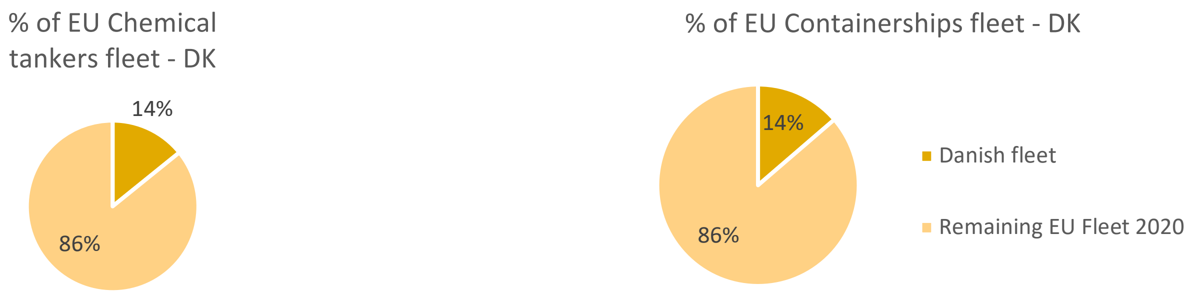
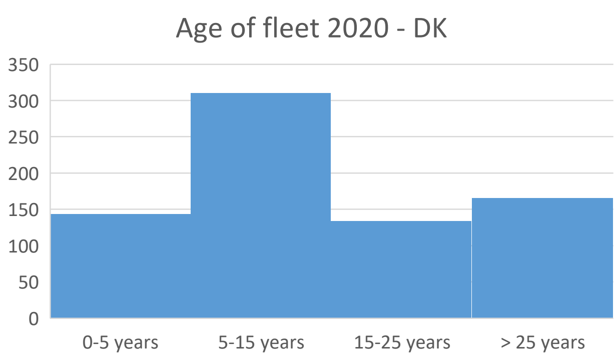


Figure A2. 19: Share of the flag of Denmark in the EU MS chemical tankers and containerships fleets.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Denmark is below.



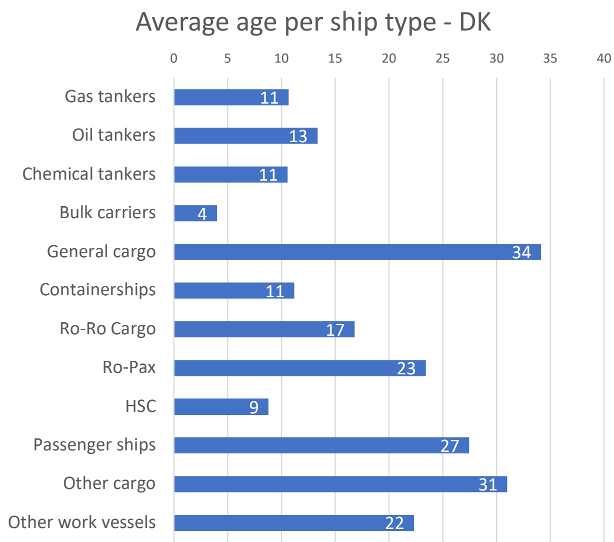


Figure A2. 20: Age of fleet with the flag of Denmark. Overall and average age per ship type.

The percentage of ships with the flag of Denmark that belongs to shipowners registered in the country is shown below.

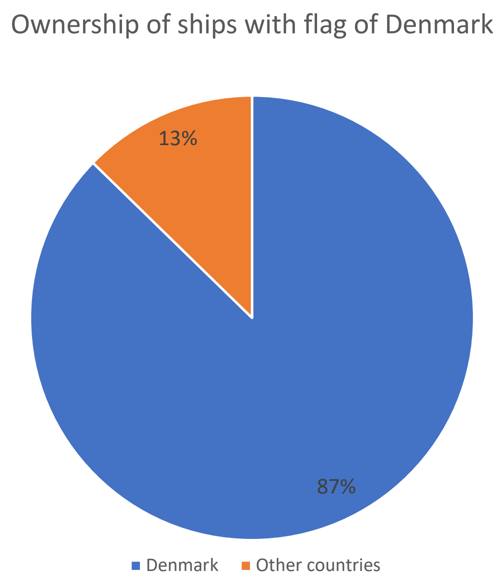
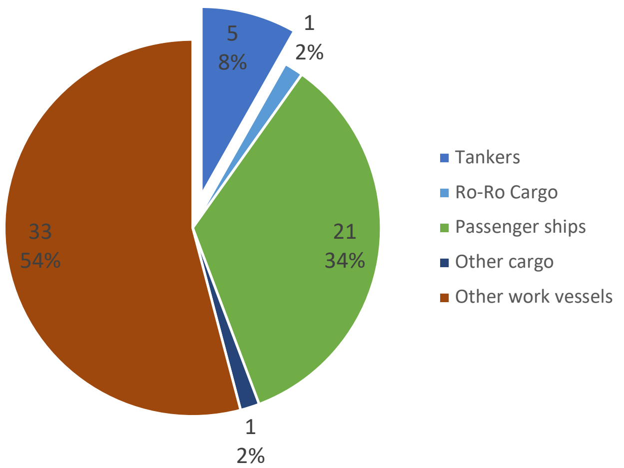


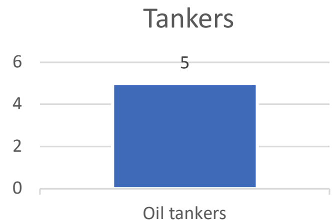
Figure A2. 21: Percentage of Danish fleet owned by the shipowners of Denmark.

Estonia

There are 61 ships registered with the flag of Estonia.

The division of those per ship type is shown below. Most ships flying the flag of Estonia are other work vessels (54%) and passenger ships (34%). There are 21 passenger ships including 20 Ro-Pax and 5 oil tankers part of the Estonian fleet.





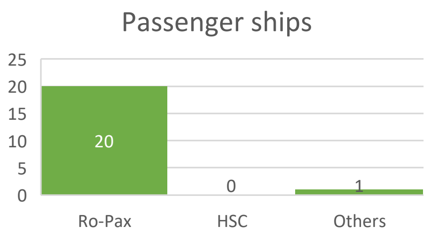
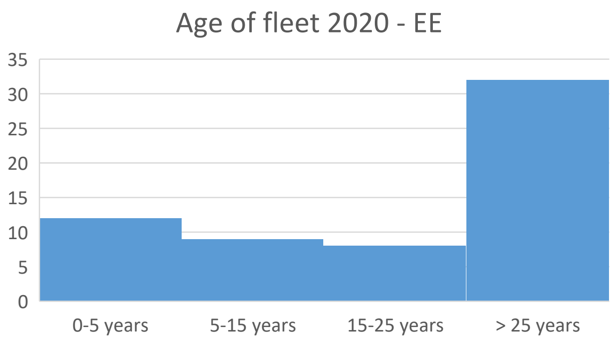


Figure A2. 22: Estonian fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Estonia is below.



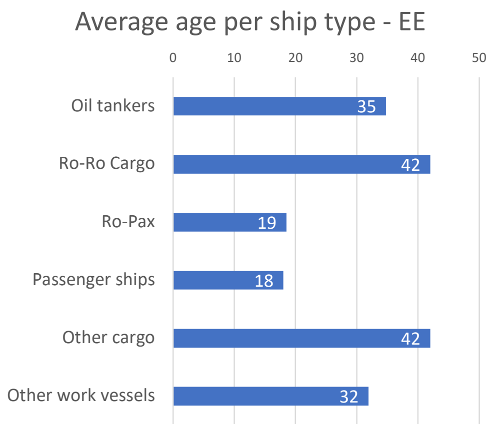


Figure A2. 23: Age of fleet with the flag of Estonia. Overall and average age per ship type.

The percentage of ships with the flag of Estonia that belongs to shipowners registered in the country is shown below.

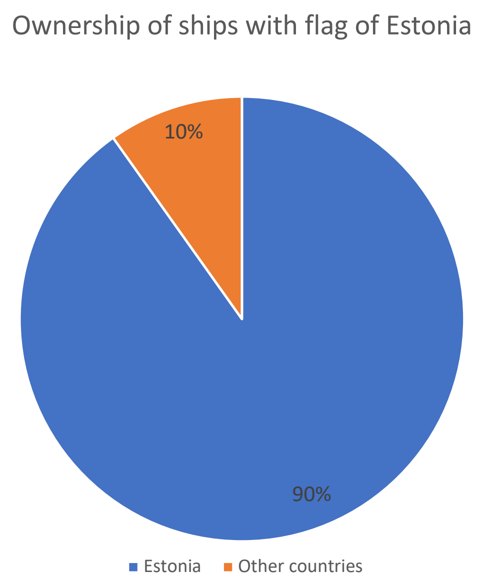


Figure A2. 24: Percentage of Estonian fleet owned by the shipowners of Estonia.

Finland

There are 251 ships registered with the flag of Finland corresponding to 2% of the EU MS fleet.

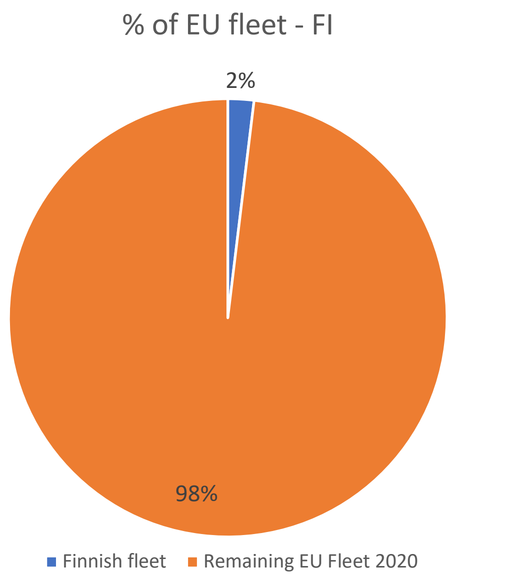


Figure A2. 25: Share of the flag of Finland in EU MS fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Finland are other work vessels (40%) passenger ships (27%), general cargo (15%) and Ro-Ro cargo ships (11%).

There are 67 passenger ships including 51 Ro-Pax and 16 HSC ships part of the Finnish fleet that correspond to 4% of the total EU MS passenger transport capacity.

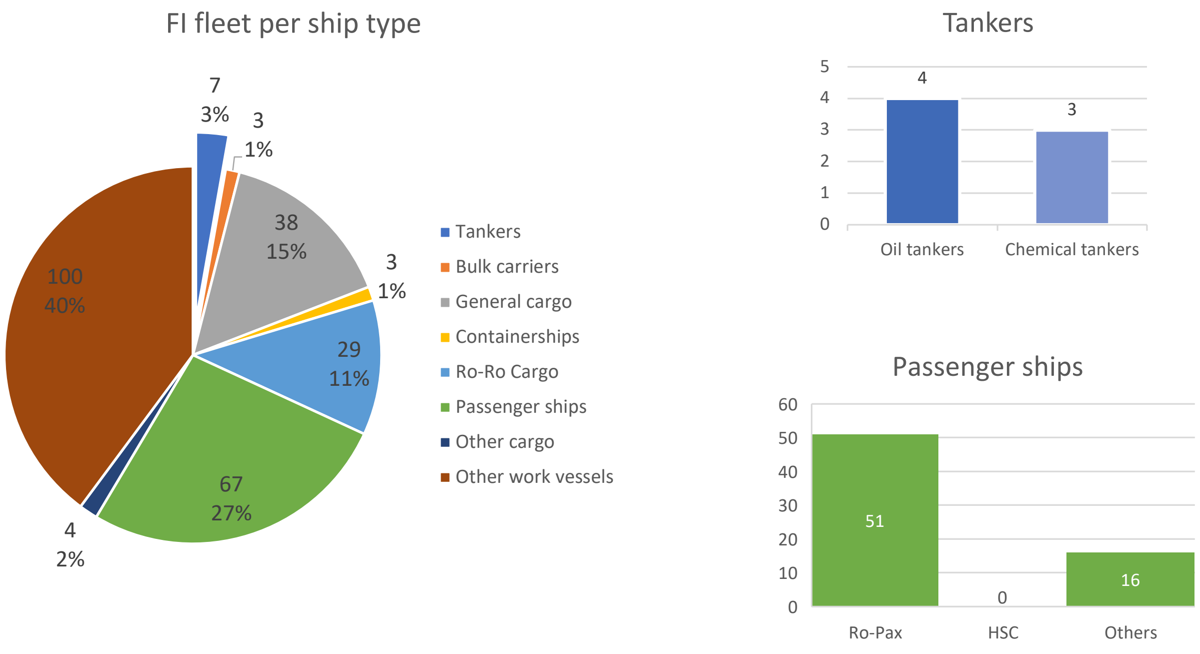
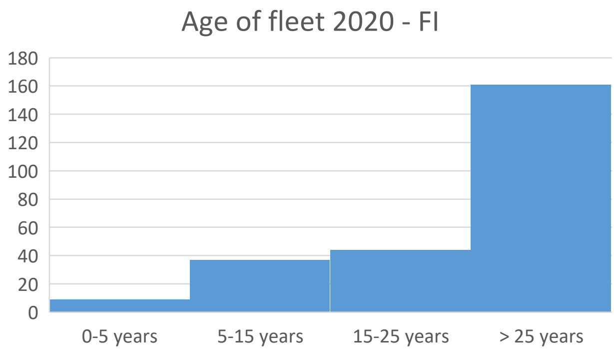


Figure A2. 26: Finnish fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Finland is below.



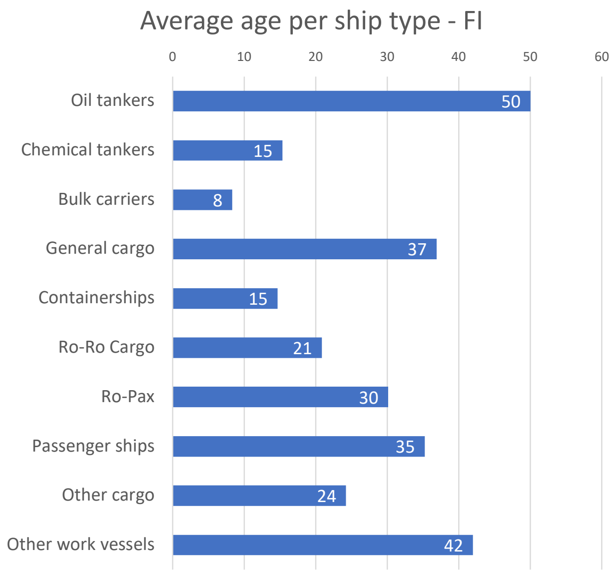


Figure A2. 27: Age of fleet with the flag of Finland. Overall and average age per ship type.

The percentage of ships with the flag of Finland that belongs to shipowners registered in the country is shown below.

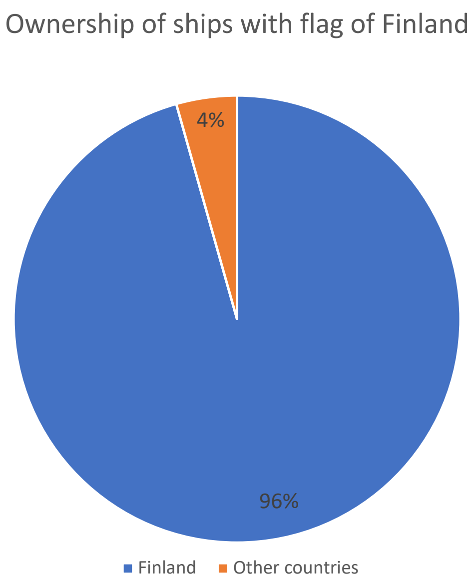


Figure A2. 28: Percentage of Finnish fleet owned by the shipowners of Finland.

France

There are 509 ships registered with the flag of France corresponding to 4% of the EU MS fleet.

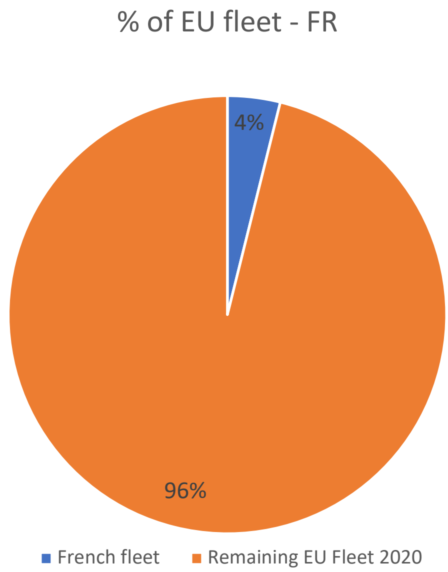


Figure A2. 29: Share of the flag of France in EU MS fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of France are other work vessels (54%) and passenger ships (23%).

There are 116 passenger ships including 48 Ro-Pax and 18 HSC part of the French fleet.

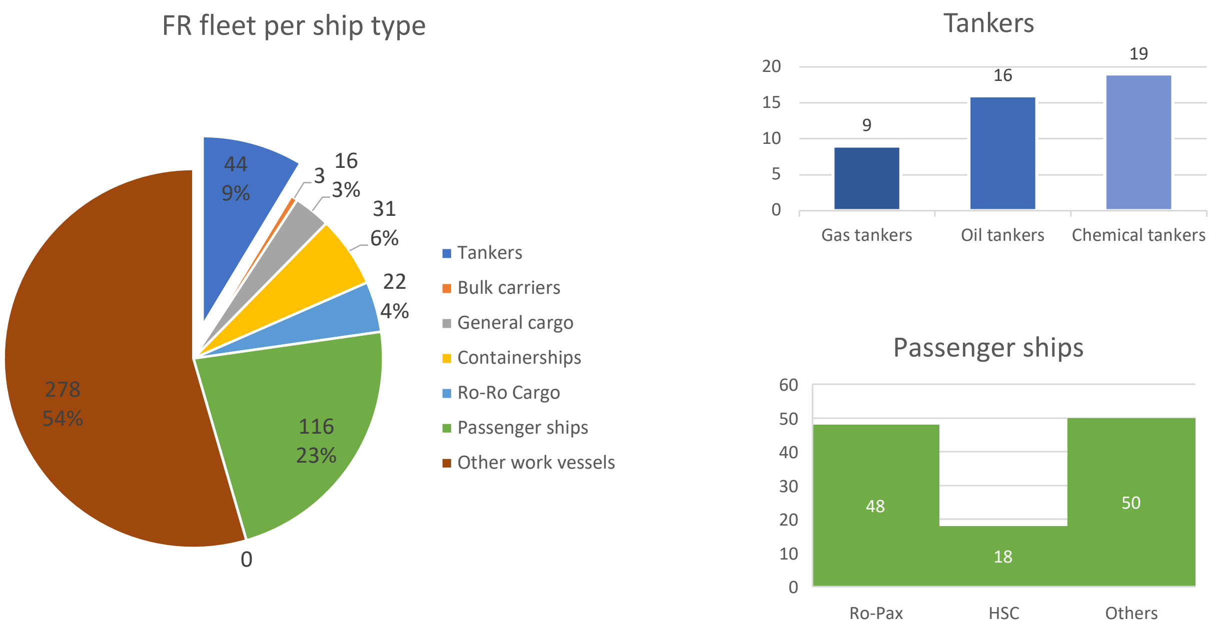
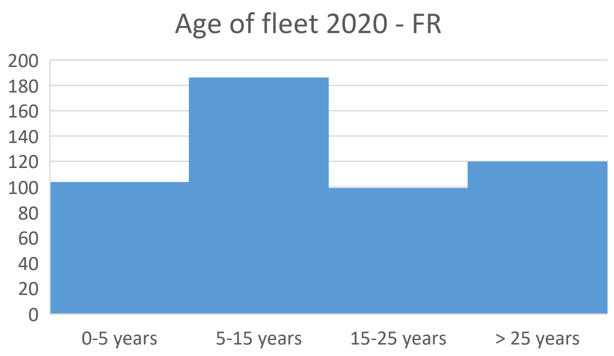


Figure A2. 30: French fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of France is below.



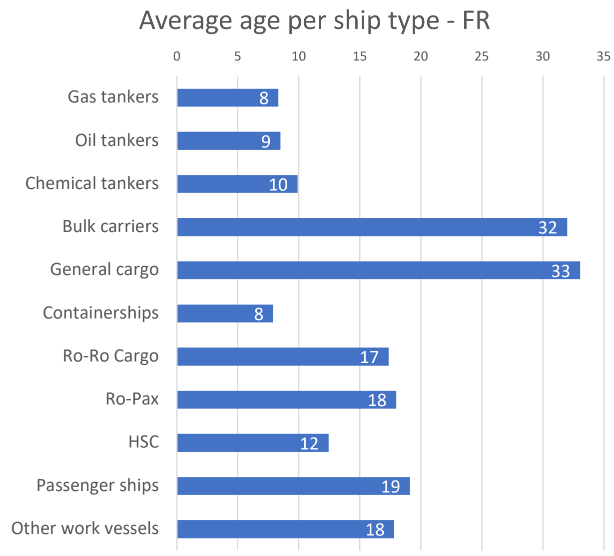


Figure A2. 31: Age of fleet with the flag of France. Overall and average age per ship type.

The percentage of ships with the flag of France that belongs to shipowners registered in the country is shown below. In addition, 21% of the ship with the flag of France belong to shipowners based outside the EU.

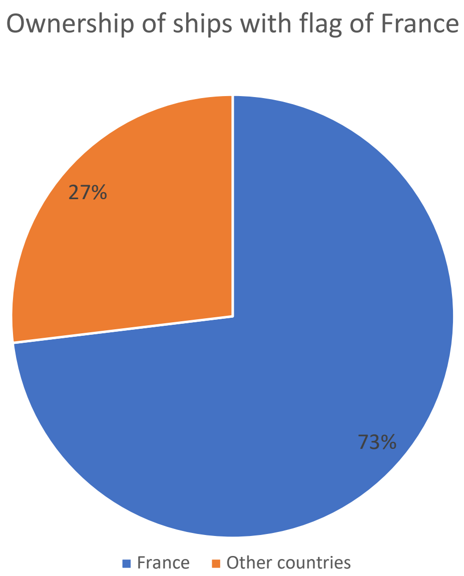


Figure A2. 32: Percentage of French fleet owned by the shipowners of France.

Germany

There are 548 ships registered with the flag of Germany corresponding to 4% of the EU MS fleet.

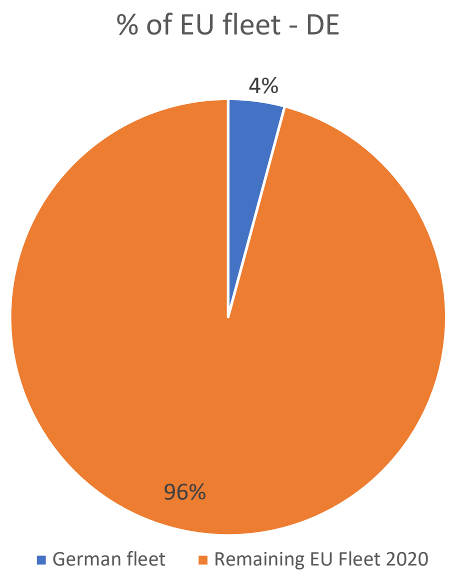


Figure A2. 33: Share of the flag of Germany in EU MS fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Germany are other work vessels (49%) followed by passenger ships (18%) and containerships (14%). There are 99 passenger ships including 25 Ro-Pax and 3 HSC part of the German fleet.

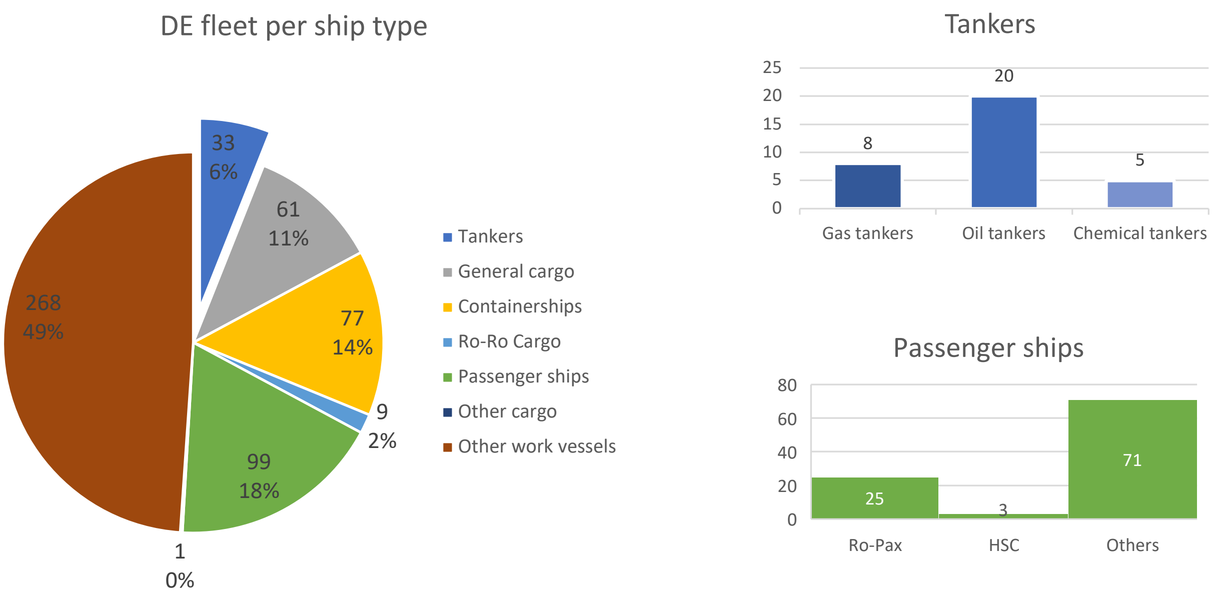
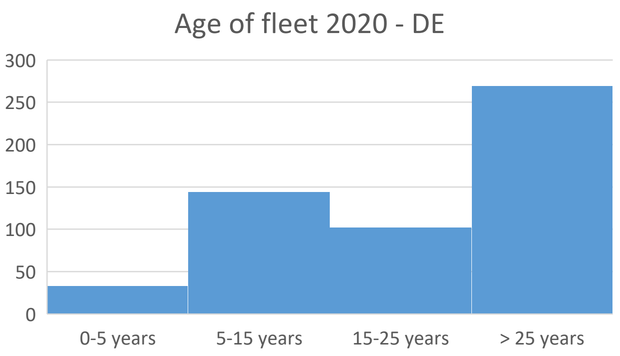


Figure A2. 34: German fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Germany is below.



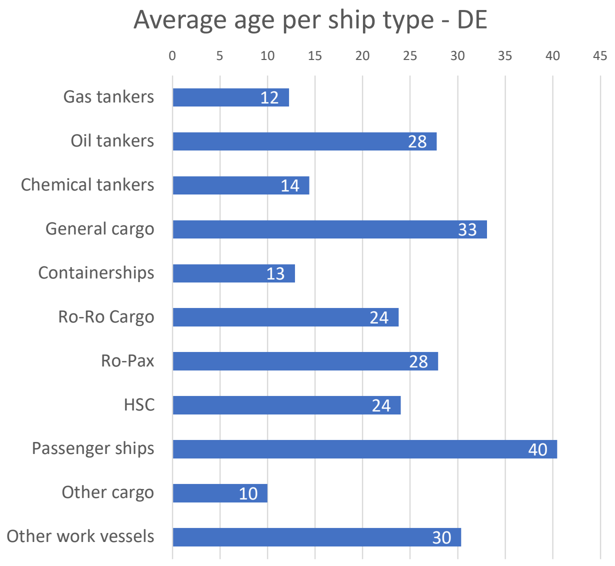


Figure A2. 35: Age of fleet with the flag of Germany. Overall and average age per ship type.

The percentage of ships with the flag of Germany that belongs to shipowners registered in the country is shown below.

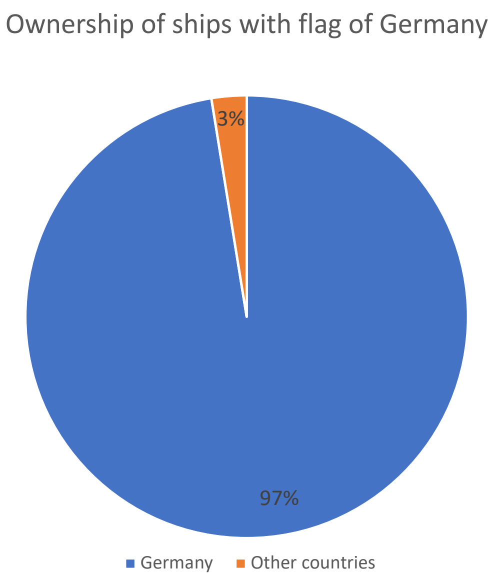


Figure A2. 36: Percentage of German fleet owned by the shipowners of Germany.

Greece

There are 1151 ships registered with the flag of Greece corresponding to 9% of the EU MS fleet.

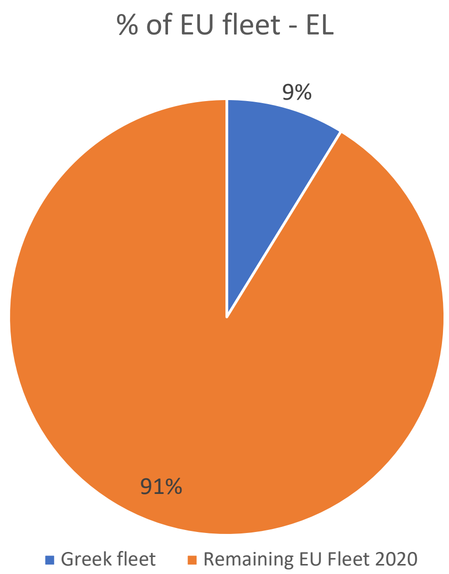


Figure A2. 37: Share of the flag of Greece in EU MS fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Greece are tankers (34%) followed by passenger ships (31%), other work vessels (16%) and bulk carriers (14%). There are 352 passenger ships including 186 Ro-Pax and 25 HSC ships part of the Greek fleet.

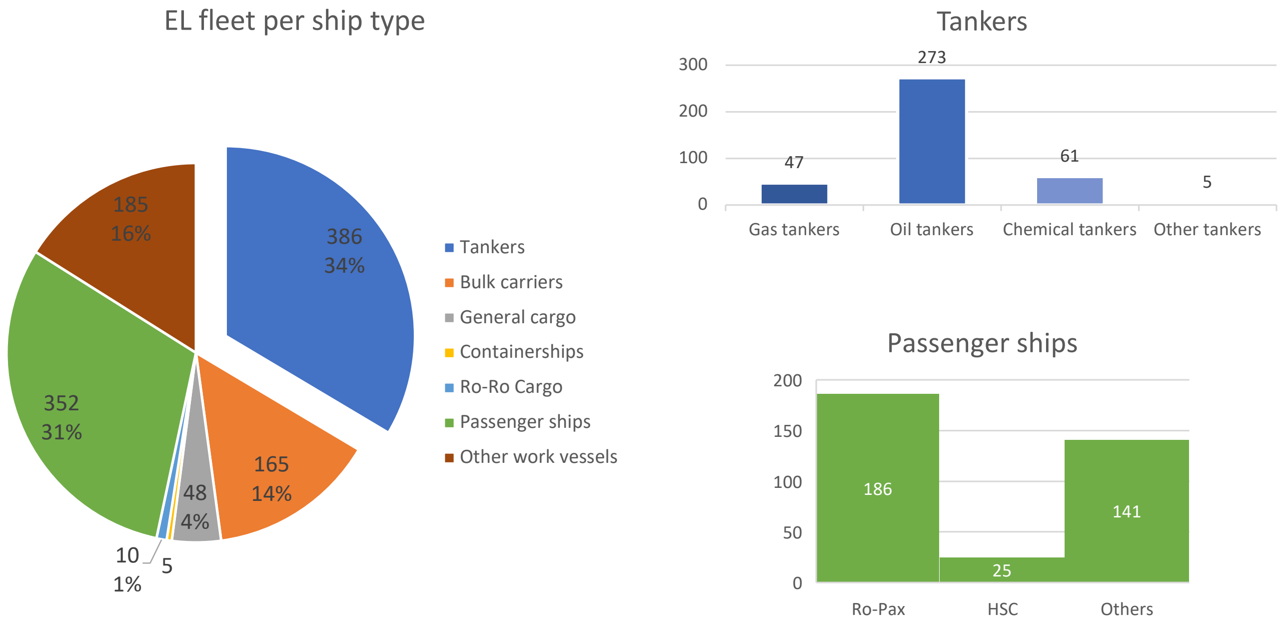


Figure A2. 38: Greek fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The oil tankers of Greece correspond to 31% of the EU MS fleet of that ship type in terms of number of ships, the other tankers correspond to 20% of the EU MS fleet and the Ro-Pax to 17% of the EU MS fleet.

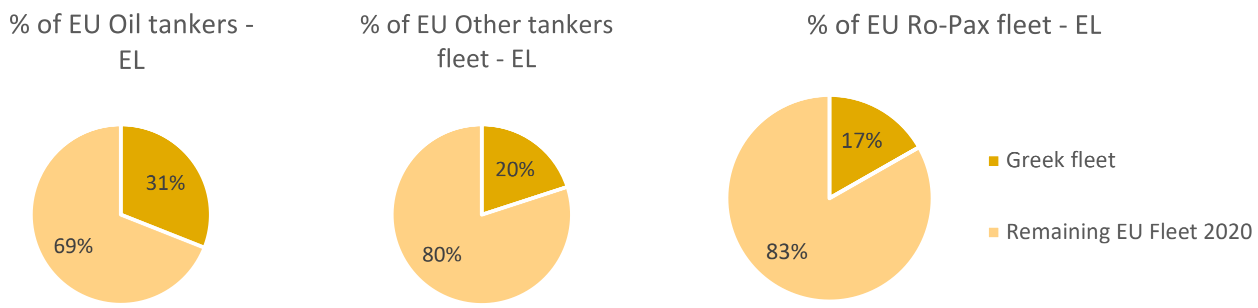
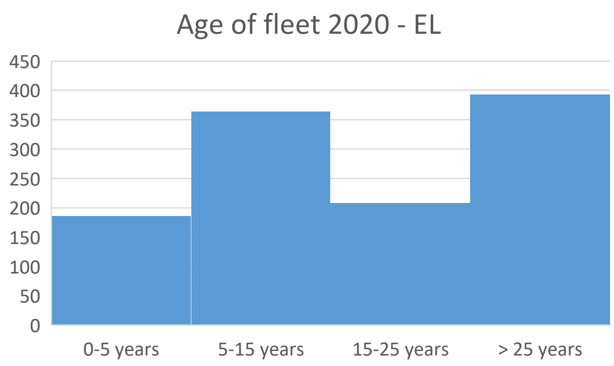


Figure A2. 39: Share of the flag of Greece in the EU MS oil, other tankers and Ro-Pax fleets.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Greece is below.



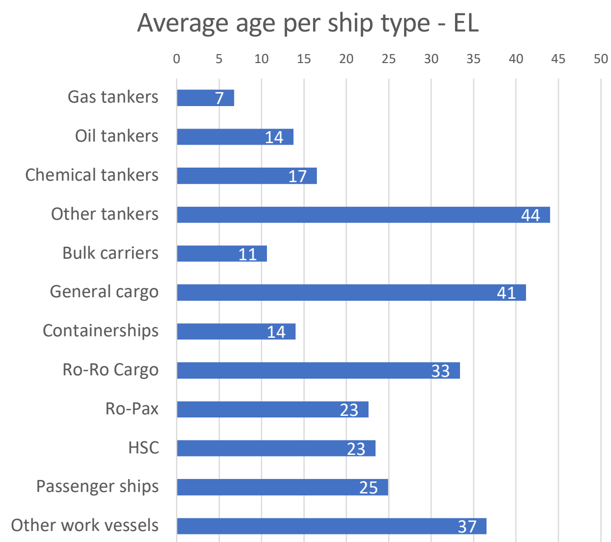


Figure A2. 40: Age of fleet with the flag of Greece. Overall and average age per ship type.

The percentage of ships with the flag of Greece that belongs to shipowners registered in the country is shown below.

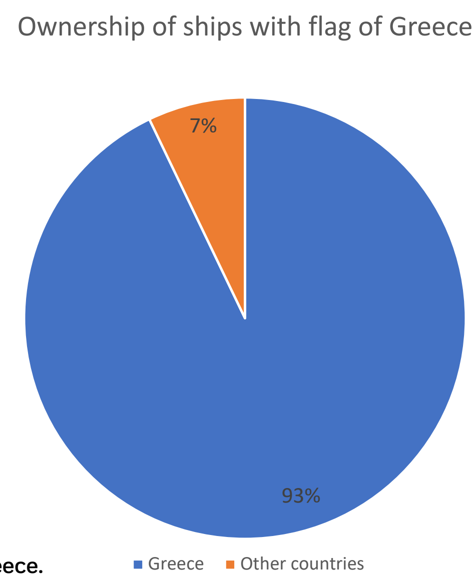
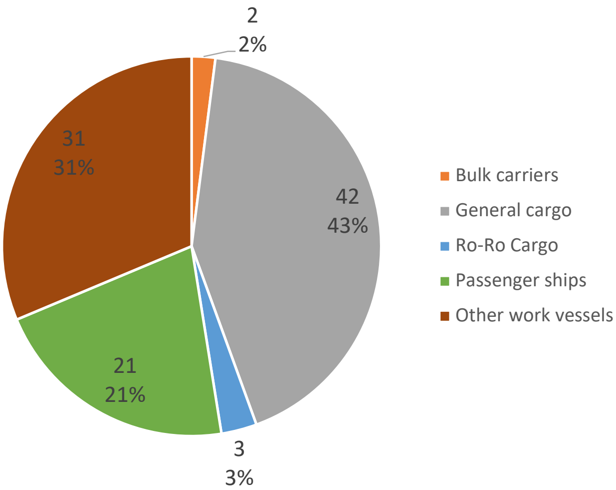


Figure A2. 41: Percentage of Greek fleet owned by the shipowners of Greece.

Ireland

There are 99 ships other than fishing vessels registered with the flag of Ireland corresponding to 1% of the EU MS fleet.

The division of those per ship type is shown below. Most ships flying the flag of Ireland are general cargo vessels (43%), other work vessels (31%) and passenger ships (21%). There are 21 passenger ships including 4 Ro-Pax and 1 HSC ships.



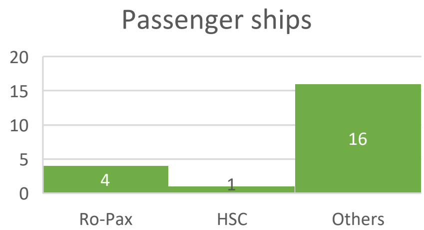
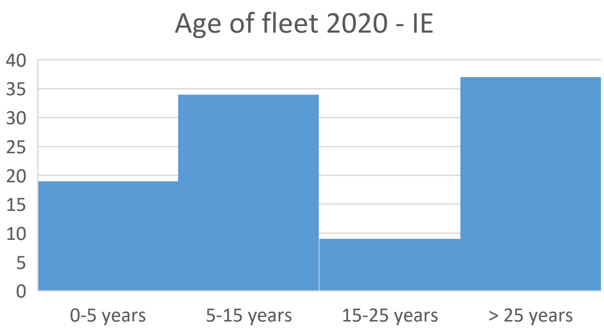


Figure A2. 42: Irish fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Ireland is below.



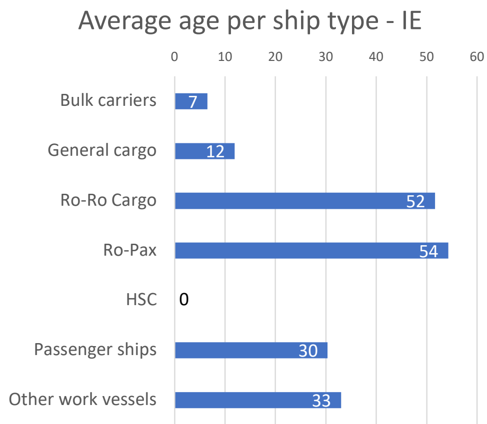


Figure A2. 43: Age of fleet with the flag of Ireland. Overall and average age per ship type.

The percentage of ships with the flag of Ireland that belongs to shipowners registered in the country is shown below.

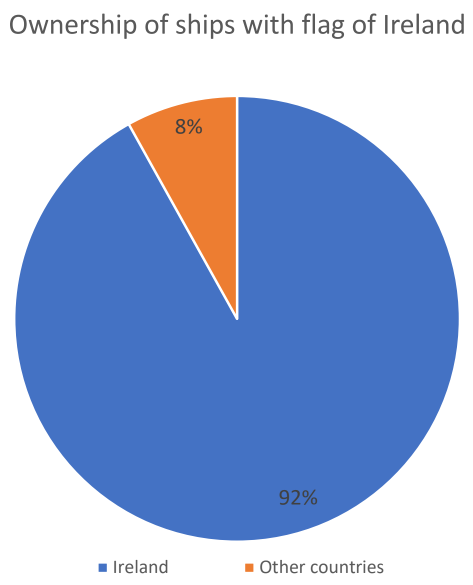


Figure A2. 44: Percentage of Irish fleet owned by the shipowners of Ireland.

Italy

There are 1200 ships registered with the flag of Italy corresponding to 9% of the EU MS fleet.

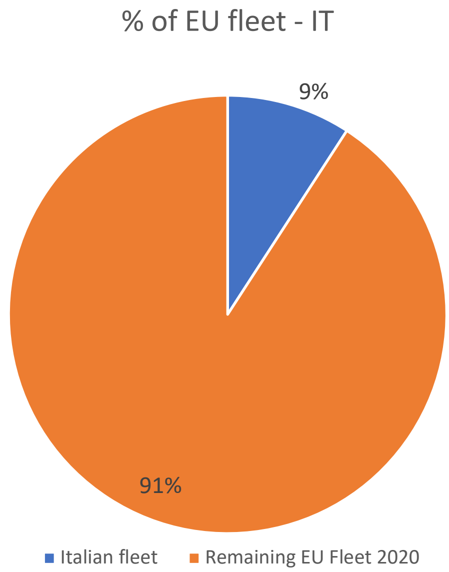


Figure A2. 45: Share of the flag of Italy in EU MS fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Italy are other work vessels (44%) followed by passenger ships (28%) and tankers (14%). There are 336 passenger ships including 162 Ro-Pax and 48 HSC ships part of the Italian fleet, the latter corresponding to 22% of the EU MS fleet of HSC in terms of number of ships.

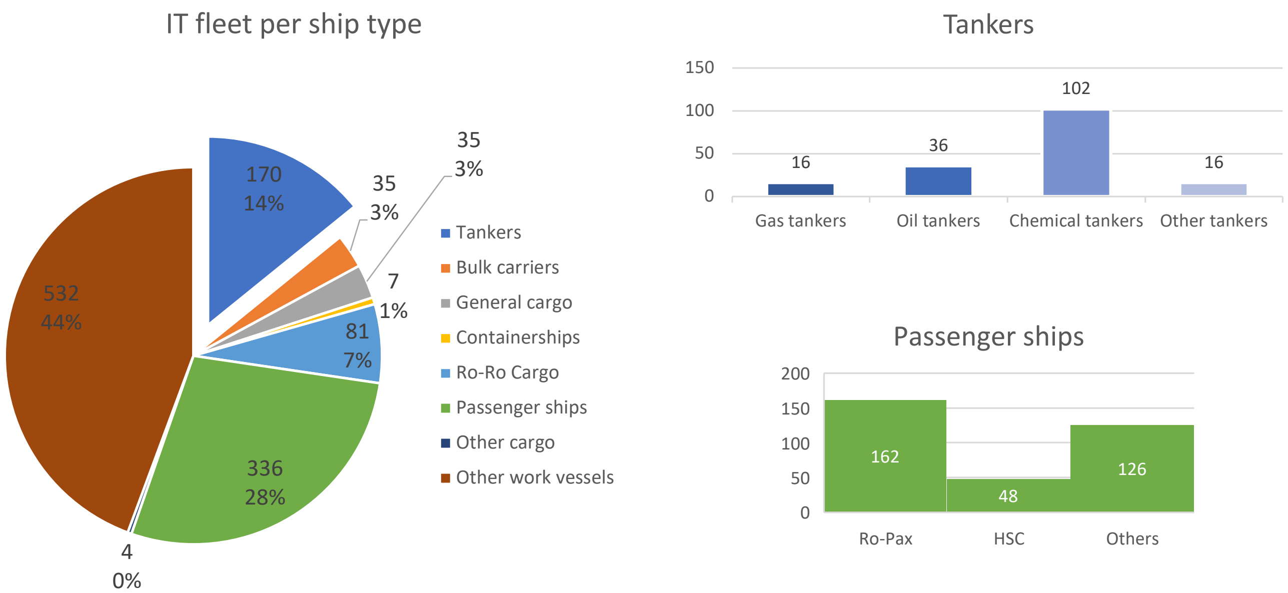


Figure A2. 46: Italian fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The other tankers of Italy correspond to 64% of the EU MS fleet of that ship type in terms of number of ships, the Ro-Ro cargo ships correspond to 20% of the EU MS fleet, the HSC to 22% of the EU MS fleet.

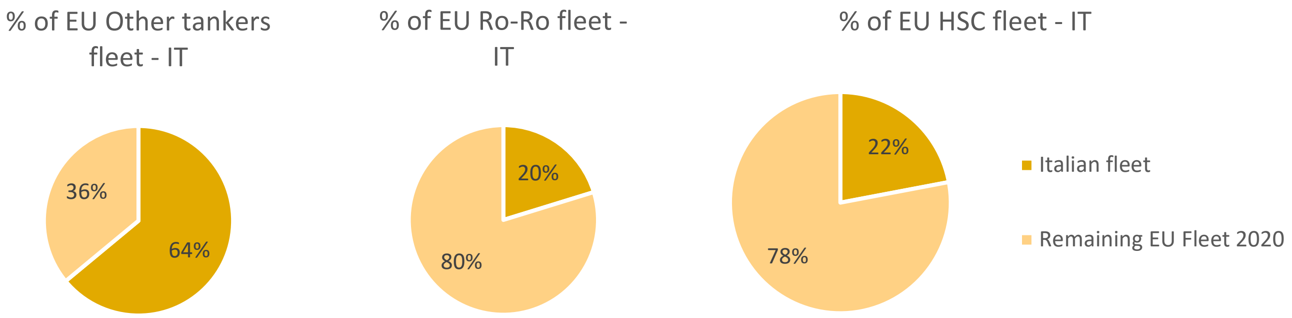
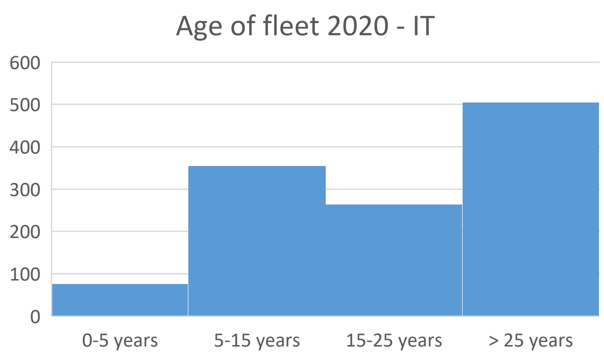


Figure A2. 47: Share of the flag of Italy in the EU MS other tankers, Ro-Ro and Ro-Pax fleets.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Italy is below.



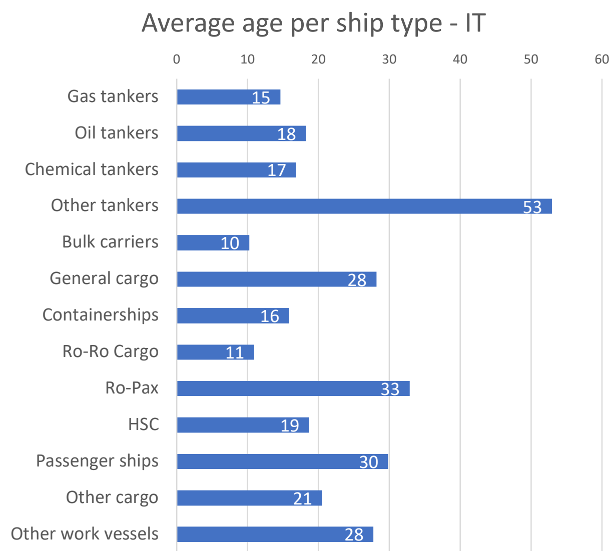


Figure A2. 48: Age of fleet with the flag of Italy. Overall and average age per ship type.

The percentage of ships with the flag of Italy that belongs to shipowners registered in the country is shown below.

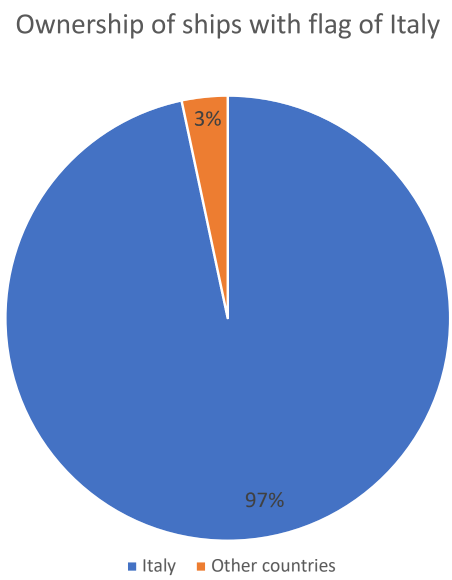


Figure A2. 49: Percentage of Italian fleet owned by the shipowners of Italy.

Latvia

There are 65 ships registered with the flag of Latvia.

The division of those per ship type is shown below. Most ships flying the flag of Latvia are other work vessels and general cargo ships. There are 5 passenger ships including 3 Ro-Pax part of the Latvian fleet.

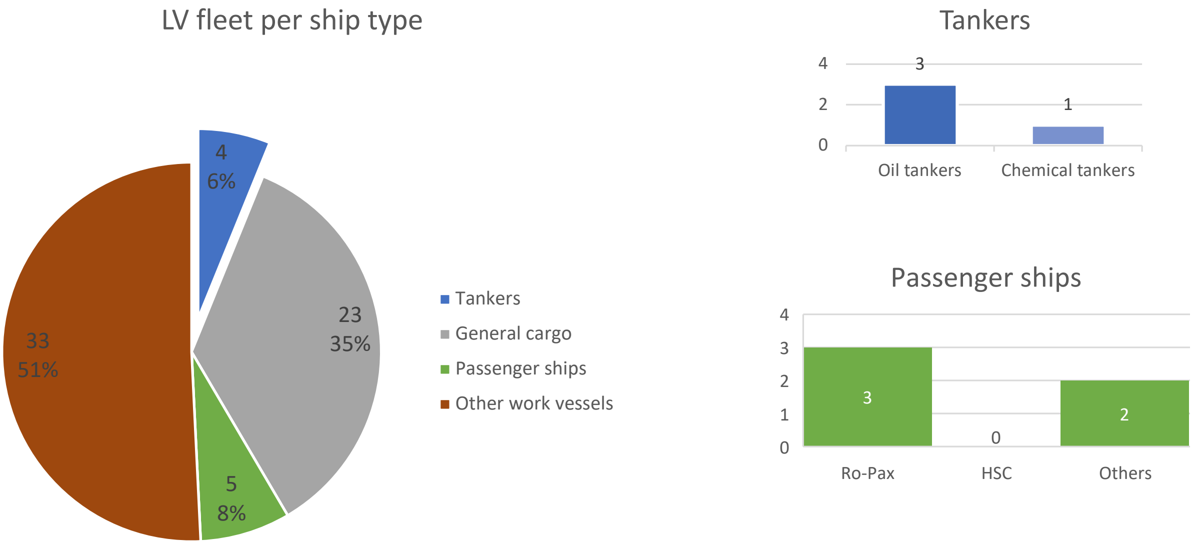


Figure A2. 50: Latvian fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Latvia is below.

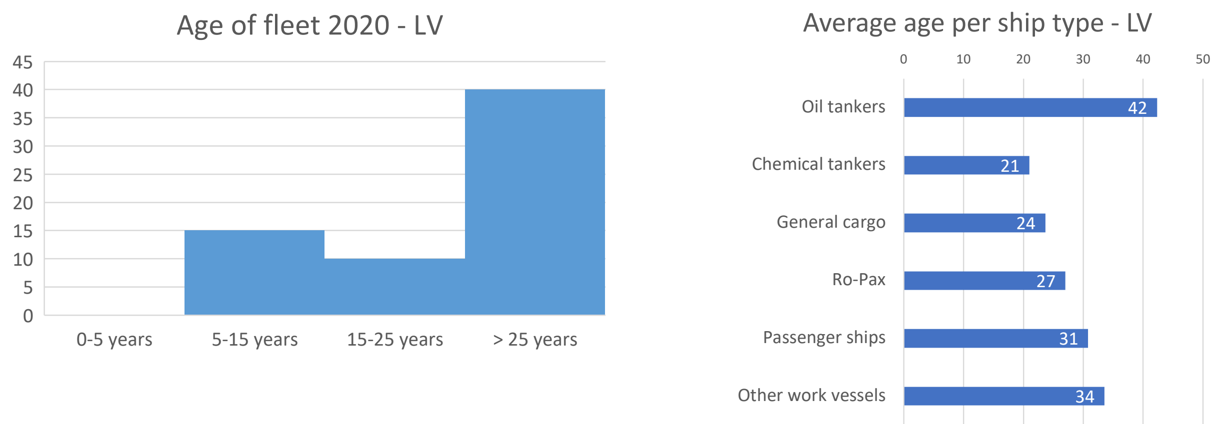
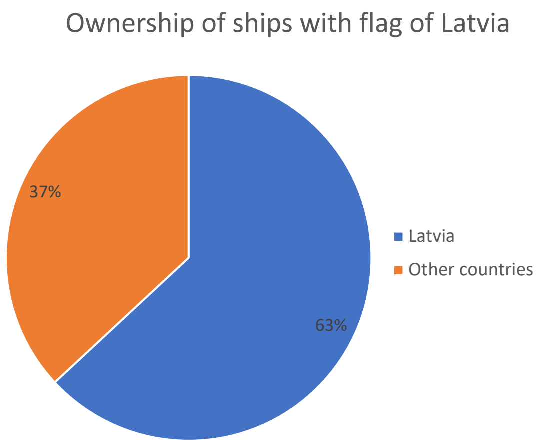


Figure A2. 51: Age of fleet with the flag of Latvia. Overall and average age per ship type.

The percentage of ships with the flag of Latvia that belongs to shipowners registered in the country is shown below. That percentage has been decreasing over the past 5 years.



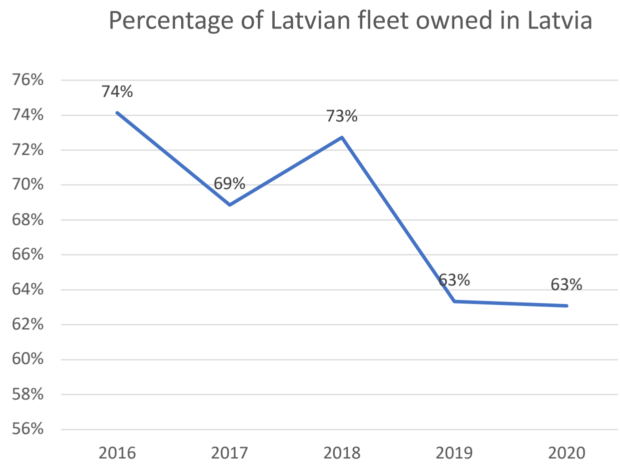


Figure A2. 52: Percentage of Latvian fleet owned by the shipowners of Latvia. Evolution over the past 5 years.

Lithuania

There are 53 ships registered with the flag of Lithuania.

The division of those per ship type is shown below. Most ships flying the flag of Lithuania are either other work vessels or general cargo ships. There are 8 Ro-Pax ships part of the Lithuanian fleet.

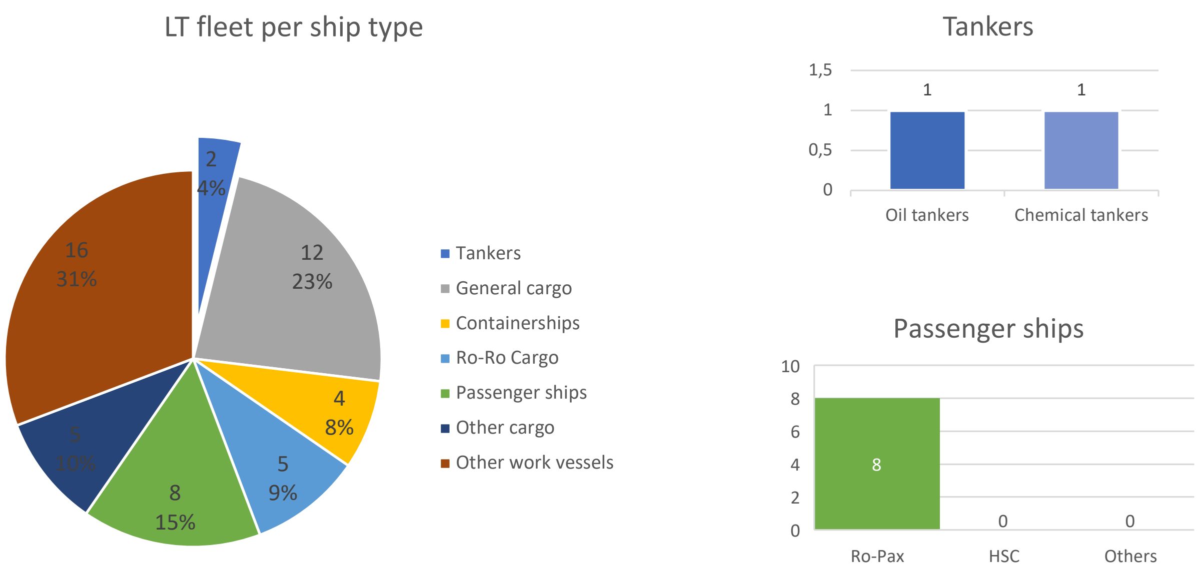


Figure A2. 53: Lithuanian fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Lithuania is below.

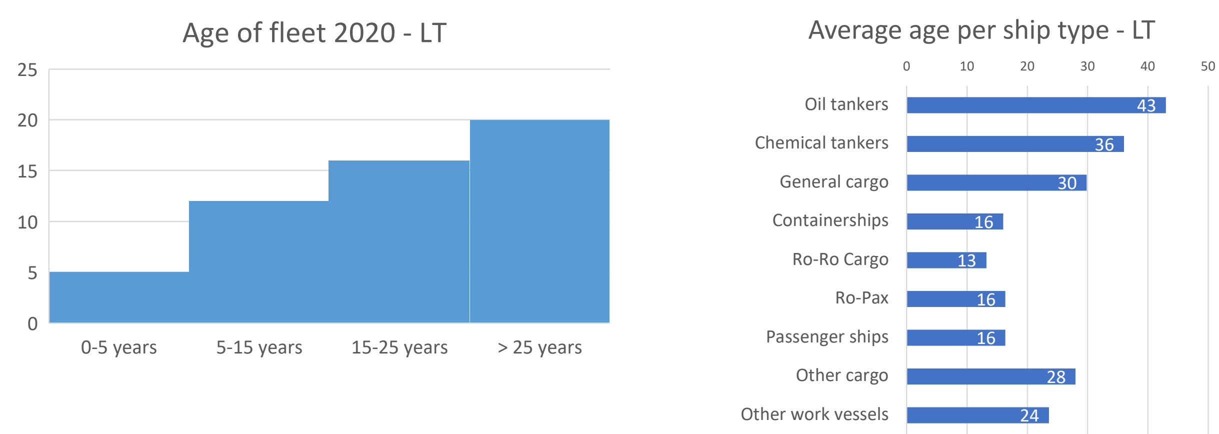


Figure A2. 54: Age of fleet with the flag of Lithuania. Overall and average age per ship type.

The percentage of ships with the flag of Lithuania that belongs to shipowners registered in the country is shown below.

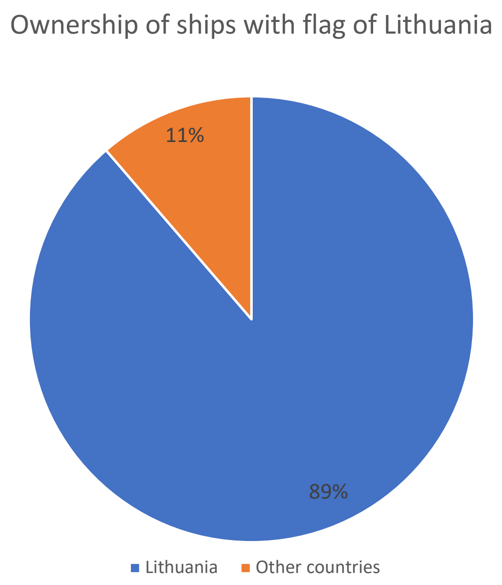
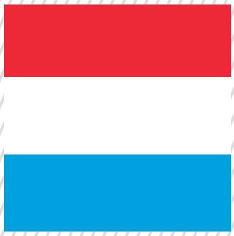


Figure A2. 55: Percentage of Lithuanian fleet owned by the shipowners of Lithuania.

Luxembourg



There are 156 ships registered with the flag of Luxembourg corresponding to 1% of the total EU MS fleet.

The division of those per ship type is shown below. Most ships flying the flag of Luxembourg are other work vessels. There are no passenger ships in the Luxembourgish fleet.

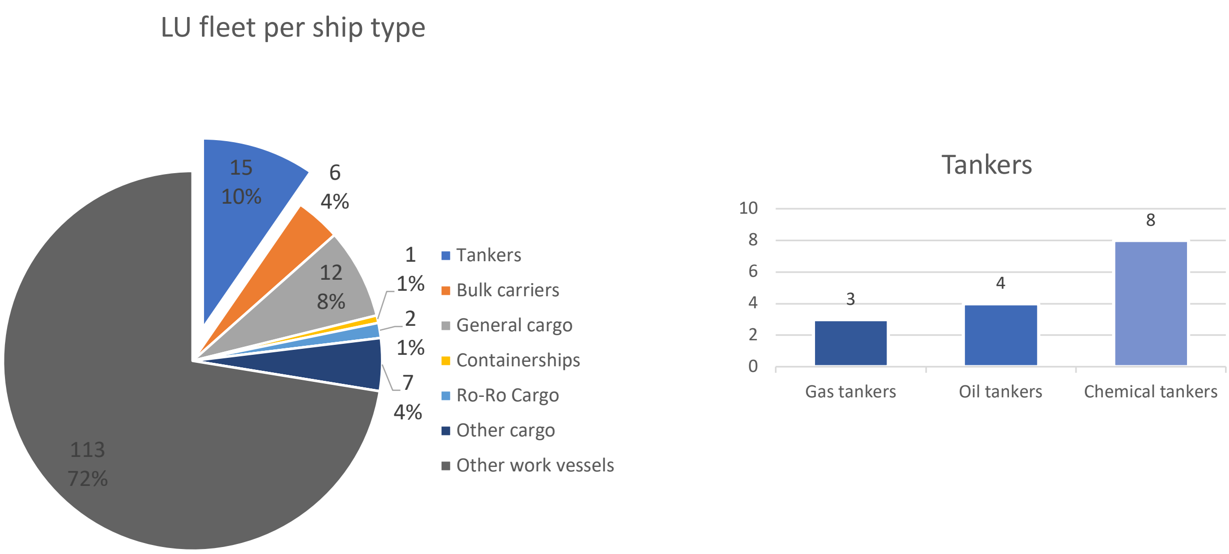


Figure A2. 56: Luxembourgish fleet per ship type including number of tankers per subtype.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Luxembourg is below.

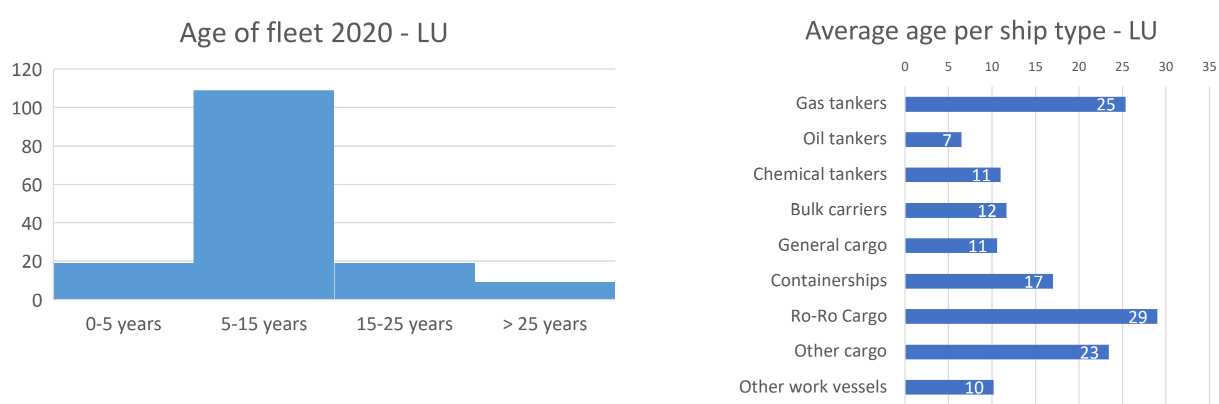
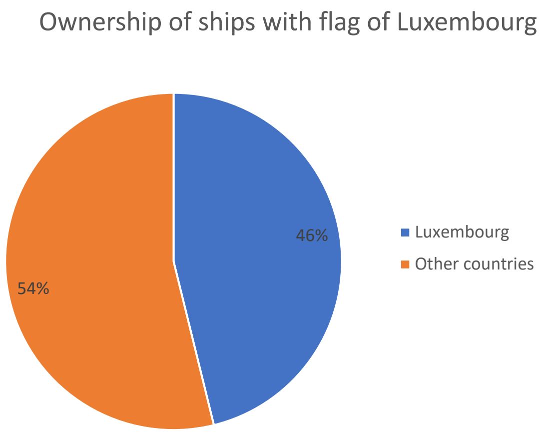


Figure A2. 57: Age of fleet with the flag of Luxembourg. Overall and average age per ship type.

The percentage of ships with the flag of Luxembourg that belongs to shipowners registered in the country is shown below. That percentage has been increasing in the last 5 years.



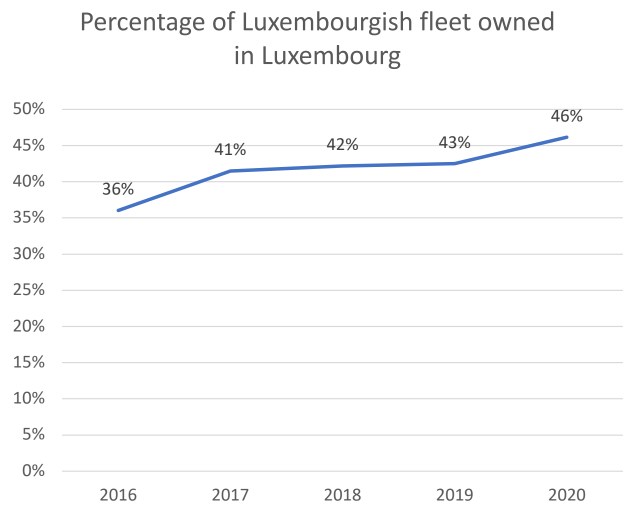
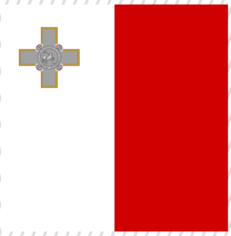


Figure A2. 58: Percentage of Luxembourgish fleet owned by the shipowners of Luxembourg. Evolution over the past 5 years.

Malta



There are 2099 ships registered with the flag of Malta corresponding to 16% of the EU MS flagged fleet.

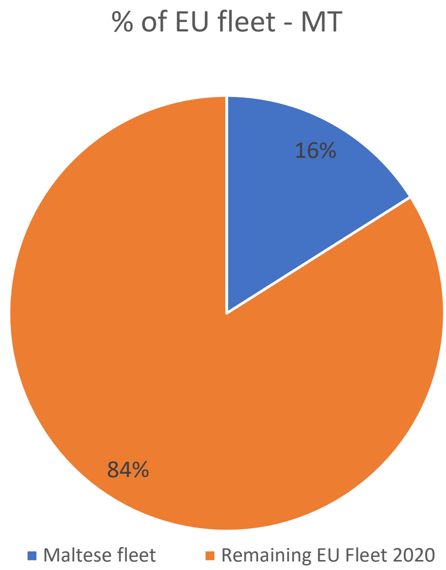


Figure A2. 59: Share of the flag of Malta in EU MS flagged fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Malta are tankers (35%) and bulk carriers (27%). There are 79 passenger ships including 4 Ro-Pax and 8 HSC ships part of the Maltese fleet.

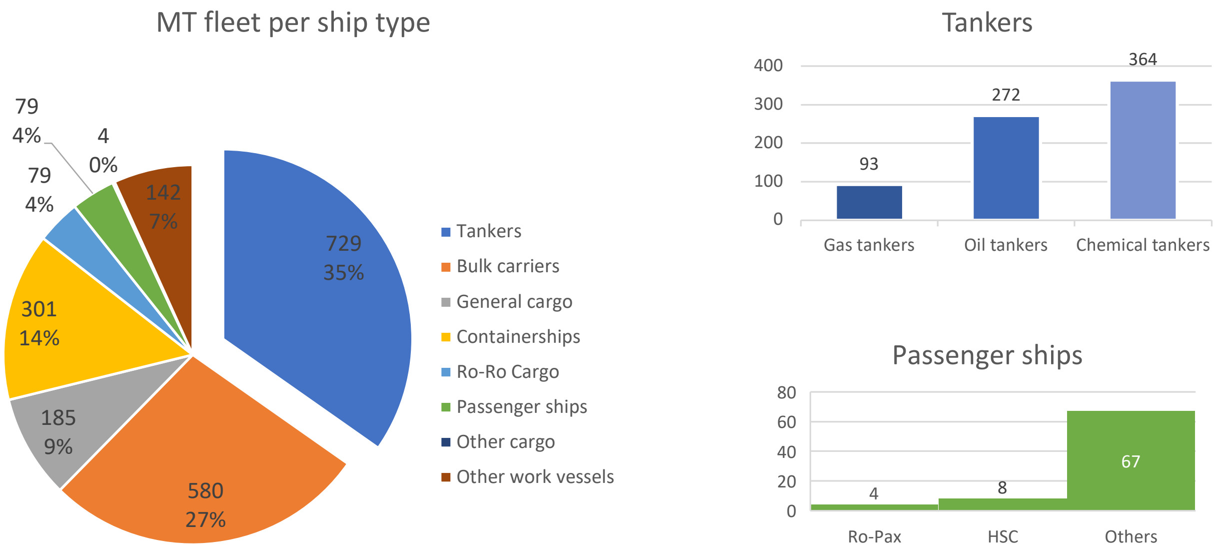


Figure A2. 60: Maltese fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The tankers of Malta correspond to 32% of the EU MS flagged fleet of that ship type in terms of number of ships, the bulk carriers correspond to 45% of the EU MS flagged fleet and the containerships to 28% of the EU MS flagged fleet.

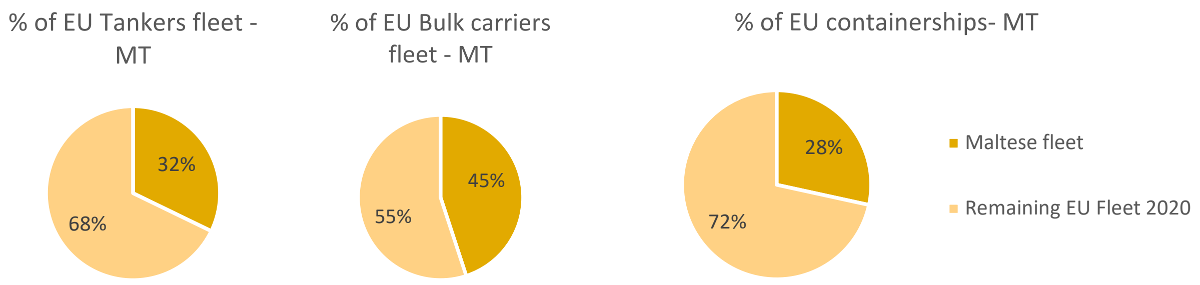
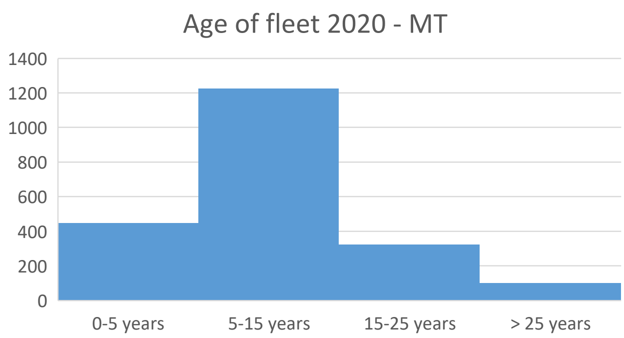


Figure A2. 61: Share of the flag of Malta in the EU MS flagged tankers, bulk carriers and containerships fleets.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Malta is below.



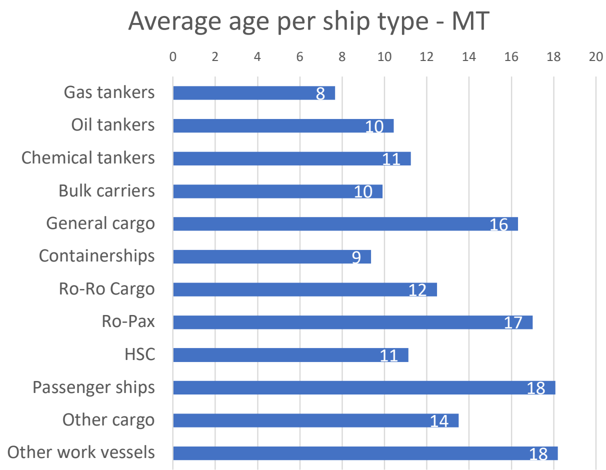


Figure A2. 62: Age of fleet with the flag of Malta. Overall and average age per ship type.

The percentage of ships with the flag of Malta that belongs to shipowners registered in the country is shown below. That percentage has been increasing in the last 5 years. In addition, 33% of the ships flying the flag of Malta belong to shipowners based outside the EU.

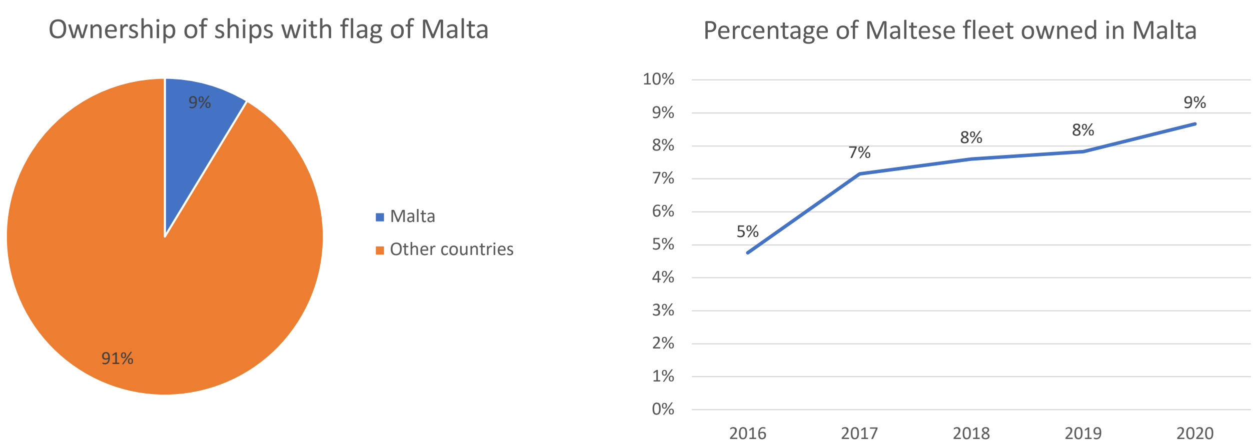


Figure A2. 63: Percentage of Maltese fleet owned by the shipowners of Malta. Evolution over the past 5 years.

Netherlands

There are 1124 ships registered with the flag of the Netherlands corresponding to 9% of the EU MS flagged fleet.

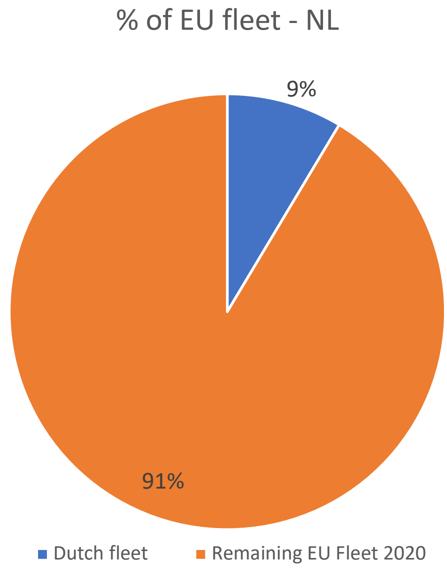


Figure A2. 64: Share of the flag of the Netherlands in EU MS flagged fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of the Netherlands are general cargo ships (46%) followed by other work vessels (33%). There are 62 passenger ships including 16 Ro-Pax and 2 HSC ships part of the Dutch fleet.

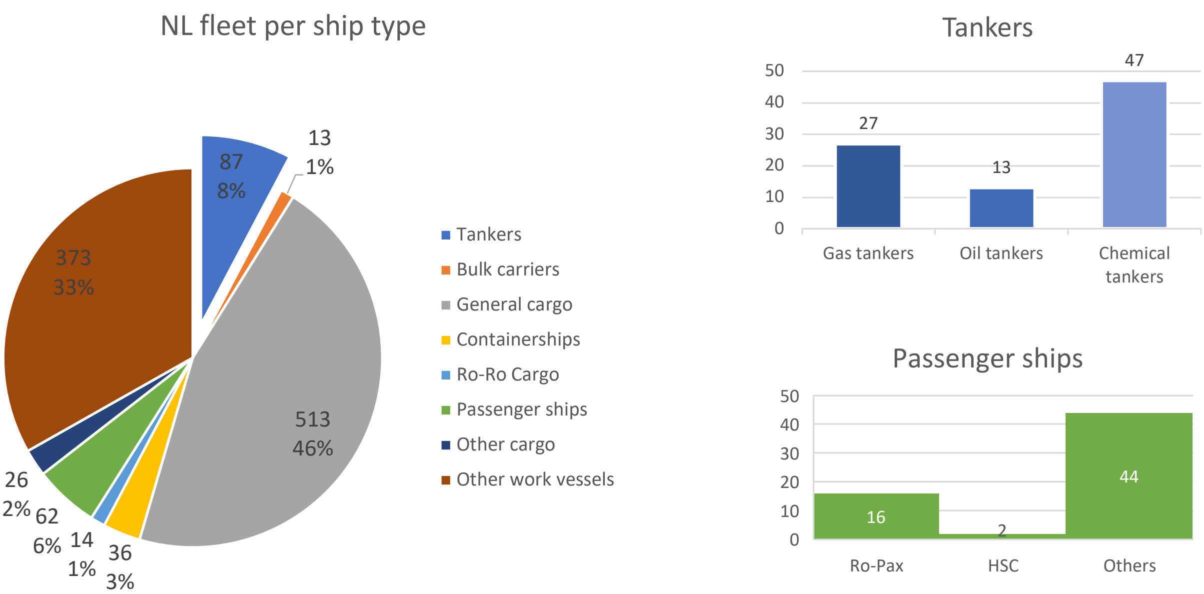
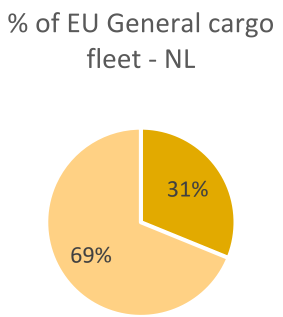


Figure A2. 65: Dutch fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The general cargo ships of the Netherlands correspond to 31% of the EU MS flagged fleet of that ship type in terms of number of ships and the other cargo ships to 32% of the EU MS flagged fleet.



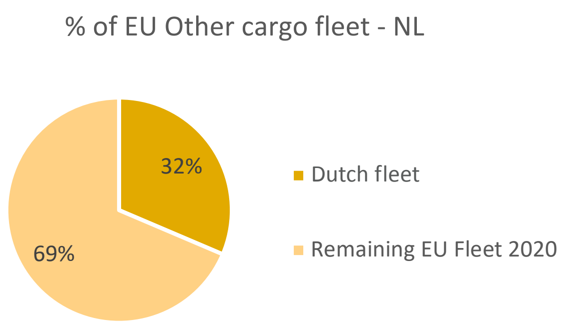
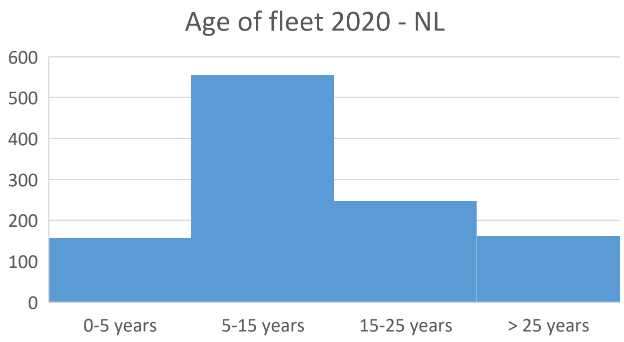


Figure A2. 66: Share of the flag of the Netherlands in the EU MS flagged general cargo and other cargo ships fleets.

The overall fleet age categories and the average age per ship type of the ships flying the flag of the Netherlands is below.



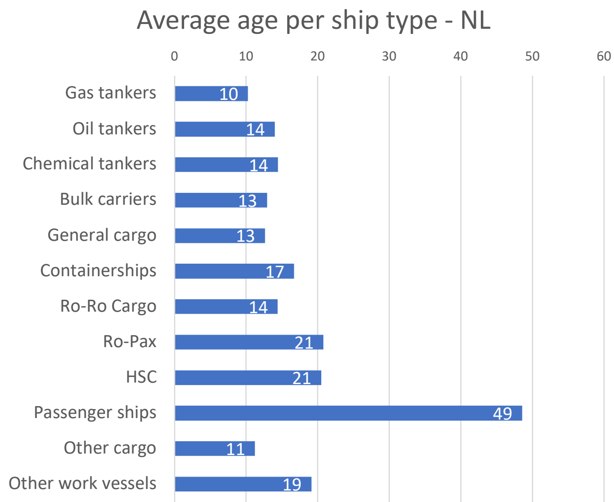


Figure A2. 67: Age of fleet with the flag of the Netherlands. Overall and average age per ship type.

The percentage of ships with the flag of the Netherlands that belongs to shipowners registered in the country is shown below.

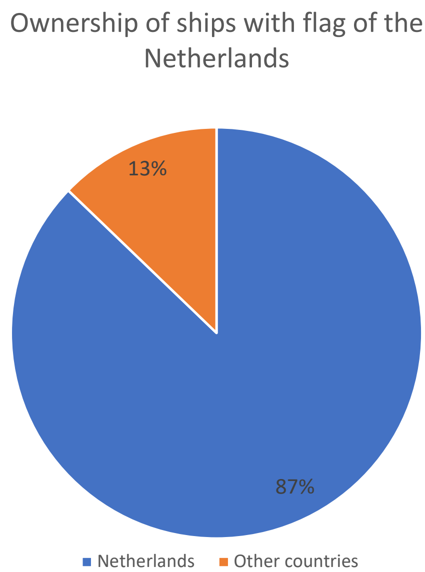


Figure A2. 68: Percentage of Dutch fleet owned by the shipowners of the Netherlands.

Poland

There are 110 ships registered with the flag of Poland corresponding to 1% of the total EU MS fleet.

The division of those per ship type is shown below. Most ships flying the flag of Poland are other work vessels. There are 24 passenger ships including 8 Ro-Pax part of the Polish fleet.

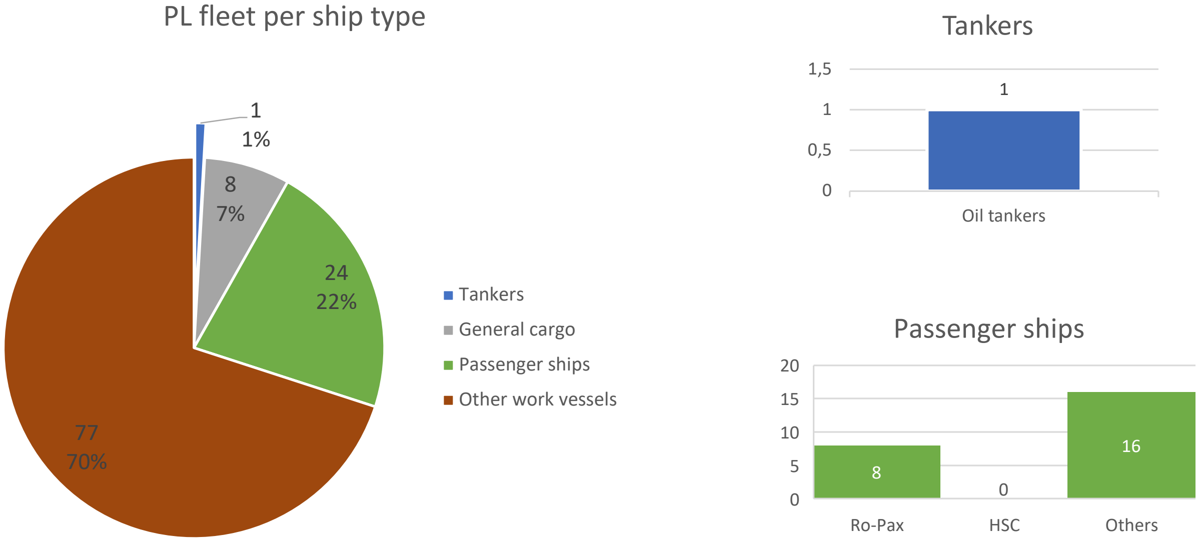


Figure A2. 69: Polish fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Poland is below.

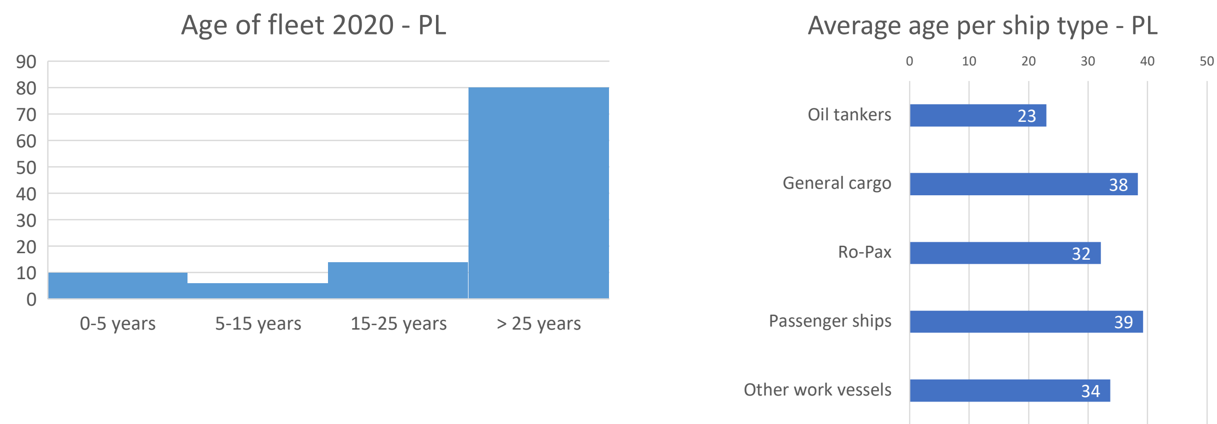


Figure A2. 70: Age of fleet with the flag of Poland. Overall and average age per ship type.

The percentage of ships with the flag of Poland that belongs to shipowners registered in the country is shown below.

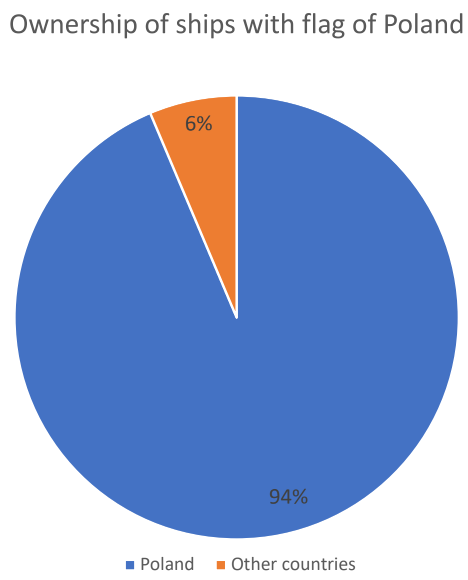
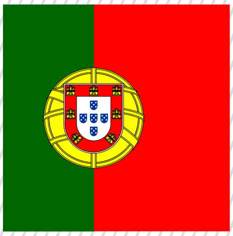


Figure A2. 71: Percentage of Polish fleet owned by the shipowners of Poland.

Portugal



There are 716 ships registered with the flag of Portugal corresponding to 5% of the EU MS flagged fleet.

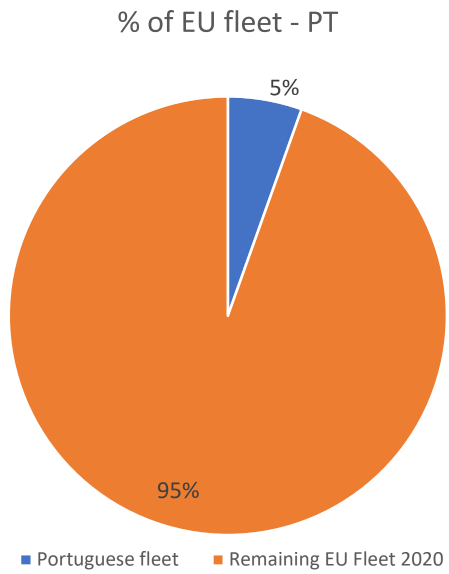


Figure A2. 72: Share of the flag of Portugal in EU MS flagged fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Portugal are containerships (36%), followed by general cargo ships (19%). There are 53 passenger ships including 10 Ro-Pax and 14 HSC ships part of the Portuguese fleet.

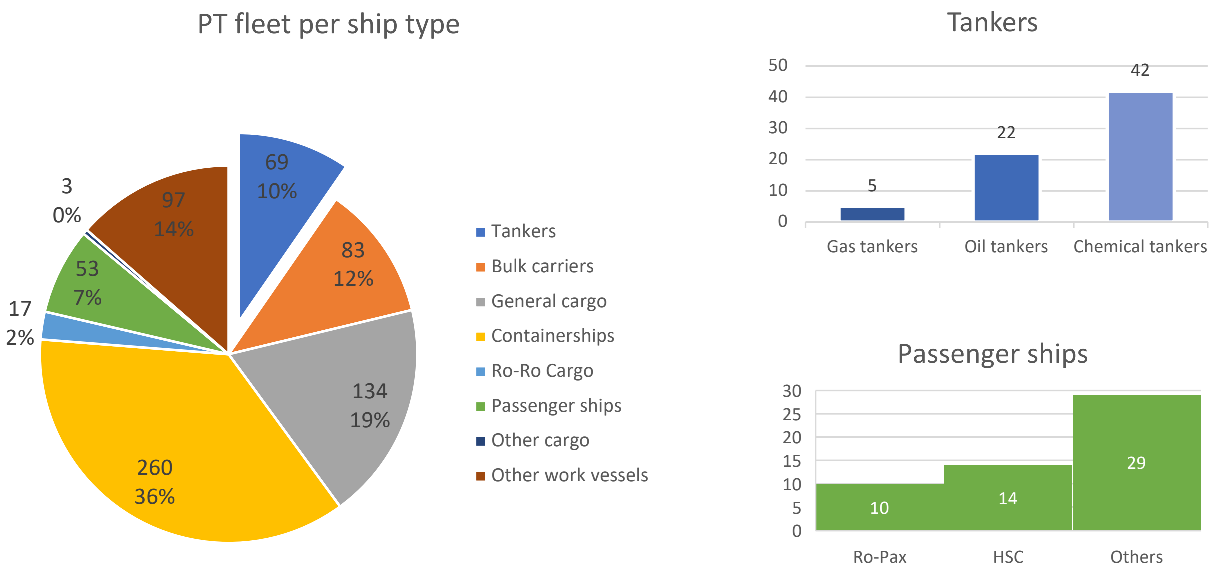


Figure A2. 73: Portuguese fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The containerships of Portugal correspond to 25% of the EU MS flagged fleet of that ship type in terms of number of ships.

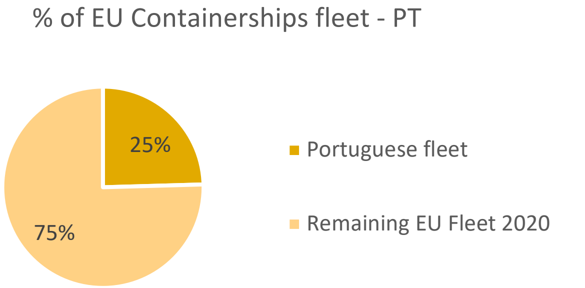
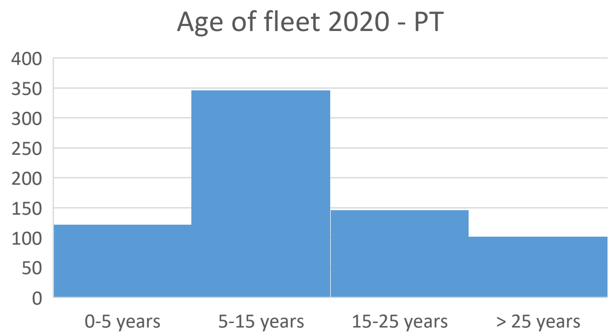


Figure A2. 74: Share of the flag of Portugal in the EU MS flagged containerships fleet.

The overall fleet age categories and the average age per ship type of the ships flying the flag of the Portugal is below.



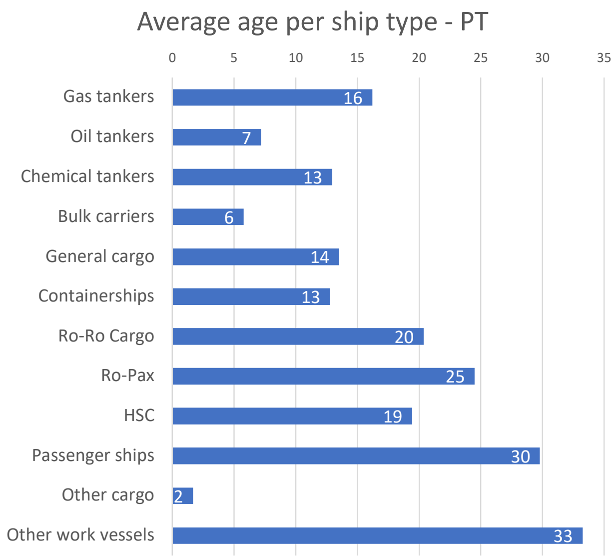
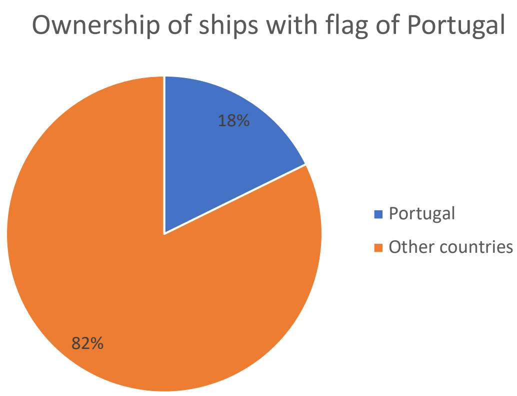


Figure A2. 75: Age of fleet with the flag of Portugal. Overall and average age per ship type.

The percentage of ships with the flag of Portugal that belongs to shipowners registered in the country is shown below. That percentage has been decreasing over the past 5 years.



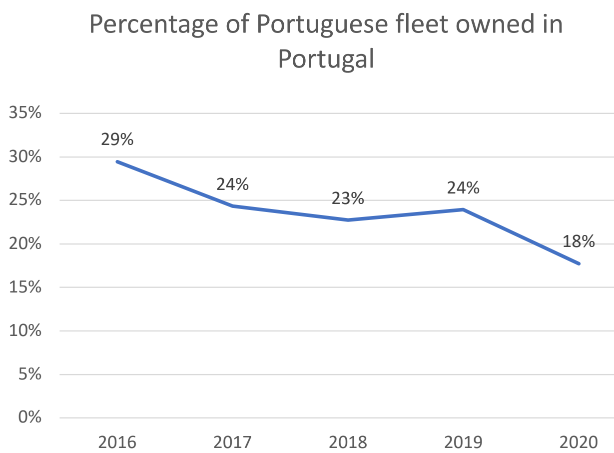


Figure A2. 76: Percentage of Portuguese fleet owned by the shipowners of Portugal. Evolution over the past 5 years.

Romania

There are 78 ships registered with the flag of Romania. The division of those per ship type is shown below. Most ships flying the flag of Romania are other work vessels. There are no passenger ships part of the Romanian fleet.

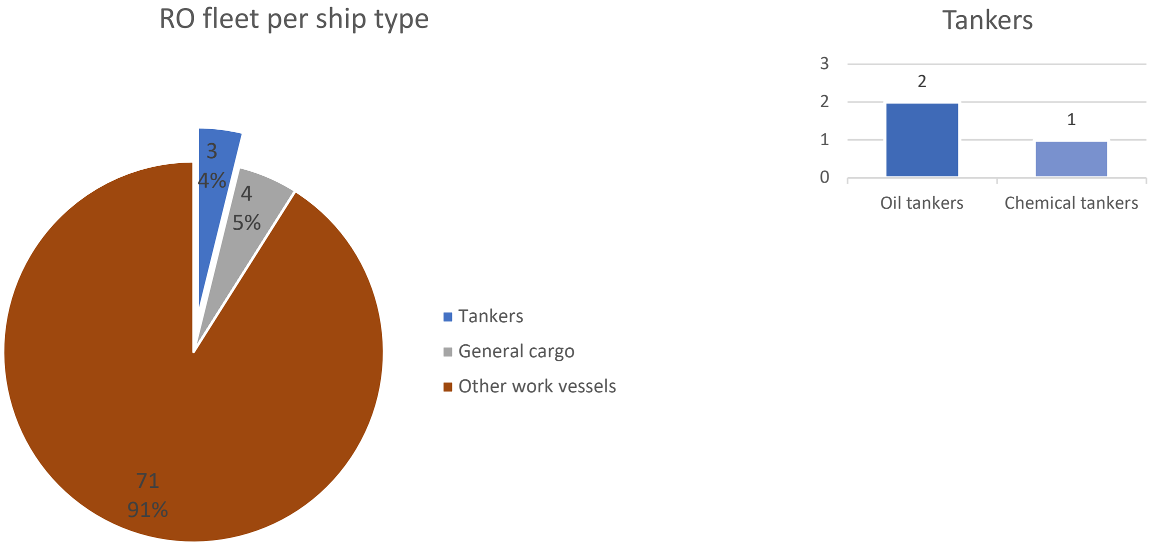
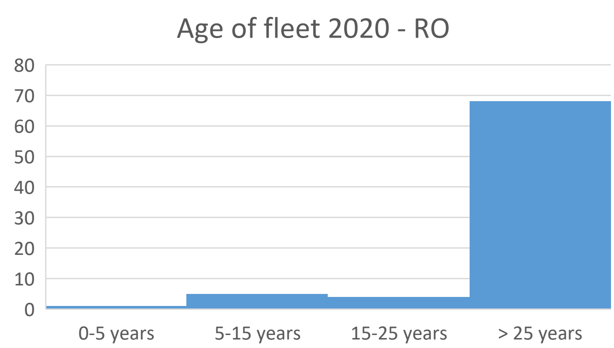


Figure A2. 77: Romanian fleet per ship type including number of tankers per subtype.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Romania is below.



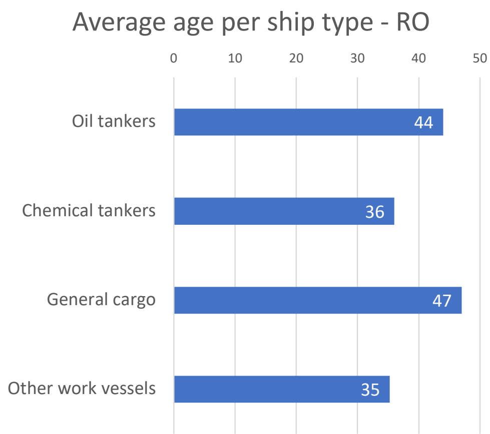


Figure A2. 78: Age of fleet with the flag of Romania. Overall and average age per ship type.

The percentage of ships with the flag of Romania that belongs to shipowners registered in the country is shown below.

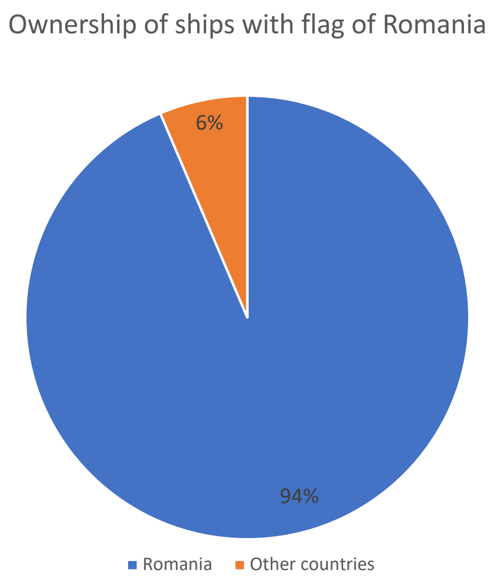


Figure A2. 79: Percentage of Romanian fleet owned by the shipowners of Romania.

Slovenia

There are 7 work vessels flying the flag of Slovenia with an average age of 21 years all belonging to Slovenian shipowners.

Spain

There are 522 ships registered with the flag of the Spain corresponding to 4% of the EU MS flagged fleet.

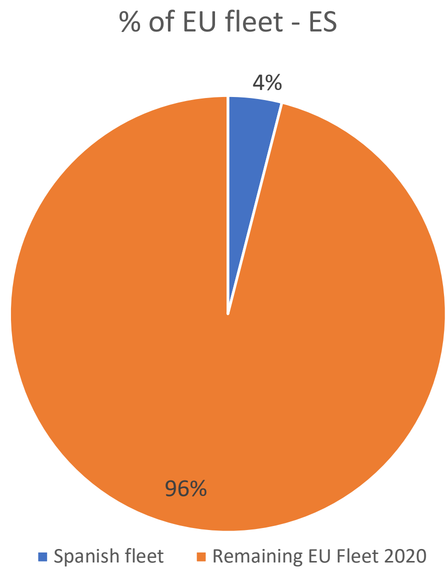


Figure A2. 80: Share of the flag of Spain in EU MS flagged fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Spain are other work vessels (61%) and passenger ships (25%).

There are 132 passenger ships including 24 Ro-Pax and 27 HSC ships part of the Spanish fleet.

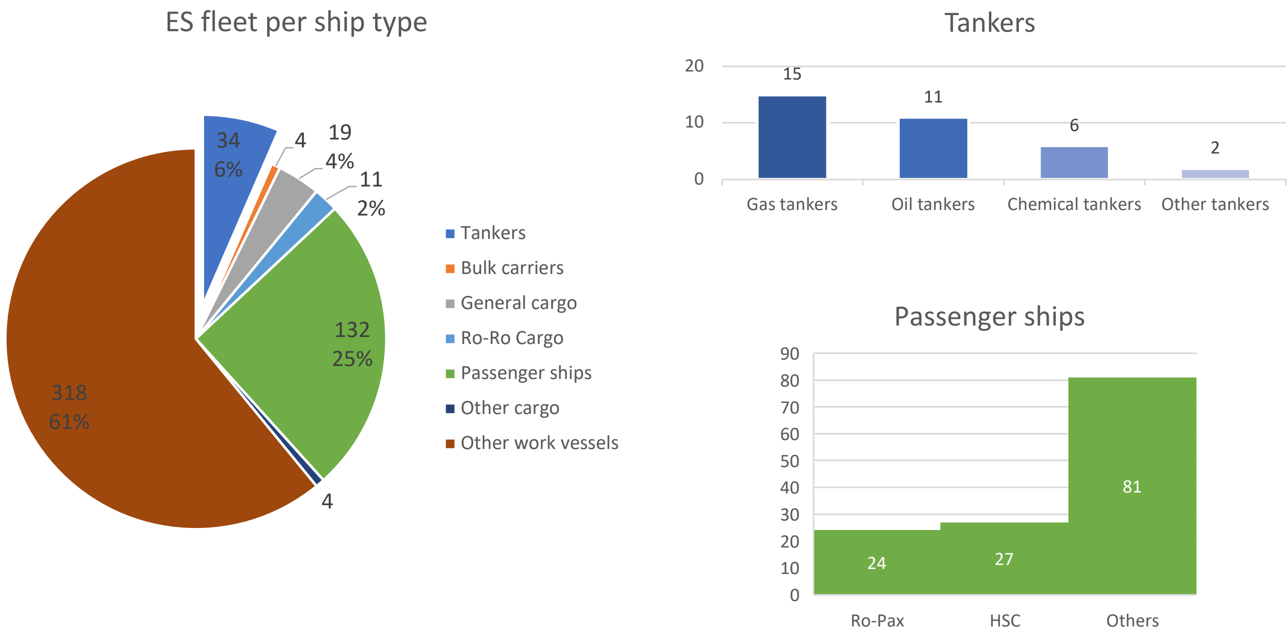


Figure A2. 81: Spanish fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The HSC of Spain correspond to 12% of the EU MS flagged fleet of that ship type in terms of number of ships.

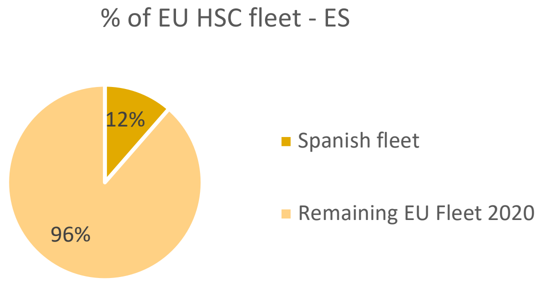
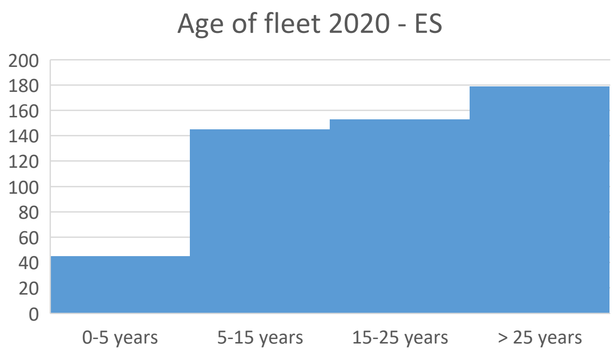


Figure A2. 82: Share of the flag of Spain in the EU MS flagged HSC fleet.

The overall fleet age categories and the average age per ship type of the ships flying the flag of the Spain is below.



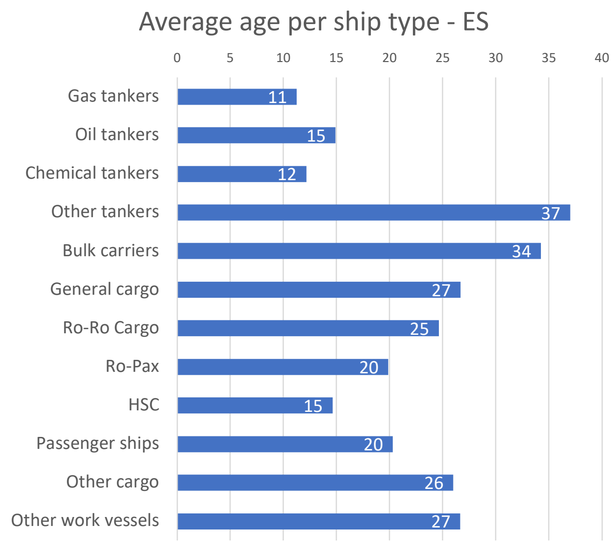
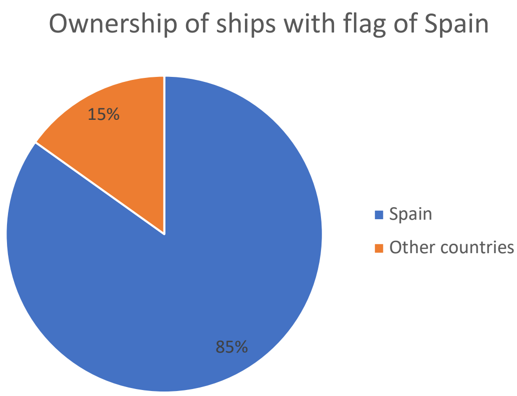


Figure A2. 83: Age of fleet with the flag of Spain. Overall and average age per ship type.

The percentage of ships with the flag of Spain that belongs to shipowners registered in the country is shown below. That percentage decreased in the last year of 2020.



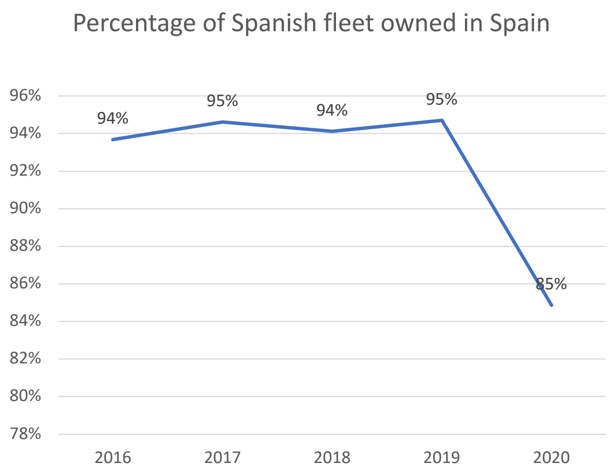


Figure A2. 84: Percentage of Spanish fleet owned by the shipowners of Spain. Evolution overthe past 5 years.

Sweden

There are 354 ships registered with the flag of Sweden corresponding to 3% of the EU MS flagged fleet.

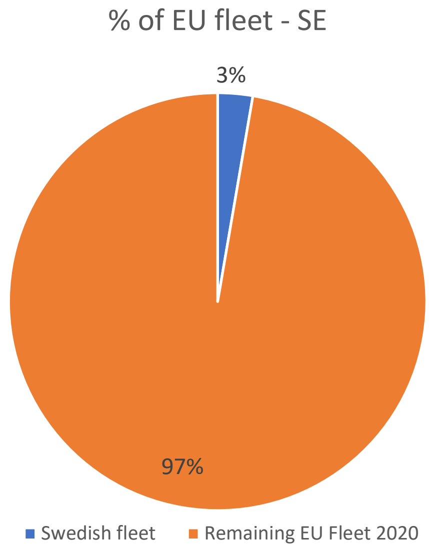
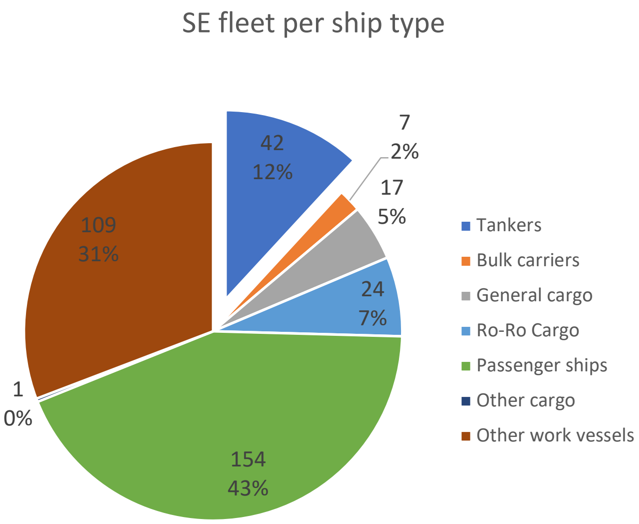
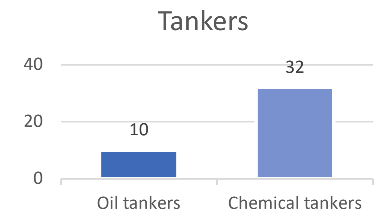


Figure A2. 85: Share of the flag of Sweden in EU MS flagged fleet.

The division of those per ship type is shown below. Most ships flying the flag of Sweden are passenger ships (43%), followed by other work vessels (31%).

There are 154 passenger ships including 55 Ro-Pax and 6 HSC part of the Swedish fleet.





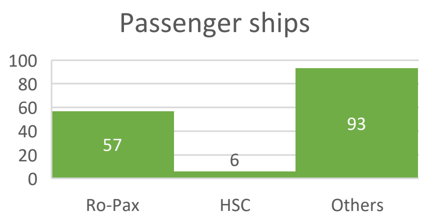
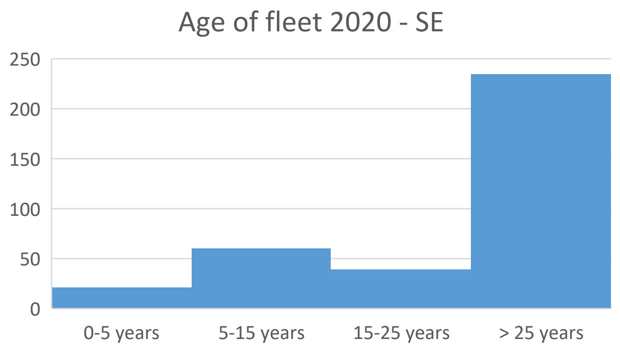


Figure A2. 86: Swedish fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Sweden is below.



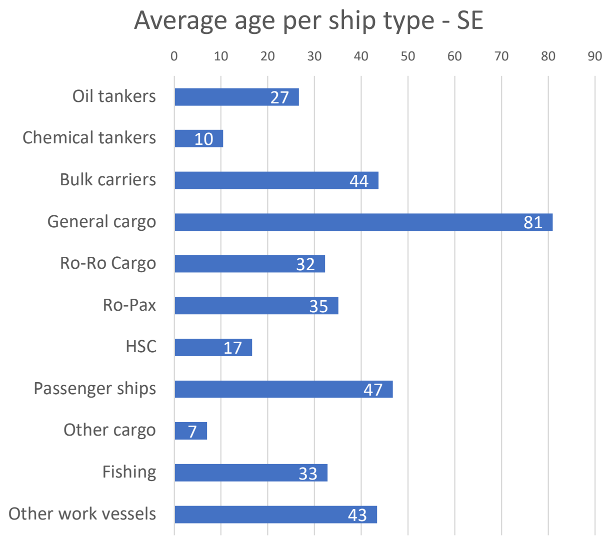


Figure A2. 87: Age of fleet with the flag of Sweden. Overall and average age per ship type.

The percentage of ships with the flag of Sweden that belongs to shipowners registered in the country is shown below.

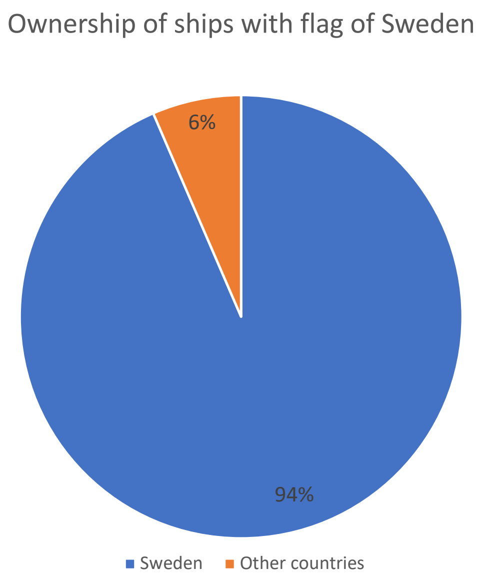


Figure A2. 88: Percentage of Swedish fleet owned by the shipowners of Sweden.

Iceland

There are 36 ships other than fishing vessels registered with the flag of Iceland. Most of those are passenger ships (44%) and other work vessels (39%). There are 16 passenger ships including 3 Ro-Pax part of the Icelandic fleet.

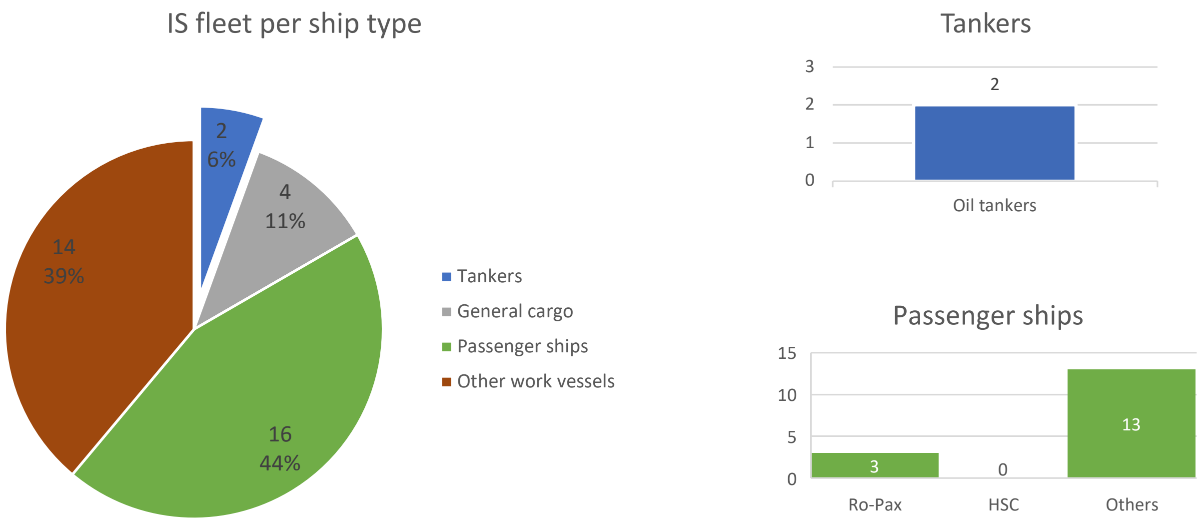


Figure A2. 89: Icelandic fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Iceland is below.

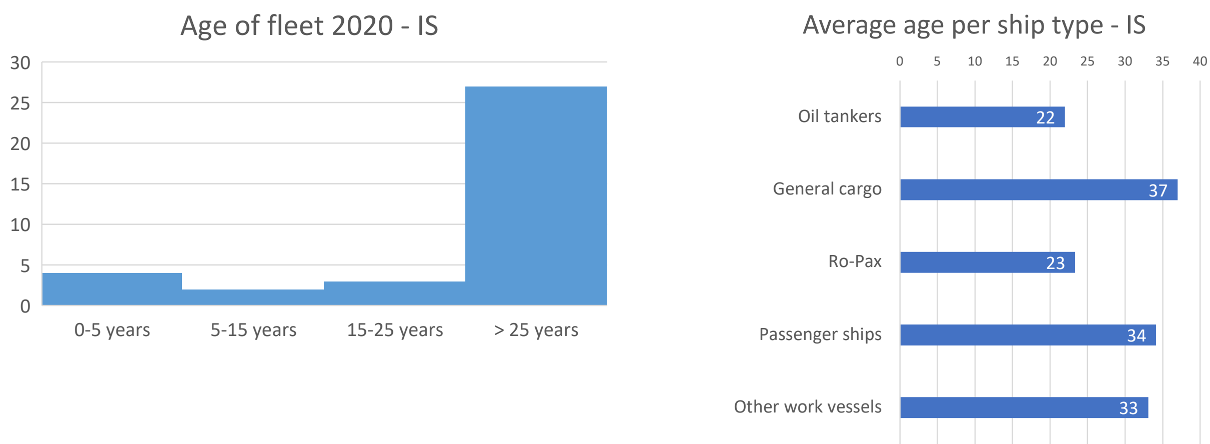


Figure A2. 90: Age of fleet with the flag of Iceland. Overall and average age per ship type.

The percentage of ships with the flag of Iceland that belongs to shipowners registered in the country is shown below.

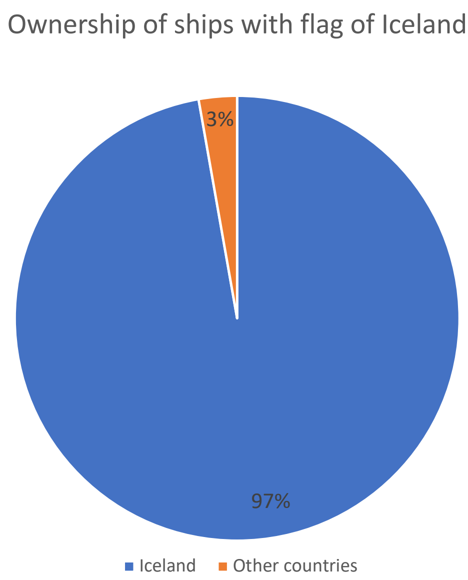
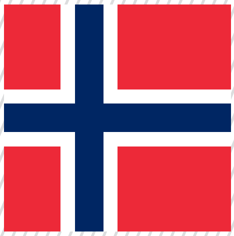


Figure A2. 91: Percentage of Icelandic fleet owned by the shipowners of Iceland.

Norway



There are 1589 ships registered with the flag of Norway corresponding to 12% of the EU MS flagged fleet.

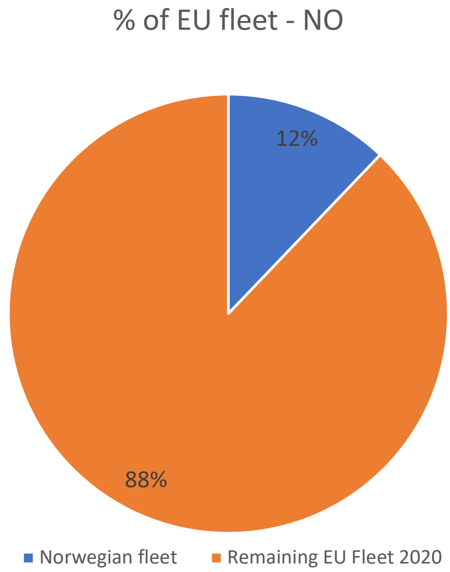
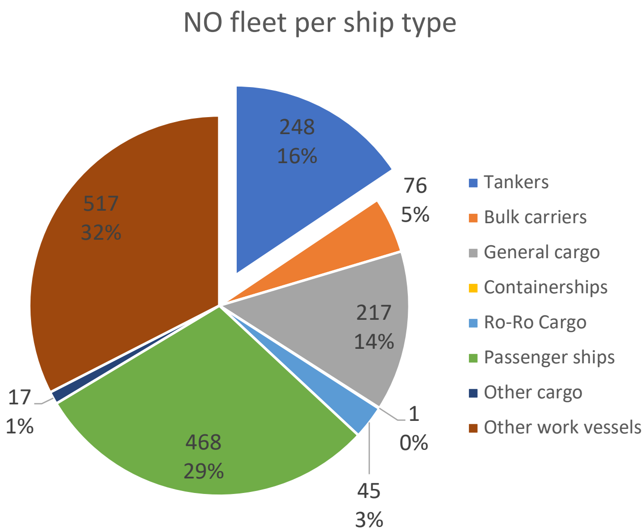
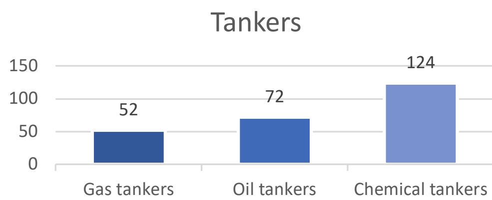


Figure A2. 92: Share of the flag of Norway in EU MS flagged fleet.

The division of those per ship type is shown below. The largest number of ships flying the flag of Norway are other work vessels (32%) and passenger ships (29%).

There are 468 passenger ships including 308 Ro-Pax and 32 HSC ships part of the Norwegian fleet.





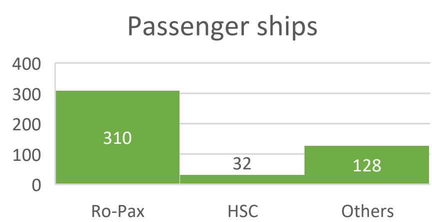


Figure A2. 93: Norwegian fleet per ship type including number of tankers per subtype and number of Ro-Pax and HSC.

The Ro-Pax of Norway correspond to 28% of the EU MS flagged fleet of that ship type in terms of number of ships and the other cargo ships to 21% of the EU MS flagged fleet.

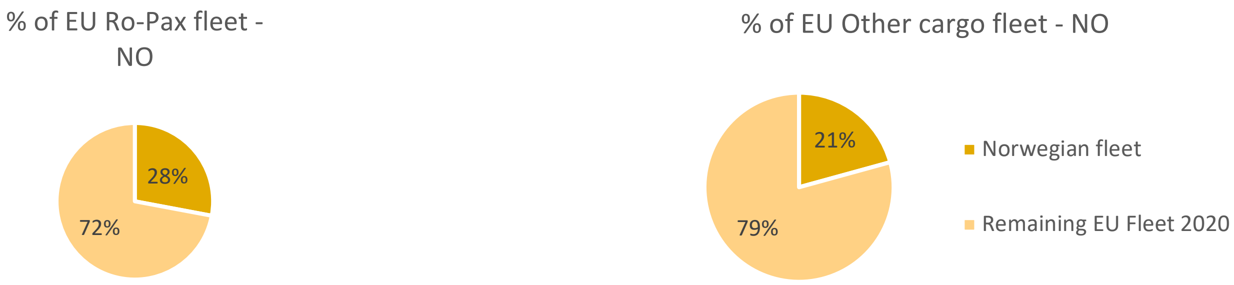
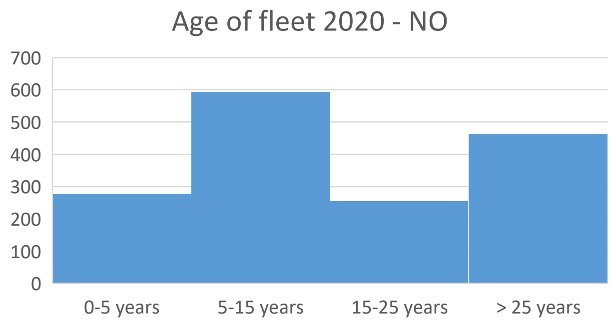


Figure A2. 94: Share of the flag of Norway in the EU MS flagged Ro-Pax and other cargo ships fleets.

The overall fleet age categories and the average age per ship type of the ships flying the flag of Norway is below.



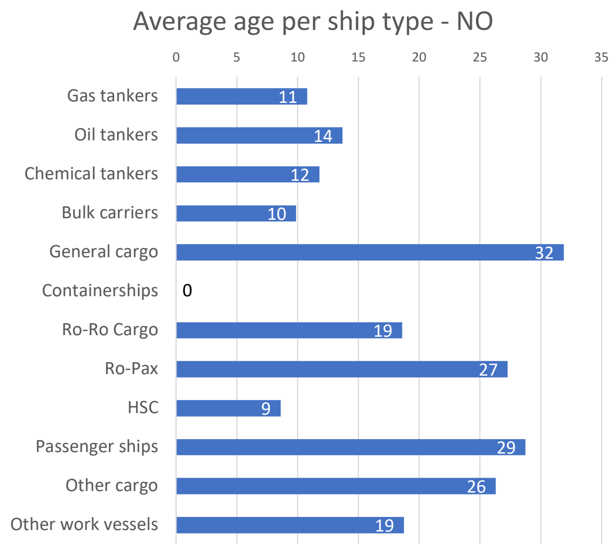


Figure A2. 95: Age of fleet with the flag of Norway. Overall and average age per ship type.

The percentage of ships with the flag of Norway that belongs to shipowners registered in the country is shown below.

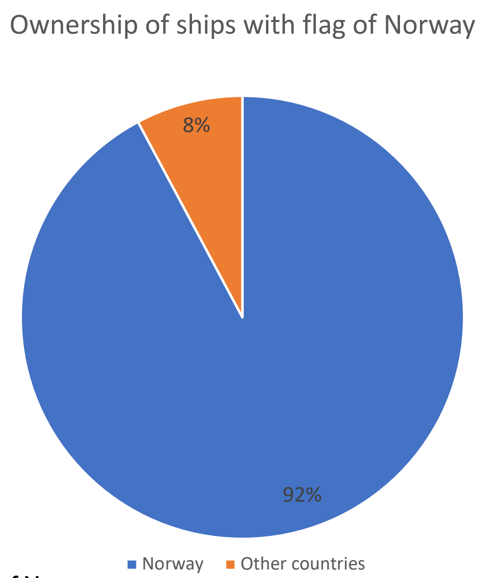


Figure A2. 96: Percentage of Norwegian fleet owned by the shipowners of Norway.

Annex 3 Summary tables on alternative fuels

Fuel/ Power System	Characteristics					Use/ Energy Transformation	Safety (CLP Criteria - Regulation (EC) No 1272/2008)				Regulatory		
	Physical presentation	Energy Density (Specific Energy, LHV) MJ/l (MJ/kg)		Flashpoint (°C)	Flammability Limits (% Vol of mixture in air)		Fire/ Explosion	Toxicity	Health Hazards	Other Hazard (Low Temperature/ Pressure, etc)	Standard for Use as Marine Fuel	Standard for Bunkering	IMO Regulatory Framework
		Without Containment	Contained										
HFO/ IFO/ MDO (included as reference)	Liquid at atmospheric conditions	35.8	13.6	60	(not classified as flammable liquid, but instead as combustible liquid) For diesel vapours: 1 - 10	Internal Combustion Engines (Diesel Cycle, 2-stroke and 4-stroke, low, medium, high speed) Gas Turbines For MDO also Fuel Cells, following reforming.	Not classified as explosive of flammable under CLP criteria Flammable and Explosive vapour concentrations are possible in extreme operating conditions	Harmful if inhaled	May cause cancer May cause damage to organs through prolonged or repeated exposure, May cause skin dryness	No other relevant hazard	ISO 8217 – Standard for marine fuels	ISO 13739 – Standard for bunkering procedures	SOLAS regulation II-2/4.2.1 (flashpoint requirement)
Natural Gas	Liquefied at -163°C (at 1atm) Liquefied Natural Gas (LNG)	20.3 (48)	13.6 (30.4)	-175	4.5-16.5	Internal Combustion Engines (multi-fuel, Otto or Diesel Cycle, 2-stroke and 4-stroke, low, medium, high speed) Gas Turbines Fuel Cells, following reforming. PEM, HT-PEM, MCFC, SOFC	Extremely flammable gas. Explosion of contained concentration. Boiling Liquid Vapour Explosion (BLEVE) Rapid Phase Transition (RPT)	Not classified as toxic Not toxic, but can act as an asphyxiant by replacing oxygen in enclosed spaces	Not classified as a health hazard	Refrigerated gas (-163°C) that may cause cryogenic burns or affect structural integrity due to brittle fracture.	ISO 23306:2020 Specification of liquefied natural gas as a fuel for marine applications Methane Number calculation ISO/TR 22302:2014(EN)	ISO/TS 18683 ISO 20519 Specification for bunkering of liquefied natural gas fuelled vessels Class guidelines/ technical ref available SGMF Guidelines	SOLAS regulation II-1, Part-G Reg.56, 57 IGF Code, Part A-1
	Compressed at 200 - 250bar Compressed natural gas (CNG)	9 (48)	8.5 (4.5)	n/a			All the Fire/ Explosion associated to LNG, except BLEVE and RPT.			Safety hazard associated to storage of flammable gas under pressure.	No Reference	No Reference. Unlike LNG, CNG should be likely "bunkered" via embarkation/ disembarkation of pressurized CNG cylinders	

Fuel/ Power System	Characteristics					Use/ Energy Transformation	Safety (CLP Criteria - Regulation (EC) No 1272/2008)				Regulatory		
	Physical presentation	Energy Density (Specific Energy, LHV) MJ/l (MJ/kg)		Flashpoint (°C)	Flammability Limits (% Vol of mixture in air)		Fire/ Explosion	Toxicity	Health Hazards	Other Hazard (Low Temperature/ Pressure, etc)	Standard for Use as Marine Fuel	Standard for Bunkering	IMO Regulatory Framework
		Without Containment	Contained										
Methanol (MeOH)	Liquid at atmospheric conditions	15.6 (19.7)	13.6 (14.5)	17	6-36	Internal Combustion Engines (multi-fuel, Otto or Diesel Cycle, 2-stroke and 4-stroke, low, medium, high speed) Gas Turbines Fuel Cells, following reforming.	Highly flammable liquid and vapor. Burns with a nearly invisible flame but is less flammable than gasoline Creates Ignitable atmosphere inside storage tanks (at temperatures 5-35°C)	Toxic if swallowed, Toxic in contact with skin, Toxic if inhaled. Toxic to humans, the lethal dosage of methanol is between 30 and 10 ml per kilogram body weight	Causes damage to organs	No low-temperature hazard Corrosive Material compatibility in fuel distribution and use is critical	No Reference for Quality of MeOH as marine fuel.	No Reference (Experience has been gained from existing MeOH fuelled ships but no standardization of bunkering processes or equipment exists) Class guidelines/ technical ref available	SOLAS regulation II-1, Part-F Reg.55 MSC.1/ Circ.1621 - IMO Interim Guidelines for the Safety of Ships Using Ethyl/Methyl alcohol as Fuel
Biofuels (oil replacement drop-in liquids) FAME, HVO, SVO (Blended product characteristic properties may differ)	Liquid at atmospheric conditions	HVO 34.4 (44.1) FAME (B100) 32.9 (37.1) SVO 31.9 (36)	HVO 31.9 (30.8) FAME (B100) 29.6 (26) SVO 28.7 (25.2)	>60	(not classified as flammable liquid, but instead as combustible liquid) For vapour concentrations 0.3 - 10	Internal Combustion Engines (Diesel Cycle, 2-stroke and 4-stroke, low, medium, high speed) Gas Turbines Also Fuel Cells, following reforming.	Not classified as explosive of flammable under CLP criteria Flammable and Explosive vapour concentrations are possible in extreme operating conditions	Not classified as toxic	May be fatal if swallowed and enters airways, Causes skin irritation, May cause damage to organs through prolonged or repeated exposure	Potentially relevant Hazards related to degradation, cold flow properties, corrosion, degradation of rubber seals. Critical blend properties affecting fuel behaviour	ISO 8217 – Standard for marine fuels NOTE: HVO can be produced to meet the specifications for MDO/MGO. FAME only accepted up to 7% blend in MDO (B7) SVO possible to meet IFO grade specifications.	ISO 13739 – Standard for bunkering procedures (Standard procedures for bunkering can be considered fully applicable to oil replacement biofuels)	SOLAS regulation II-2/4.2.1 (flashpoint requirement)

Fuel/ Power System	Characteristics					Use/ Energy Transformation	Safety (CLP Criteria - Regulation (EC) No 1272/2008)				Regulatory		
	Physical presentation	Energy Density (Specific Energy, LHV) MJ/l (MJ/kg)		Flashpoint (°C)	Flammability Limits (% Vol of mixture in air)		Fire/ Explosion	Toxicity	Health Hazards	Other Hazard (Low Temperature/ Pressure, etc)	Standard for Use as Marine Fuel	Standard for Bunkering	IMO Regulatory Framework
		Without Containment	Contained										
Hydrogen (H2)	Liquefied at --253°C (at 1atm) Liquefied Hydrogen (LH2)	9.2 (120)	5 (17.2)	<253 °C	4-75	Internal Combustion Engines (Dual Fuel ICE, HP, 4-stroke (SI) Dual-Fuel ICE, LP, 2-stroke Fuel Cells, without need for reforming.	Extremely flammable gas, over a wide range of gas-air mixture concentrations Heating may cause violent combustion or explosion. Reacts violently with halogens, oxidizing materials, and greases	Not classified as toxic	Not classified as a health hazard	Refrigerated liquefied gas (-253°C) that may cause deep cryogenic burns or affect structural integrity due to brittle fracture.	No reference for marine use Existing Hydrogen Fuel Quality Standards: ISO 14687:2019. Hydrogen fuel quality -- Product specification and SAE J2719	No reference	SOLAS regulation II-1, Part-F Reg.55 No interim guidelines yet developed
	Compressed at 700bar Compressed Hydrogen (CH2)	4.7 (120)	2.7 (6.7)	n/a						Safety hazard associated to storage of flammable gas under pressure.			
Ammonia (NH3)	Liquefied at -34°C (at 1bar) or 20°C (at 10bar)	(-34°C - 1bar) 11.3 (18.4)	(-34°C - 1bar) 9.2 (11.7)	-35	15-25	Dual Fuel ICE, HP ICE, 4-stroke (SI) Fuel Cell Direct Ammonia Fuel Cell (DAFC) Solid Oxide Fuel Cell (SOFC)	Flammable mixtures in air over a narrow flammability range. Reacts with halogens, interhalogens and oxidizers and may cause violent reactions or explosions	Highly toxic to humans, form low to high concentrations. Severe effects from prolonged exposure	Highly hazardous to health. Acute exposure can cause severe injuries in area of contact (eyes, skin)	Corrosive to several metal alloys and material. Careful selection of materials is required.	No standard for use of ammonia as marine fuel	No reference (existing experience with ammonia cargo and LNG/LPG fuel may be good reference point)	SOLAS regulation II-1, Part-F Reg.55 No interim guidelines yet developed
Liquefied Petroleum Gas (LPG)	Pressurised (8.4 bar at 20°C) Liquefied (1 bar at -48°C)	(depends on composition) 22.6 (46.3) (propane) 25.8 (45.4) (n-butane)	(depends on composition) 15 (32)	Pro -60 (butane))	1.8 - 9	Dual Fuel ICE, HP Gas Turbines ICE, 4-stroke (SI) Fuel Cells	Extremely flammable gas. Explosion of contained concentration. BLEVE	Not classified as toxic Not toxic, but can act as asphyxiant	Not classified as a health hazard	Low temperature hazard if refrigerated. Flammable gas under pressure for pressurized containment.	No standard for marine use ISO 9162, Petroleum products — Fuels (class F) — LPG — Specifications Reference	No bunkering standard. Can benefit from experience with LNG bunkering and cargo transfer operations.	SOLAS regulation II-1, Part-F Reg.55 Interim guidelines under development

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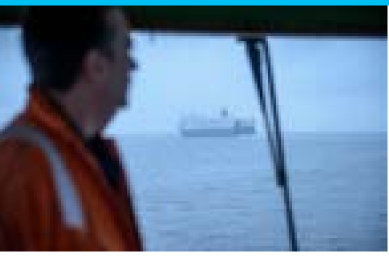


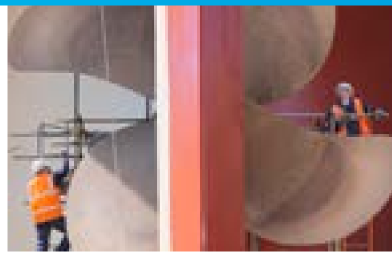

ABOUT THE EUROPEAN MARITIME SAFETY AGENCY

The European Maritime Safety Agency (EMSA) is one of the European Union's decentralised agencies. Based in Lisbon, Portugal, the Agency's mission is to ensure a high level of maritime safety, maritime security, prevention of and response to pollution from ships, as well as response to marine pollution from oil and gas installations. The overall purpose is to promote a safe, clean and economically viable maritime sector in the EU.

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