Safety and Shipping 1912-2012

From Titanic to Costa Concordia

An insurer's perspective from Allianz Global Corporate & Specialty

Cardiff University
Prifysgol Caerdydd

Allianz

Foreword

Dr. Sven Gerhard, AGCS's Global Product Leader: Hull & Marine Liabilities (Hamburg), has a Doctorate in Law, and is the author of several publications on marine insurance law. He holds honorary posts in the Board of the German Maritime Law Association and Hanseatic Marine Underwriters and is a visiting lecturer on marine insurance law at the University of Münster and the Frankfurt School of Finance.

In the digital era in which we live, shipping may seem to many to be a traditional industry, far removed from the lives of most of us. But this could not be further from the truth: shipping connects the world. As this report shows, seaborne trade continues to grow fast, playing a critical role in connecting the global economy and driving economic prosperity. Not only that, but shipping remains a key mode of transport for many private individuals, as part of their livelihoods or indeed for leisure purposes, as shown by the growth of the cruise industry. For these reasons, among others, shipping safety should be of direct interest to us all, a point brought into sharp and tragic focus by the recent grounding of the *Costa Concordia* off Italy in January 2012 and the sinking of the *Rabaul Queen* off Papua New Guinea in February 2012, almost 100 years exactly after that most famous of marine disasters – the loss of the *Titanic*.

Working with the Seafarers International Research Centre (SIRC) in the United Kingdom, we at Allianz Global Corporate & Specialty (AGCS) have produced this report to highlight not only the importance of shipping, but also the improvements in safety which have underpinned its growth over the last century. The report highlights some of the issues the worldwide industry faces, and we hope its publication will encourage an open and pragmatic dialogue with ship-owners, allowing both clients and AGCS to assess risks in a transparent and fair manner. As marine insurers, we believe that we have an important role to play by actively encouraging and recognizing best practice wherever we find it through our underwriting and risk consulting activities. Furthermore, as marine insurers, we would like to raise awareness of future challenges in the industry, because we believe that only by engaging in open discussions on these challenges can we work with our clients and others to address them – to the mutual benefit of us all and for the future success of the industry.

Dr. Sven Gerhard
Global Product Leader: Hull & Marine Liabilities
Allianz Global Corporate & Specialty
Hamburg - March 2012

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Executive Summary

Maritime safety affects everyone, from blue collar factory workers and school children, to journalists and company chief executives. The global population depends on a safe and efficient shipping trade network for modern day living to continue unchecked. In the 100 years since the loss of the *RMS Titanic*, the maritime industry has worked steadily to improve safety performance so that the 23 million tonnes of cargo and 55,000 cruise passengers that travel by ship every day do so safely and efficiently in the vast majority of cases.

At the turn of the twentieth century, one of the most renowned shipping tragedies of all time occurred in the midst of the Atlantic Ocean. In April 1912, the *RMS Titanic*, the pride and joy of White Star Line, sank on her maiden voyage from Southampton, UK to New York, USA. *Titanic*, at the time the world's largest passenger steamship, struck an iceberg four days into the crossing and sank to the ocean bed taking 1,513 lives. Since that human tragedy, the maritime industry has actively endeavored to improve safety records and it is no understatement to say that shipping in 2012 is a far safer form of transport for passengers, cargo, seafarers and ships. However, notwithstanding these advances, significant challenges remain as the recent *Costa Concordia* and *Rabaul Queen*[1] disasters have demonstrated.

No one separate development can be singled-out for this progress: today's safer shipping environment is the culmination of a number of initiatives, research, regulations, and innovations. This report outlines some of the major areas where the shipping industry has benefitted from improvements, explains how shipping in the twenty-first century is now safer than ever, and reviews current and future challenges to maritime safety. Perhaps of most interest are the emerging challenges facing the industry. Here, key findings include:

- **Ship sizes** have increased significantly, dwarfing the *Titanic* in comparison. The largest modern container ships, such as Maersk's new Triple-E class, pose challenges for insurers due to their sheer scale and value. Other ships are pushing the design envelope, breaking new ground in terms of design challenges which has led to concerns about structural integrity.

- **Cruise ships:** Despite the strong passenger safety record of the cruise industry, the modern trend towards ultra-large cruise ships, carrying over 6,000 passengers, poses new challenges, especially in terms of evacuation and rescue in remote environments. The International Maritime Organisation (IMO) has introduced regulations addressing such risks, including proactive risk management with improved fire safety systems and a focus on the need for such vessels to be their 'own best lifeboat' so that, in the event of a casualty, persons can stay safely on board, as the ship proceeds to port.

- **Training and labor:** with increased cost pressure, many ship-owners look to source crews from emerging economies due to lower wage demands. Despite IMO attention through international standards, training regimes and assessment are not consistent and may lead to variations in crew and officer competence.

- **Crewing levels** in a competitive industry continue to pose risks, despite the greatly improved efficiency of modern vessels, and may compromise margins of safety. Some commentators regard minimum crewing levels as too low, and point out they do not allow for the inevitable extra tasks that 24 hour operations require – with 'human factor' risks such as fatigue being significant causes of accidents.

- **Inadequate risk management** is identified as a key challenge which can be addressed through improved safety management systems and processes.

- **Piracy** continues to threaten shipping, especially off Somalia and the Horn of Africa where 28 ships were attacked in 2011, with attacks also being seen in other regions (such as West Africa). The economic impact of piracy was estimated to be around $7 billion in 2011.

- **Language barriers** are also cited as potential risks, given the dependence on English as the 'language of the seas'. With increasingly multi-national crews, concern has been raised about communication in an emergency, or even misunderstandings in routine operations.

- **Arctic and Polar waters:** climate change is opening up access to previously impassable seaways, but the development of new routes, such as the North East Passage, pose great challenges in terms of ice navigation, environmental concerns, and design and construction demands, as well as emergency procedures in extremely hostile environments.

- **Poor enforcement & coordination:** with a complex regulatory environment, coordination of such regulations needs to be improved. Despite an alignment of objectives, individual enforcement bodies do not always coordinate actions, nor is it easy to enforce responsibility in the event of an incident.

- **Bureaucracy** is cited as a pressure on crews and officers, diverting them from other tasks and potentially compromising safety. This is compounded by minimum crewing levels which place further burdens on already hard-pressed crews. Allocating responsibility for such matters, perhaps via a 'purser' role, could address this challenge.

- **Fire** remains a major on-board risk especially in 'Ro-Ro' ferries (with relatively open decking) and also on passenger ships with increased 'hotel' services and large passenger numbers.

Key facts and figures

- Despite a trebling of the world fleet to over 100,000 ships in 2010, and a total fleet tonnage now approaching 1 billion gross tonnes, shipping losses have decreased significantly from 1 ship per 100 per year (1912) to 1 ship per 670 per year in 2009.
- World seaborne trade continues to grow rapidly, driven by globalization and supported by containerization, having trebled since 1970 to over 8.4 billion tonnes of cargo loaded per annum.
- Marine transport can be regarded as one of the safest means of passenger transport overall: in Europe, it is ranked after rail, air and bus/coach as the fourth safest means, with far lower fatal accident rates than car, motorcycle, bicycle or walking.
- However, seafaring remains dangerous as a profession. While professional seafarer fatality rates have fallen – for example, in the UK per 100,000 seafarer-years, from 358 (in 1919) to 11 in 1996-2005 – this fatality rate is still twelve times higher than in the general workforce. Despite inconsistent data, other country statistics appear to be considerably higher: for example Hong Kong recorded 96 per 100,000 seafarers per annum for 1996-2005, and Poland a rate of 84 per 100,000 seafarers per annum for the same period.
- Most losses can be attributed to 'human error' – a broad category estimated to be responsible for between 75%-96% of marine casualties. Pressures of competition (often shore-based) and fatigue are frequently cited as significant causes – a particular matter of concern in busy shipping areas such as the Baltic where crews may have little time to rest between periods of duty.
- The most common primary causes of shipping losses are foundering (49% of losses), wrecking/stranding (18%) and fire/explosion (15%) while hull or machinery failure only accounts for around 2% of losses.
- Dry (bulk) cargo vessels have higher than average loss rates (44% of losses, despite representing 20% of the world fleet by number). Conversely, tankers, container vessels and offshore industry ships have relatively low loss rates.
- Shipping is highly concentrated into modern sea-lanes as vessels navigate between major ports to optimize efficiency. This results in clustering of losses in certain key regions. Accident 'black spots' include South China, Indo-China, Indonesia and Philippines (17% of losses in 2001-2011), followed by East Mediterranean and Black Sea (13%), and Japan, Korea and North China (12%). The seas around the British Isles also show relatively high loss concentrations (8%).

While these emerging safety risks need to be addressed to further improve incident records going forward, in its review of safety improvements since the *Titanic* accident, this report finds that much progress has been already made in attending to safety issues.

Driving safety

Safety has improved through a combination of technology, cultural and training improvements, and regulations, as well as through new construction and design techniques.

Additionally, past experience demonstrates that major accidents have often been the catalysts for key changes: for example, the International Convention for the Safety of Life at Sea (SOLAS) of 1914 was spurred on by the loss of the *Titanic*. A similar impact can be expected from the *Costa Concordia* incident – just as we have previously seen with the *Herald of Free Enterprise* (1987), the *Exxon Valdez* (1989), and the *Estonia* (1994) losses, which drove the creation of Safety Management Systems under the ISM Code.

Technology & design in focus

Technology has been a key driver of safety, from the introduction of gyrocompasses and the first use of aviation to spot icebergs in 1914 to the mandatory use of Electronic Chart Display & Information Systems (ECDIS) in 2012.

Military innovations drove improvements in the mid-20th century – for example, in Radar and in wireless communications – while later technologies such as Automatic Radar Plotting Aid (ARPA), Global Positioning Systems (GPS) and Automatic Identification System (AIS), have reduced accidents through greatly improving 'situational awareness' via increased access to real time information.

In addition, search and rescue efforts are greatly assisted by modern (satellite-assisted) location-finding technologies such as radar transponders and distress beacons.

However, experts warn of dependence on single technologies, citing examples where reliance on technology has led to major incidents.

Improvements have also stemmed from changes in construction and design processes. Shipbuilding techniques such as pre-fabrication and welding have improved quality and structural integrity, while computer-aided design has radically speeded up the design process, allowing modeling to replace physical trial and error.

Training & Culture

Over the past one hundred years, training has moved from being localized and unregulated to a global footing and is now subject to close international scrutiny. The Standards of Training Certification and Watch-keeping for Seafarers Convention (STCW) in 1978 established international benchmarks in this area – and has since been enforced by the IMO through publishing its 'White List' of countries which comply with these standards.

Safety Management Systems have also driven an increased safety culture, in part arising from the failures of the previous piecemeal approach highlighted in the aftermath of the *Herald of Free Enterprise* disaster in 1987. Spurred by this accident, the International Safety Management Code (ISM Code), which the IMO adopted in 1993, has driven best practice to be more widely accepted and institutionalized in the industry.

However, inadequate risk management remains a challenge – with one survey attributing this as a main or contributing factor in nearly 40% of accidents.

Regulation

The maritime industry is now highly regulated, with a large number of organizations responsible for different facets of safety. However, it is the primary body, the IMO, formed in 1948, as a United Nations agency, which has driven much international regulation.

Prior to the IMO's formation, the first SOLAS convention was driven by the loss of the *Titanic*, and on being adopted by its international signatories in 1914 formed a landmark treaty on marine safety. Subsequent revisions, combined with other key IMO conventions such as the International Regulations for Preventing Collisions at Sea (COLREG) and the International Convention on Loadlines, have further tightened safety rules.

Such regulations have not simply reduced the risk of accidents; they have also addressed the challenges of responding to an accident with, for example, the Global Maritime Distress and Safety System (1999) establishing improved global procedures for search and rescue.

The industry itself has also played an active part in self-regulating to improve standards: for example, oil tanker owners have set higher standards since environmental disasters such as the *Exxon Valdez* by tightening risk management procedures and establishing vetting systems, forcing others to adopt similar safety standards.

Quality control and enforcement

Working with the IMO, Members States check operational safety at ports around the world through the Port State Control (PSC) system.

Established under the STCW convention in 1978, national PSC can inspect and detain ships when necessary to enforce standards. The results of inspections are published freely online, creating considerable transparency in this process.

While the number of inspections has increased with increased trade, detentions have notably decreased: in the Asia Pacific region, inspections increased by 48% from 2001-2010, but detentions dropped by 5%.

Flag States further support the global enforcement of IMO legislation. Flag states are those under whose national flag a ship sails, and on whose register of shipping each vessel is recorded.

However, "open registries" or "Flags of Convenience" have also emerged since the 1950s, and some have attracted criticism for a perceived relaxation of regulatory control, either through non-ratification of legislation, or non-enforcement of ratified legislation.

Classification Societies offer another important element to maintaining safety standards. These independent bodies develop and apply technical standards to ship design and construction. They have, however, been subject to criticism for failing on occasion to spot potential technical weaknesses in advance and, more recently, when some Societies have started to enter into ship design services – a move that has raised concerns in respect of conflicts of interest when the Societies may classify the very ships they have themselves designed. Nonetheless, other commentators refer to the improvements in ship safety that have been achieved through the design contributions of some Societies.

Marine insurers such as AGCS should also contribute through transparent underwriting and dialogue with ship-owners, supported by proactive risk consulting to reduce risk in advance. Insurers can encourage best practice in marine operations, recognizing the efforts of leading ship-owners to reduce risk – for the benefit of all parties.

SCOPE OF REPORT

Scope of Report

This report focuses on global developments in shipping safety and associated accidents over the period from 1912 to 2012, with specific reference to losses of commercial ships of 100 gross tonnes (GT) or more, and does not include information on smaller vessels or pleasure craft. Although fatality rates are referred to, the main focus of the report is on shipping losses as defined below.

To measure shipping losses for the purposes of this report, only 'total losses' or 'constructive total losses' have been considered as defined in the Lloyd's Register Fairplay World Casualty Statistics[2]. Total losses are defined as 'propelled merchant ships of not less than 100 GT which, as a result of being a marine casualty, have ceased to exist, either by the virtue of the fact the ships are irrecoverable, or have been subsequently broken up'. Constructive total losses refer, on a similar basis, to casualties which are not economically recoverable – perhaps due to additional salvage costs – and hence are declared a total loss. This approach means that only major losses are reported in the report. As a result, this report does not provide a comprehensive analysis of *all* maritime accidents, due to the large number of minor incidents which do not result in a 'total loss'.

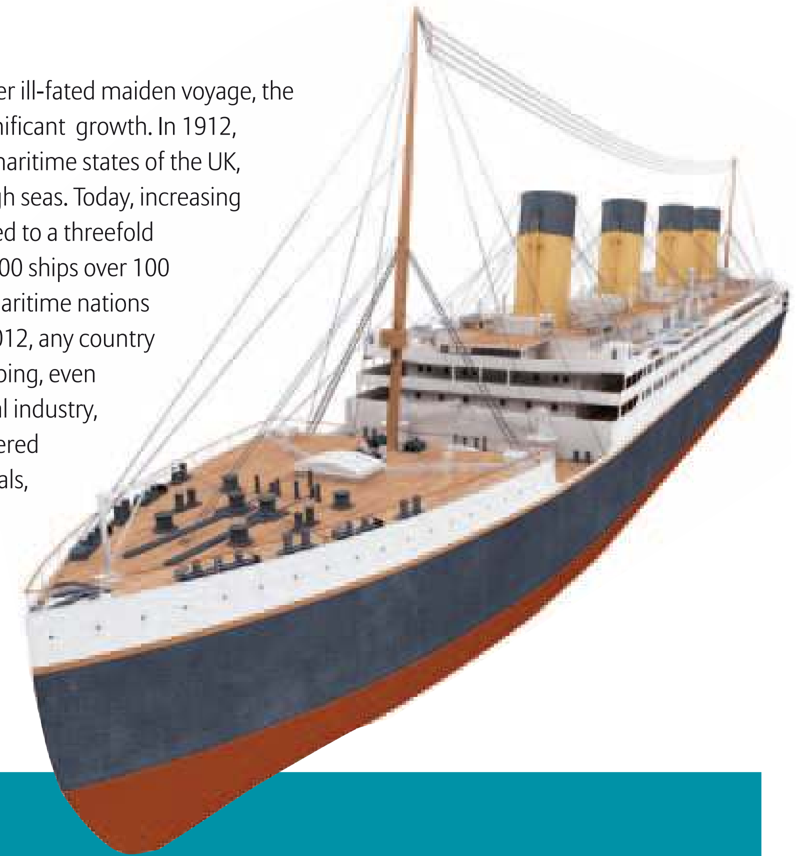
SAFER SEAS

Safer seas

A century of shipping industry growth has been marked by a decline in both ship losses and seafarer fatalities

Allianz and The Titanic
Despite a construction cost of around $7.5 million, the *Titanic* was insured for a hull value of $5 million through over 70 co-insurers including Allianz (one of the few non-British insurers to cover this ship). Total claims arising from the disaster are estimated to have totaled around $12 million (or at least $278 million in 2010 prices adjusted for US inflation).[4]

In the 100 years since the *Titanic* made her ill-fated maiden voyage, the world shipping fleet has experienced significant growth. In 1912, around 30,000 ships, dominated by the maritime states of the UK, USA, Germany and Norway, sailed the high seas. Today, increasing industrialization and globalization have led to a threefold increase in fleet size to in excess of 100,000 ships over 100 gross tonnes[3]. The traditional 'big four' maritime nations now no longer dominate the waves. In 2012, any country around the world can be involved in shipping, even those with no coastline. In this truly global industry, a ship owned by Chinese interests, registered in Panama, crewed by Philippines' nationals, calling at Mediterranean ports, served by American agents, managed in Cyprus, and insured by a multi-national panel of insurers through London brokers would not be considered unusual.



Sinking the 'unsinkable'

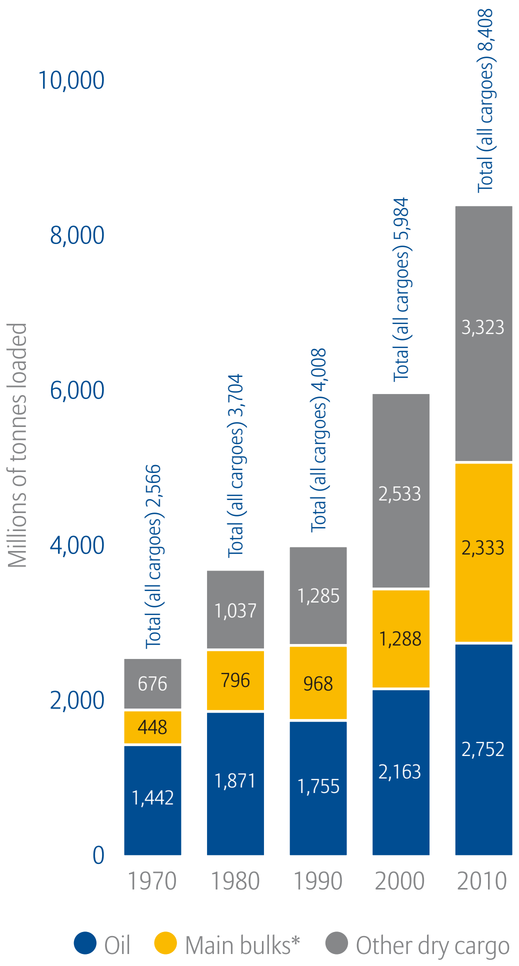
Dubbed the 'unsinkable' ship, the *RMS Titanic* captured the world's imagination like no other. When she cast off from Southampton on April 10, 1912, it was to great fanfare as her owner White Star Line had heavily publicized the maiden voyage of this engineering feat. However, an incident on departure from Southampton was perhaps a precursor of the tragic things to come. As the largest ship on the water, the *Titanic's* massive propellers managed to suck a smaller ship, the New York, into her wake as she left the harbor, causing a near collision before she had even left UK waters.

Then, four days into her voyage, late in the night of April 14, 1912, despite last minute emergency maneuvering, she struck a massive iceberg. The collision tore a 90 meter hole across the ship's hull, opening six hull compartments to the sea. From that point on the *Titanic's* sinking was irreversible. A mayday call was sent out to neighboring ships, but none were able to reach the *Titanic* before she sank to her watery grave in the Atlantic Ocean, south of Newfoundland, Canada.

Only 711 persons survived the sinking of the ship, out of 2,224 passengers and crew members. Sadly, reports indicate that the *Titanic* disaster may well have been avoided had the ship's officers paid attention to reports regarding the frozen waters they were approaching. Earlier in the evening, neighboring ships in the area had reported that the waters ahead contained numerous masses of solid ice and that approaching ships should proceed with caution. The *Titanic*, however, thought to be unsinkable, ploughed ahead at full speed. This was a mistake that proved to be fatal and undoubtedly led to the tragic loss of those 1,513 lives.

While shipping has remained the preferred freight transportation mode throughout this time, international trade has not remained static. At the beginning of the twentieth century, international trade was inevitably disrupted by the two world wars and additionally by the recession of the early 1930s. Then, in the 1950s, cargo transportation moved into a boom period and this growth has steadily continued to the current day despite predictable year-to-year fluctuations linked to changes in GDP.

Development of International Seaborne Trade, selected years



Adapted from UNCTAD Review of Maritime Transport 2011[4]

* Main bulks = iron ore, coal, grain, bauxite/alumina, phosphate rock

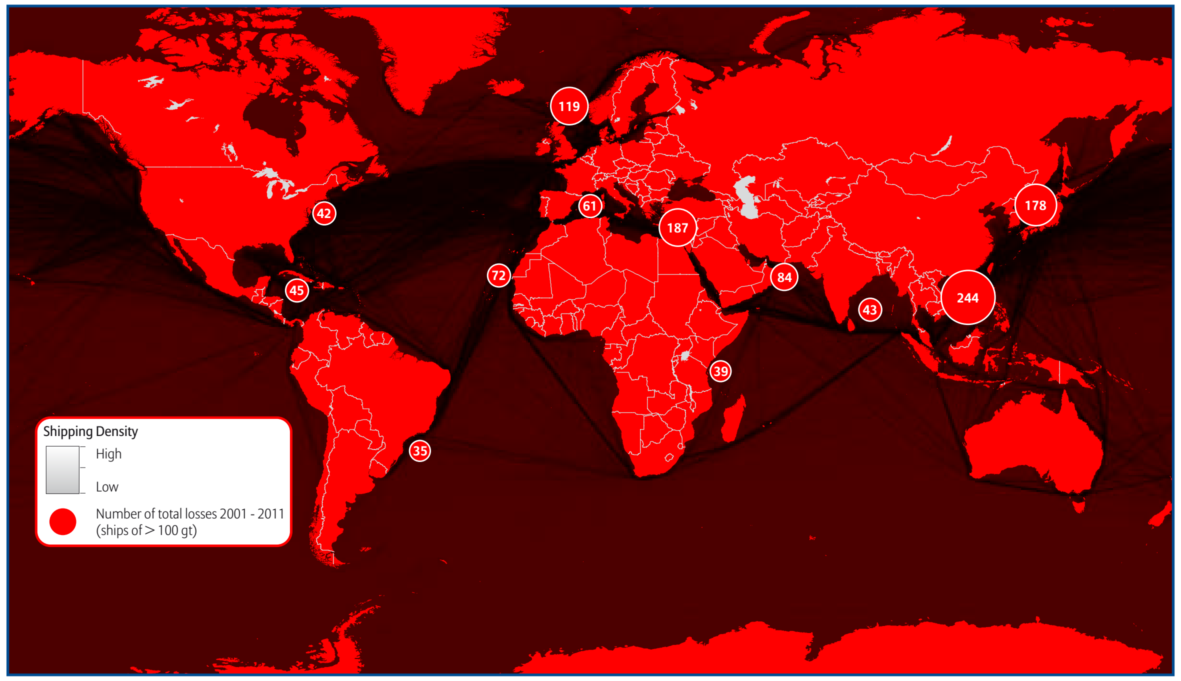
Over that time, new sectors have emerged and new freight 'drivers' have come forward. Since its introduction in 1956, container shipping has unequivocally proved the worth of standardization of cargo handling across the whole supply chain, while globalization and the subsequent outsourcing of labor and production has shifted manufacturing sites from the 'West' to the 'East', most recently to China. The Middle East has become a major force behind oil shipments around the world. Today, more than 100 million tonnes of oil are shipped each day by tankers, about half of which is loaded in the Middle East and then shipped to Japan, the United States and Europe. In the dry bulk commodities trade, Australia and South America are the dominant exporters, with China proving an insatiable consumer of major bulks today.

See Appendix (page 58) for details of major world ports.

Millions of tonnes loaded

Year	Oil	Main bulks*	Other dry cargo	Total (all cargoes)
1970	1442	448	676	2566
1980	1871	796	1037	3704
1990	1755	968	1285	4008
2000	2163	1288	2533	5984
2010	2752	2333	3323	8408

Strategic Passages and Regional Losses (Loss Dates 2001-2011)



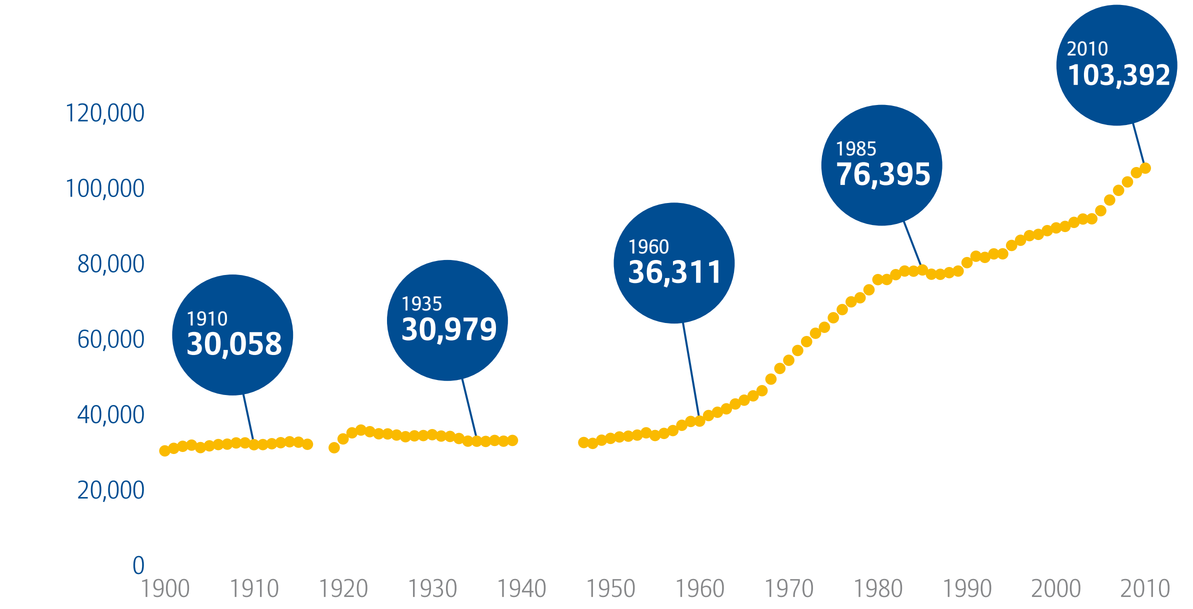
Source: Dr. Jean-Paul Rodrigue, Dept. of Global Studies & Geography, Hofstra University.
Source of loss data: Lloyd's List Intelligence World Fleet Update

S.China, Indo China, Indonesia & Philippines	244	17.0%
East Mediterranean & Black Sea	187	13.0%
Japan, Korea and North China	178	12.4%
British Isles, N.Sea, Eng.Channel, Bay of Biscay	119	8.3%
Arabian Gulf and approaches	84	5.8%
West African coast	72	5.0%
West Mediterranean	61	4.2%
West Indies	45	3.1%
Bay of Bengal	43	3.0%
United States eastern seaboard	42	2.9%
East African Coast	39	2.7%
S.Atlantic and East coast S.America	35	2.4%
Others	288	20.0%
Total	**1,437**	

"Shipping is an industry that connects everyone."

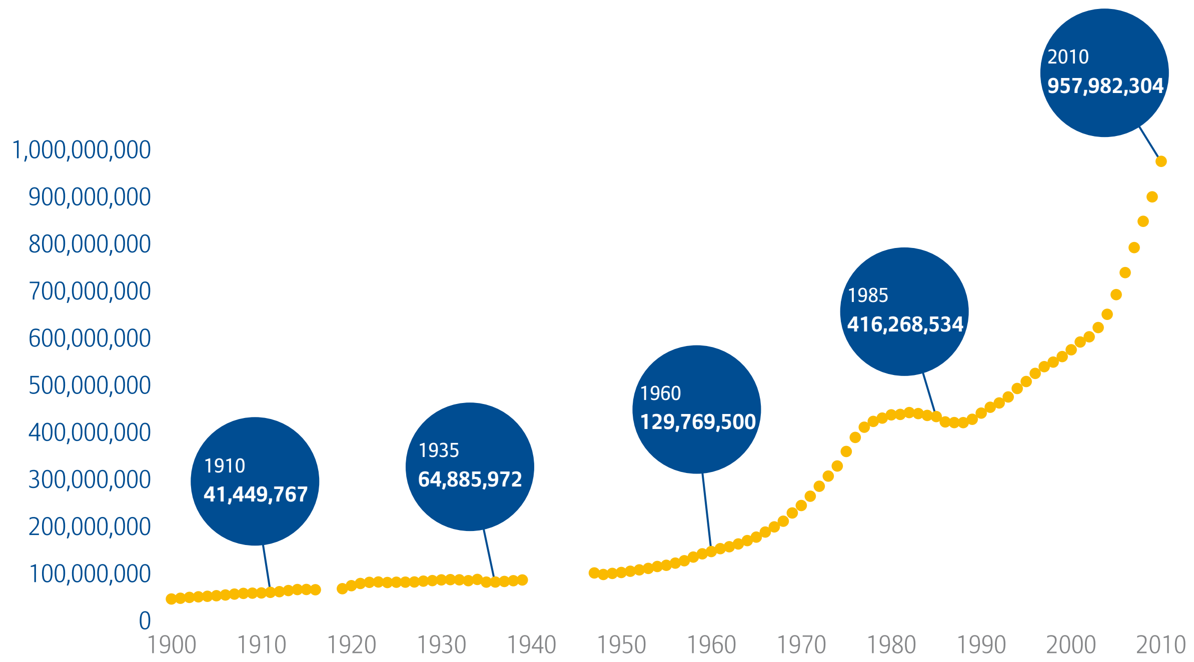
Captain Rahul Khanna,
AGCS Senior Risk Consultant – Marine

World fleet size by number of ships: 1900-2010



Source: Lloyd's Register Fairplay, World Fleet Statistics 1900-2010

World fleet size by tonnage: 1900-2010



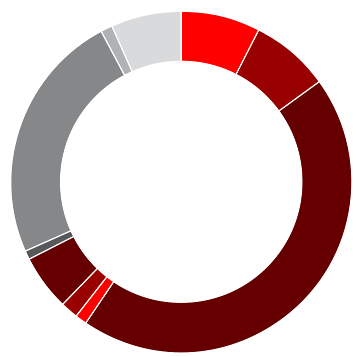
Source: Lloyd's Register Fairplay, World Fleet Statistics 1900-2010

Tonnage is in Gross Tonnage (GT) for all years accept 1900-1916 where figures are a mixture of GT and Net Tonnage (NT). For this period World Fleet Statistics lists GT for steam vessels, and NT for sailing vessels, thus world tonnage is a combination of the two.

Thankfully, this exponential growth in trade and seaborne traffic has not been mirrored in a growth in fatalities among professional seafarers, although seafaring remains a dangerous profession. The fatal accident rate in UK shipping was 11 per 100,000 seafarer-years from 1996 to 2005, down from 39 per 100,000 in 1986-1995, and 53 per 100,000 in 1976-1985. The improvement on earlier data is even more pronounced: in 1919, the UK fatality rate was 358 per 100,000 seafarer-years. On an international scale, the fatal accident rate in the UK fleet – which has fallen sharply over time – is extremely low. As a comparison, in Hong Kong the fatal accident rates from 1996-2005 was 56 per 100,000 seafarer-years, while Poland recorded 84 and Denmark 90 over the same period[6]. Data available from individual maritime administrations such as the UK Maritime and Coastguard Agency support the notion that fatality rates in the shipping sector have fallen over recent decades. Indeed, since 1912, the fatality record of the shipping industry has improved more quickly than that for land-based occupational sectors and improvements in the structural integrity and seaworthiness of ships have undoubtedly aided this progress. However, it must be noted that reliable comparative data across international maritime fleets is not fully available, and so comparisons between countries should be regarded as an approximation only[7].

Total losses by ship type: 2000-2010

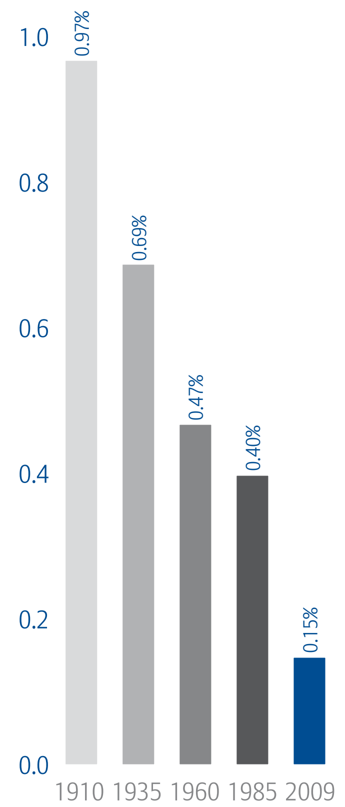
(number of losses)



Tankers	121	7.6%
Bulk Carriers	120	7.6%
Cargo Vessels	706	44.5%
Containers	17	1.1%
Reefers	24	1.5%
Passengers/General Cargo	83	5.2%
Passenger Cruise	17	1.1%
Fishing	375	23.6%
Offshore Industry	20	1.3%
Other	103	6.5%

Source: Lloyd's Register Fairplay, World Fleet Statistics 2000-2010

Total losses – % of world fleet



Source: Calculated from Lloyd's Register World Casualty Statistics 1900-2010

And total losses of ships are on the decline: Lloyd's Register Casualty Statistics reveal a global pattern of falling losses in the period 1910 to 2010. One ship in every 100 was lost in 1910, a rate which has improved to around one ship in every 670 as at 2010. Based on Lloyd's Register data for 2000-2010, shipping losses broadly reflect the distribution of ship types in the world fleet, although cargo vessels (general cargo, ro-ro cargo, other dry cargo) make up a disproportionate number of losses (44% of losses, despite representing 20% of the world fleet by number). Conversely, tankers (including LNG/LPG carriers and crude oil tankers) have a relatively low loss rate at 8% of losses despite representing 13% of the total world fleet, as do container vessels (4% of fleet; 1% of losses) and offshore industry ships (5% of fleet; 1% of losses).

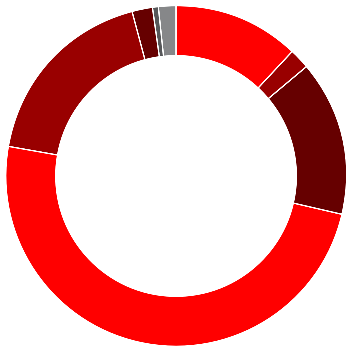
Total losses by ship type: 2000-2010

	Number of Total Losses 2000-2010	Average fleet no. 2000-2010	% of fleet	% of losses
Tankers	121	12056	13%	8%
Bulk Carriers	120	7173	8%	8%
Cargo Vessels	706	18915	20%	45%
Containers	17	3683	4%	1%
Reefers	24	1265	1%	2%
Passenger/ General Cargo	83	6021	6%	5%
Passenger Cruise	17	449	0%	1%
Fishing	375	23815	25%	24%
Offshore Industry	20	4284	5%	1%
Other	103	16359	17%	6%
	1586	**94021**		

These losses include some losses outside normal operational activities (for example, while under repair or under tow prior to scrapping.)
Source: Lloyd's Register Fairplay, World Fleet Statistics

European Maritime Safety Agency figures for 2007-2010 confirm that only 6% of major shipping accidents in European Union waters involved sinkings ('foundering'). Collisions and groundings are far more common accidents, representing 71% of accidents in European waters[8]. However, worldwide, the most common cause of total losses remains from foundering which represented 49% of ship losses from 2000-2010 according to the Lloyd's Register data. Worldwide, hull or machinery failure only accounts for around 2% of losses.

Causes of total loss (2000-2010)
(number of losses)



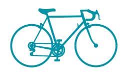
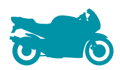
Collision	190	12.0%
Contact	34	2.1%
Fire/Explosion	233	14.7%
Foundering	778	49.1%
Wrecked/Stranded	286	18.0%
Hull/Machinery	33	2.1%
Missing	6	0.4%
Other	26	1.6%

Source: Lloyd's Register Fairplay, World Fleet Statistics 2000-2010.
See Appendix for definitions of loss categories.

Sea travel itself is generally considered one of the safest modes of passenger transport. The European Transport Safety Council data[10] ranks marine transport in Europe as the 4th safest means of passenger transport after bus/coach, rail and air. Car travel is significantly more risky, but that risk increases further for cycling and walking – around 7-9 times riskier than car travel – and further still for motorcycle/scooter travel, being 20 times riskier than car travel. US transport fatality figures for 2009 support these findings[9], with ship-related fatalities second safest only to air transport; however these figures do not take into account the popularity of the mode.

Sea travel is one of the safest means of passenger transport

Passenger fatality rates by transport mode for Europe

	Per 100 million passenger hours	Per 100 million passenger kilometers
	2	0.07
	8	0.25
	14.8*	0.46*
	16	0.035
	2	0.035
	25	0.7
	25	6.4
	75	5.4
	440	13.8

* Water (all vessels): Source ESTC Report 1999: significantly impacted by Estonia disaster (850 fatalities) in 1994.

Source: European Transport Safety Council 2003

Key drivers of marine safety

- Regulation
- Technology
- Design and construction standards
- Safety Management Systems
- Incident Reviews
- Culture of Safety
- Competition
- Training

Building a solid future

Ship construction evolution and navigation innovations have radically reduced safety risks

Today's ship construction techniques are a far cry from methods employed for the construction of the *Titanic*. A labor intensive affair, ships in 1912 were generally pieced together bit by bit by teams of riveters, and skilled men were employed to construct vessels in relatively small dockyards. Modern day shipbuilding utilizes the technological innovations which underpin contemporary construction, such as welding, computer-aided design, and prefabrication.

In the *Titanic's* era, Europe was the centre for shipbuilding and was a big source of work for people and demand for raw materials. At the turn of the century, shipyards consisted of molding areas, iron works, platers' sheds, joiners and cabinet makers' 'shops', blacksmiths, plumbers, French polishers, shipbuilding berths and 'fitting out' docks. Much of what was built, and finished, was created on site. One hundred years later, and Europe has lost its place as the primary shipbuilder to more cost-conscious shipyards in Asia, specifically Japan, Korea and the People's Republic of China. In 2010, China and the Republic of Korea together built more than 72% of the deadweight tonnes of ships constructed[11].

Similarly, just as the hub for shipbuilding has changed so too have shipbuilding techniques and much of that which is undertaken at a shipyard today could be categorized as assembly, rather than pure construction. Today, modern ships arrive at dry-docks in prefabricated sections to be welded together and a shipbuilder is likely to engage in the 'assembly' of a number of ships consecutively. This shift to prefabrication coupled with the innovation of welding, which improved the quality of construction beyond that possible with traditional riveting[12], made, and continues to make, a marked contribution to improvements in vessel safety.

Modern bridges (here an aft bridge) are high tech environments.
Photo courtesy Kongsberg Maritime

Safety by design

Advancements in the design process itself have also been instrumental in improving safety records. In the early years of ship construction, trial and error was considered acceptable as a design "process". As a consequence, innovations in design tended to be adaptive and incremental in nature and, consequently, relatively conservative. But, by the twentieth century, many of the principles of modern-day ship design were well-established. Vessel stability was largely understood and ships were routinely compartmentalized to slow flooding and aid evacuation and search and rescue. Here, the advent of computers has further contributed to ship safety. Computer modeling and analysis has replaced lengthy and laborious calculations on stability, structures, and hydrodynamics. And as safety risks are identified, ship design can be modified and adapted to mitigate the risk itself or to develop systems to do the same[13].

Hull and structure design are not the only elements to have been drastically improved by design over the past 100 years; innovations on the bridge have also played a key role. In 1912, when the *Titanic* sailed she had very few navigational aids on board. Her compass was typical of the period and her main aids for navigation while at sea were the sextant and the chronometer combined with reference to the *Nautical Almanac*. The ship's position could not be precisely pinpointed during the hours of daylight, as several reference points only available in the night sky were required to accurately determine her location[14].

Computer modeling has revolutionized ship design.

Ship's bridge equipment

Modern ships' bridges are a far cry from those of the first half of the 20th century – and are extensively equipped with safety and navigational aids.

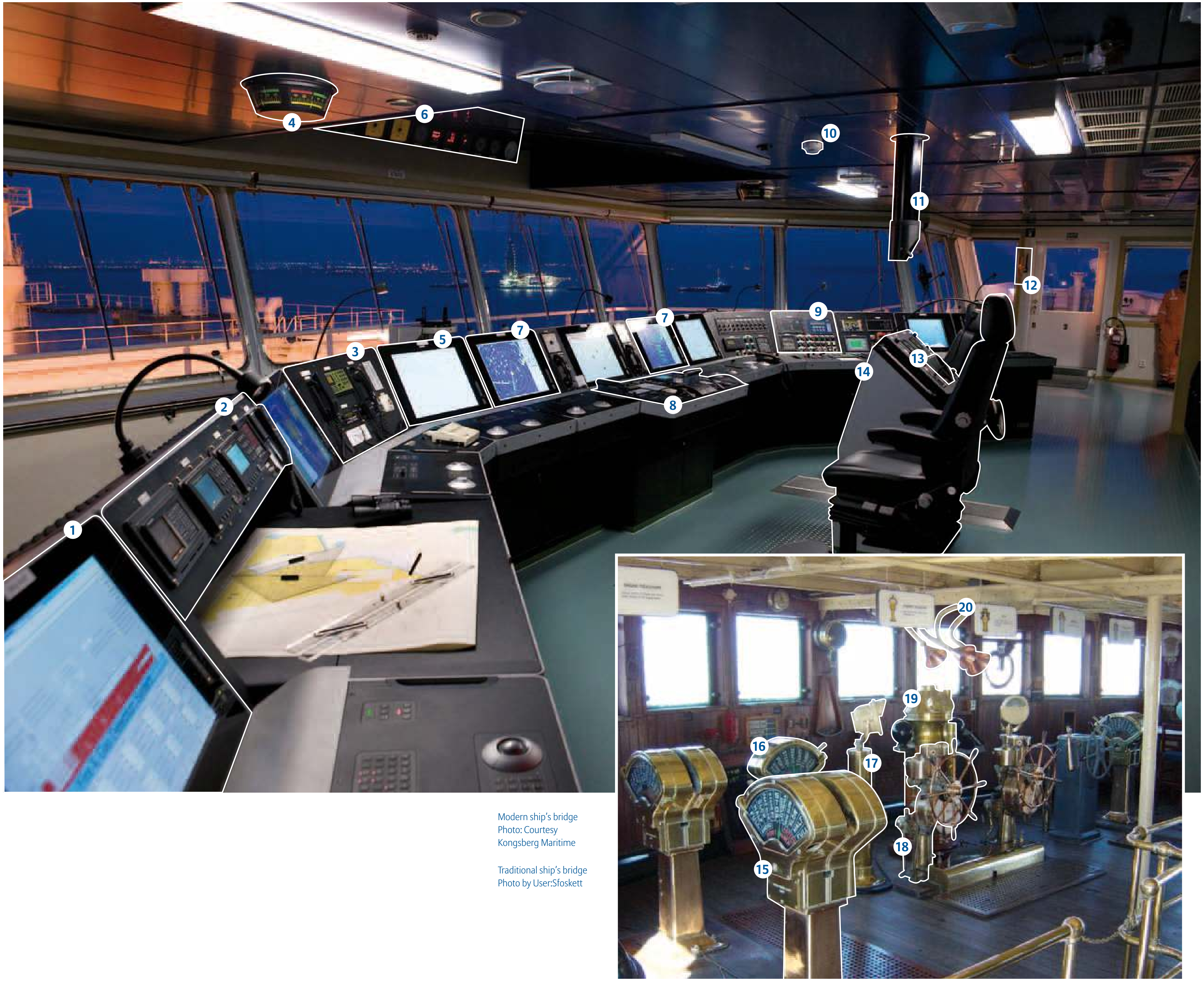
Modern day bridge

1. Fire Detection Panel
2. GPS, AIS and Speed Log Display
3. VHF radio
4. Rudder angle indicator
5. Electronic Charts Display & Information System (ECDIS)
6. Clinometer, Anemometer, Tachometer, Echo sounder
7. Radars (10cm and 3cm)
8. Engine controls
9. Switch panel (lighting etc)
10. Smoke alarm
11. Magnetic compass display
12. Search and Rescue transponder
13. Gyro compass
14. Steering stand

Traditional bridge

(*RMS Queen Mary* launched 1934)

15. Telegraph for port engines
16. Steering telegraph
17. Compass repeater
18. Steering stand for port rudder
19. Magnetic compass
20. Voicepipes



Modern ship's bridge
Photo: Courtesy Kongsberg Maritime

Traditional ship's bridge
Photo by User:Sfoskett

A modern day bridge is, by comparison, an extremely high-tech environment, removing the need for guesswork and vastly improving safety. The compass found aboard the *Titanic* has been replaced by the gyrocompass, which finds 'true north' rather than magnetic north and remains unaffected by external magnetic fields. The introduction of gyrocompasses also made possible the introduction of autopilot. Very high frequency radio allows today's ships to communicate with port authorities, broadcast safety information/distress calls, and contact other vessels in their vicinity. Depth finders utilize echo sounding, providing modern vessels with warning of the potential for grounding and playing a key role in the development of accurate sea-charts. Radar – a mandatory requirement under the International Convention for Safety of Life at Sea (SOLAS) – has further revolutionized navigation, offering officers of the watch the capacity to anticipate hazards and obstacles some time before they can actually see them. And radar combined with automatic radar plotting aid (ARPA) to replace the manual plotting of vessel movements, has improved the accuracy and speed of plotting and enhanced the situational awareness of officers keeping a navigational watch.

Fixing position

Arguably, however, the most important advancement in the safer navigation of ships came in the last quarter of the twentieth century: the Global Positioning System, or GPS, has revolutionized navigation across the globe. Its application has become so widespread that it is used by hill walkers and cyclists, alongside motorists and merchant ships. Developed in the United States, GPS relies upon the positioning of 31 satellites (as of 2010). GPS, and the more accurate enhanced 'Differential' version or 'DGPS', is remarkable for its position-fixing accuracy and the global scale on which this can be achieved. GPS furnishes navigators with a range of information which is critical to safe passage and is not weather, or location, dependent. It is cheaper, easier, faster and more precise than the position fixing systems which predated it – with maximum accuracy potential of under one square meter with DGPS systems in optimal conditions.

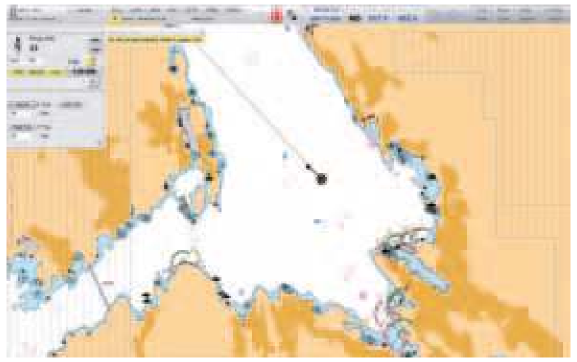
Furthermore, just as position fixing has been revolutionized by the application of satellites so too has communication. The *Titanic* carried radio equipment with a range that was limited to 200 miles. Within a century, technological innovation has transformed communications equipment allowing personnel aboard ships anywhere in the world to remain in touch with those ashore, 24 hours a day. At the time of the sinking of the *Titanic*, such systems were rudimentary and mainly relied on the transmission of information from ship to ship. It was easy to miss such messages as they required the radio officer to be present at his/her monitoring station[15]. In the case of the sinking of the *Titanic*, for example, the first distress messages she transmitted were missed by the *Carpathia* as the radio officer was on the bridge[16].

> "Technology is seen as the savior of everyone, rather than just a tool – how it improves your life depends on how you use it."
>
> Paul Newton, UK Head of Hull & Liability, AGCS

Paul M. Newton, AGCS UK Head of Hull & Liability (London), has 23 years' Marine Insurance experience, and is Chairman of the International Underwriting Association's Marine Technical Committee.

Situational awareness

And bridge hardware itself continues to evolve. Among the newest pieces of bridge kit that have contributed to safer navigation are the Automatic Identification System (AIS) and the Electronic Chart Display and Information System (ECDIS). AIS is an automatic tracking system that allows ships to identify one another and to be identified by both ships and by shore-stations. In principle, AIS assists officers of the watch in tracking targets and predicting their actions. The information provided by AIS equipment can include unique identification, position, course, and speed, and can be displayed on a screen or an ECDIS. ECDIS itself has a number of benefits: the updating of charts takes place automatically and does not rely upon the diligence of seafarers – thus the latest information is always available to navigators – access to any chart is available via the system, and the system can interface very effectively with ARPA/Radar, improving situational awareness and safety[17].



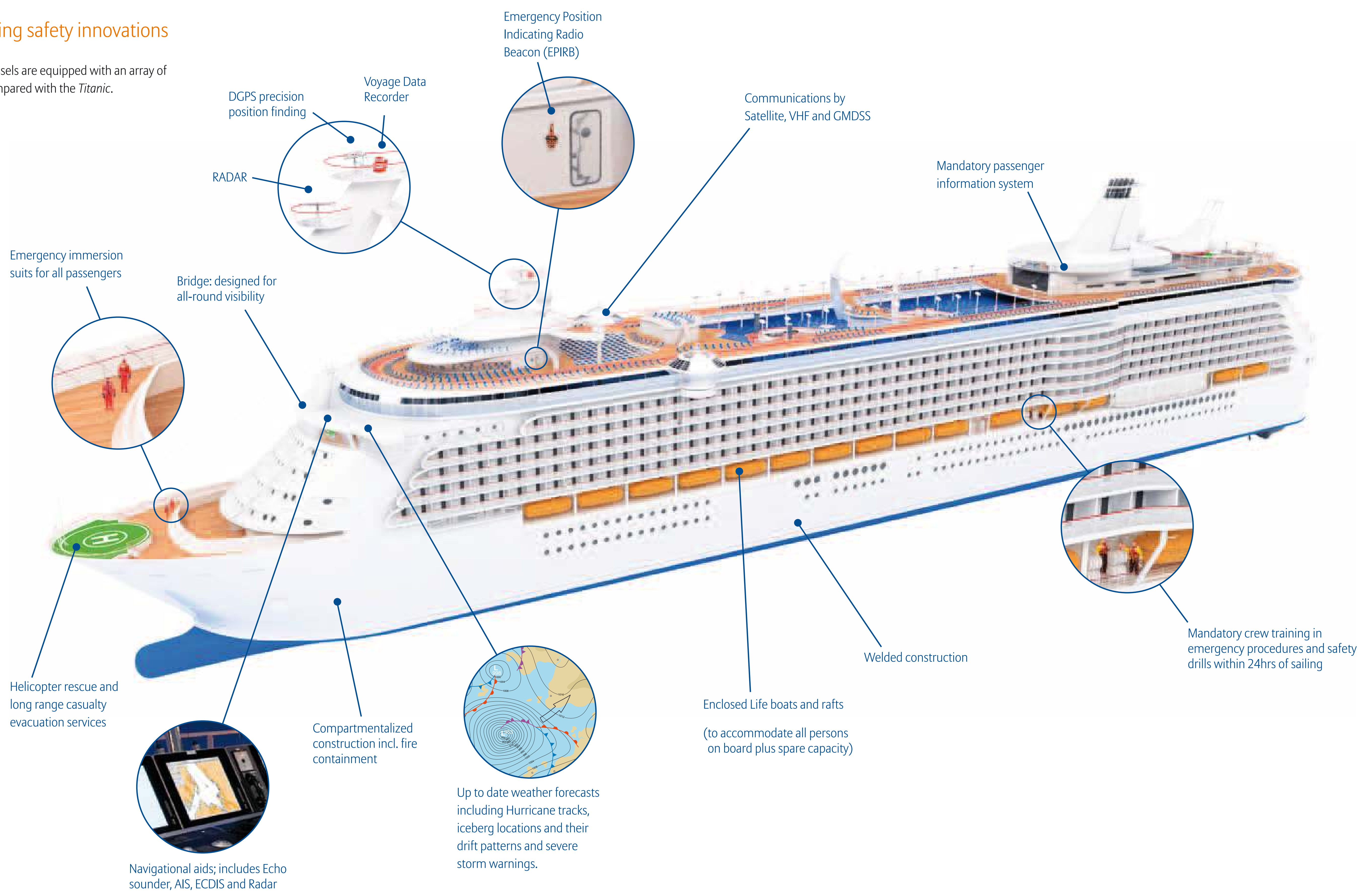
ECDIS display (Photo Courtesy Kongsberg Maritime)

Advances in weather monitoring and forecasting have also enhanced safety at sea. Described as the art and science of developing the "best route" for a ship based on the existing weather forecasts, ship characteristics, ocean currents and special cargo requirements, optimum ship routing is consider essential for modern day ship operators. For most transits this will mean the minimum transit time that avoids significant risk to the vessel, crew and cargo. The goal is not to avoid all adverse weather but to find the best balance to minimize time of transit and fuel consumption without placing the vessel at risk to weather damage or crew injury.

These technological advancements have already radically reduced the risks associated with navigation, which has led to vast improvements in safety since the *Titanic's* day. But there will undoubtedly be more to come, as our knowledge of the marine environment is further enhanced in the future.

Modern shipping safety innovations

Modern passenger vessels are equipped with an array of safety innovations compared with the *Titanic*.



In **safe hands**

Setting a level playing field for international seafarer training

Over a century, education and training in the maritime sector has moved from being a localized and relatively unregulated area to one subject to international scrutiny and with common baseline standards. Those considering a career at sea can today choose from a staggering array of training options at different levels around the world.

In the *Titanic's* day, training was very much a national affair as there were no agreed international training standards. Traditional maritime nations developed their own training schemes and requirements. Most, if not all of these, combined an element of apprenticeship with formal training and examination. At the time of the sinking of the *Titanic* little had changed in this general structure except that a model form of indenture had been issued by the Board of Trade which included a requirement for Masters to teach apprentices the principles of seamanship, navigation, and business on board.

Two world wars had a considerable impact on all aspects of life at sea including the recruitment and training of young men. However, voluntary apprenticeships remained the norm for seafarers followed by a period of preparatory training prior to examination. In the post-war period, in the UK and other European Nations, technical education evolved and so too did training for seafarers. By the 1960s, vocational qualifications underpinning the education of seafarer officers had been introduced and many seafarers studied for Ordinary National Diplomas in the UK and their equivalent (or higher) elsewhere. Thus, in this period national systems developed which ensured that seafarers were competent to go to sea and to safely navigate modern vessels, or to run and maintain their engines. Increasingly these systems combined a requirement for underpinning education, experience at sea, and examination.

In the 1970s and 1980s, with changes in the structure and regulation of the industry came changes in seafarer education and training. The greatest of these were driven by the introduction by the International Maritime Organisation (IMO) of the Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Convention in 1978. The IMO website describes the perceived need for this at the time as follows:

> The 1978 STCW Convention was the first to establish basic requirements on training, certification and watchkeeping for seafarers on an international level. Previously the standards of training, certification and watchkeeping of officers and ratings were established by individual governments, usually without reference to practices in other countries. As a result standards and procedures varied widely, even though shipping is the most international of all industries[18].

Tightening the rules

The STCW convention, adopted on July 7, 1978, came into force on April 28, 1984 and underwent major revisions in 1995 and 2010. One objective in amending the Convention related to the adoption for the first time of an 'enforcement' role by the IMO. Parties to the Convention are today required to submit documentation to the IMO describing compliance with the requirements of the Convention, in some detail. Following consideration by a panel of experts, that information is reviewed and all parties who fully comply with the Convention are subsequently listed by the Maritime Safety Committee as 'confirmed parties in compliance with the STCW Convention'. This list has come to be known in the industry as the 'white list' of nations with compliant agreed education and training practices. The latest revisions to the STCW Code (known as the 'Manila amendments'), which were adopted on June 25, 2010, included among other things, steps to take to reduce the possibilities for fraud, introduction of new certification for able seafarers and electricians, and the introduction of training in relation to modern technological innovations such as ECDIS.

> "It's not just providing training or providing ships; it's implementing a culture of safety,"
>
> Paul Newton, UK Head of Hull & Liability, AGCS

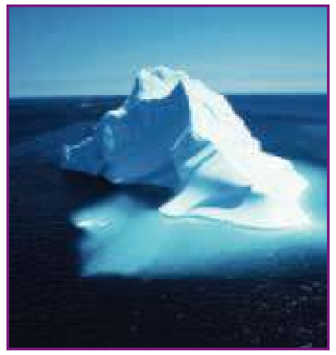
"From my underwriting perspective, when I meet and benchmark clients there is a definite feeling when companies have taken true ownership of training," says Paul Newton, UK Head of Hull & Liability, AGCS. "This could be through running internal courses, using external maritime colleges, external service providers or having a dedicated approach to the use of simulators – it can be a real mix between internal and external provision. Those companies that have taken real strides have really taken training on board and they are not just giving the key to the ship to the master and saying 'you've got some qualifications, that's fine, off you go'."

"It's not just providing training or providing ships; it's implementing a culture of safety," he says. Sven Gerhard, AGCS Global Product Leader Hull & Marine Liabilities, adds: "Paper qualifications are a great foundation – but they're not the same as experience. Whilst we welcome the international standardisation of training, as underwriters we also look for some depth of experience in senior officers when assessing a fleet."

However, the IMO has been but one of many catalysts for improvements in training and consequently safety. For example, Flag States may visit labor supply countries which seek agreements to have their licenses, issued locally, endorsed by the third party Flag State in question, on request. As part of such visits, they may scrutinize procedures and local education and training provision as well as methods of assessment. And the European Union has established a regime of inspections of maritime education and training provision and assessment via the European Maritime Safety Agency (EMSA).

Timeline: Key milestones in maritime safety since 1912

1914
International Convention for the Safety of Life at Sea (SOLAS) established – setting standards for maritime safety provisions.



1914
International Ice Patrol starts aerial monitoring of icebergs.

1922
Echo sounding applied on board to monitor depth of water.

1930
International Convention on Load Lines addresses issues on loading and stability.

1940s
Welding starts to replace riveting, later followed by prefabrication, increasing quality of ship construction.

1940s
LORAN (LOng RAnge Navigation) radio navigation system allows accurate offshore position finding to 900 miles.

Image: Wikimedia Commons/Stahlkocher

1944
DECCA position fixing allows accurate position finding up to 400 miles offshore.

1948
International Maritime Organization (IMO) established, and entered into force in 1958.

1960s
Computer-aided ship design revolutionizes ship design.

1960s
Widespread use of Very High Frequency radio improves ship-to-ship and ship-to-shore communication.

1965
RADAR made mandatory under 1960 SOLAS convention.

1967
"Transit" Sat Nav system: the first satellite-based positioning system for merchant ships, giving regular position fixes on 'transit' of a satellite.

1969
Automatic Radar Plotting Aid (ARPA) introduced (mandatory 1989), replacing manual plotting of movements.

1972
International Regulations for Preventing Collisions at Sea (COLREGS) establishes 'rules of the road' for shipping.

1973
International Convention for the Prevention of Pollution From Ships (MARPOL) addresses maritime pollution risk.

1978
International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) establishes basic training and certification requirements.

1993
International Safety Management (ISM code) adopted by IMO, establishing standards for safe management and operation of ships.

1994
Global Positioning System (GPS) fully operational, allowing accurate satellite-based position finding.

1999
Global Maritime Distress and Safety System (GMDSS) establishes protocols for ships in distress and rescue scenarios and introduces mandatory distress communication equipment on board vessels.

Photo: Hervé Cozanet from the marine-marchande.net Website

2000
IMO adopts amendments to SOLAS making "Voyage Data Recorders" (VDR) or the 'Black Box' of navigational bridge mandatory on new ships.

2004
Automatic Identification System (AIS) for vessel identification and tracking, reduces collision risk.

2004
International Ship and Port Facility Security (ISPS) Code enhances security in ports.

2012
Electronic Chart Display and Information System (ECDIS) navigation system to become mandatory, providing continuous position and navigational information.

1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

Setting the **boundaries**

Far-encompassing international regulations have kept shipping on an even keel

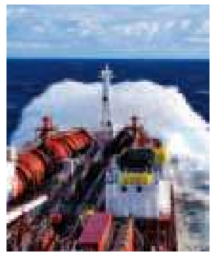
Volker Dierks, AGCS Head of Marine Hull (Hamburg) holds a Master Mariner License and spent five years at sea, after which he has worked in marine insurance for the last 28 years, focusing on underwriting and claims management.

In the *Titanic's* day, there was little in the way of national regulation specifically for shipping and universally-applied international rules were even rarer. However, post-*Titanic*, it took relatively little time for the shipping industry to acknowledge that to truly operate on a global scale, international rules and regulations were needed. Consequently, today's maritime industry is regulated by a myriad of codes, conventions and guidelines that set the boundaries for safe and efficient shipping operations.

"Regulations are the sharpest weapons we have to improve safety."

Volker Dierks, Head of Marine Hull Germany, AGCS

Undoubtedly, the catalyst for this turnaround was the establishment in 1948 of the International Maritime Organisation, a United Nations agency dedicated to shipping. With 169 Member States and three Associate Members, the IMO is unique as the only UN agency to be based in the United Kingdom. In just over half a century, this organization has been responsible for a plethora of international conventions, supported by hundreds of recommendations governing every sector of shipping. These codes and conventions cover everything from prevention of accidents and prevention of pollution to standards for ship design, construction, equipment, operation and crewing. The IMO's international Safety of Life at Sea (SOLAS) convention was in fact spawned by the *Titanic* disaster and is still the most important treaty in existence addressing maritime safety.



Turn on the red light

When, in 1992, a full 80 years after the sinking, the UK Marine Accident Investigation Branch (MAIB) published a reappraisal of the evidence concerning the role of the *SS Californian* in the loss of life associated with the sinking of *RMS Titanic* in 1912[19], there was a surprising revelation.

At the time of the accident there was no consistency relating to the color of emergency distress flares. This has led to the supposition that in the case of the sinking of the *Titanic*, distress flares may have been seen from the *Californian* but misunderstood and not acted upon. The report notes that:

"There is one rather curious point about the distress signals which is worth mentioning. In 1912, under the International Regulations then in force, such signals could be of any color (*Titanic's* were in fact white) and there was therefore nothing immediately to distinguish them from other rockets. The *Titanic* disaster led to a number of changes improving provisions for emergency at sea, but it was not until 1948 that the rules for distress signals were amended to make the (present) requirement that they be red. Had that rule been in force in 1912, when it was much more needed than now, Mr Stone [*aboard the SS Californian*] would surely not have remained passive[20]."

While it seems extraordinary that it took so many years for a simple agreement to be reached relating to the color of distress flares, the tragedy of the *Titanic* has been attributed with motivating some of the first efforts to provide more stringent international regulations relating to shipping.

As a pivotal shipping convention, SOLAS covers collision avoidance, emergency response, structural details, communications, and the carriage of potentially hazardous cargoes, among a number of other important maritime issues. Since the first version was adopted in 1914, it was revised in 1929, in 1948, in 1960, and 1974. The latest version includes the tacit acceptance procedure, which allows an amendment to enter into force on a specified date unless, before that date, objections to the amendment are received from an agreed number of parties. But fundamental though it is, SOLAS has not single-handedly improved safety in shipping. Other instrumental IMO conventions include the International Convention for the Prevention of Pollution from Ships (MARPOL 1973/78), the International Convention on Load Lines, 1966, and the Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 1972.

The International Convention on Load Lines sets rules for freeboard – the distance between the water line and the deck – and subdivision and deals with a number of issues intended to make the area beneath the freeboard deck watertight. In 2003, a comprehensive revision of the Load Lines Convention took place and as a consequence a number of improvements in safety were achieved. One new addition concerning hatch covers had important implications for Dry Bulk Carriers.

In the period 1978-1998, following the total loss of 146 bulk carriers, eleven of which were associated with hatch cover failure[21], a considerable amount of research was undertaken on the impact of green sea loading on the cargo hold hatch covers and coamings of bulk carriers. That research found that hatch cover failure was responsible for 14% of fatalities associated with serious incidents on, or total losses of, bulk carriers in the period under review and attracted some deserved attention. Ultimately, the research led to the submission of evidence to the IMO and in June 2003 the International Convention on Load Lines 1966 was revised to include provisions relating to hatchway coaming and hatch covers, and the loads they are designed to withstand. While it is difficult to put an exact figure on the number of seafarers or ships that have or will be saved as a result of this amendment to the Load Line Convention, it serves as a very good example of the areas where the IMO continues to make a significant impact on ship safety.

Likewise, the global implementation of the Collision Regulations has also had a tangible effect on safety. The 1972 Convention was designed to update and replace the Collision Regulations of 1960 which were adopted at the same time as the 1960 SOLAS Convention. One of the most important innovations in the 1972 COLREGs was the recognition given to traffic separation schemes: Rule 10 gives guidance in determining safe speed, the risk of collision and the conduct of ships operating in or

near traffic separation schemes. When the first traffic separation scheme was established in the Strait of Dover in 1967 it was on a voluntary basis, but just four years later all traffic separation schemes were made mandatory after the adoption of a resolution by the IMO Assembly[22]. Proving the effectiveness of traffic separation schemes, a study by the International Association of Institutes of Navigation (IAIN) in 1981[23] found that between 1956 and 1960 there were 60 collisions in the Strait of Dover; twenty years later, following the introduction of traffic separation schemes, there were only 16 recorded.

Search and rescue

Another convention that has helped boost safety is the Search and Rescue (SAR) convention of 1979, which was the starting point of the Global Maritime Distress and Safety System (GMDSS) regulation. After adoption in 1988, it was subsequently incorporated into SOLAS and came into full force in 1999. The GMDSS system is based upon equipment which includes Inmarsat maritime satellite systems, radar transponders (SART) located on life rafts, and Emergency Position Indicating Radio Beacons (otherwise known as EPIRBs). In operational terms, GMDSS' enforcement today means that information about a vessel in distress can and will be transmitted (automatically if necessary) anywhere in the world. The main advantages of GMDSS include automated coverage and global reach and there is little doubt that this system has greatly facilitated more effective search and rescue operations, at sea, in the twenty-first century.

Emergency Position Indicating Radio Beacon
(Photo Courtesy of Jotron www.jotron.com)

Just as the aviation industry relies on its Black Box data to give a true log of events if an incident occurs, the same applies to shipping. The requirement for carrying Voyage Data Recorders (VDRs), or Black Boxes for shipping, is enforced through Chapter V on Safety of Navigation in the IMO's SOLAS Convention. Passenger ships and ships other than passenger ships of 3,000 gross tonnage and upwards constructed on or after July 1, 2002 must carry VDRs to assist in accident investigations. As with aircraft black boxes, VDRs enable accident investigators to review procedures and instructions in the moments before an incident and help to identify the cause of any accident.

Marine Voyage Data Recorder
(Photo: Hervé Cozanet from the marine-marchande.net Website)

Safety related IMO Codes

International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended

International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997(MARPOL)

International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) as amended, including the 1995 and 2010 Manila Amendments

Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 1972

Convention on Facilitation of International Maritime Traffic (FAL), 1965

International Convention on Load Lines (LL), 1966

International Convention on Maritime Search and Rescue (SAR), 1979

Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation (SUA), 1988, and Protocol for the Suppression of Unlawful Acts Against the Safety of Fixed Platforms located on the Continental Shelf (and the 2005 Protocols)

International Convention for Safe Containers (CSC), 1972

Convention on the International Maritime Satellite Organization (IMSO C), 1976
The Torremolinos International Convention for the Safety of Fishing Vessels (SFV), 1977

International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F), 1995

Special Trade Passenger Ships Agreement (STP), 1971 and Protocol on Space Requirements for Special Trade Passenger Ships, 1973

Answering the call

The IMO is essential in regulating shipping, and just as the first SOLAS agreement was inspired by the lessons learned from the tragic *Titanic* accident, other IMO regulations have also been driven by incidents at sea. For example, ro-ro safety was given particular attention by the IMO in 1995 following the fatal loss of the *Estonia*. The ship left port with 989 passengers and crew on board but just 137 survived after an incident in the Baltic when the bow visor was ripped from the ship, opening the bow ramp and allowing for a significant, and sudden, ingress of sea water.

The *Estonia* incident led to amendments to SOLAS and also, for the first time, to the sanctioning of regional agreements between IMO members. Thus, following the November 1995 SOLAS conference, seven States (Denmark, France, Italy, Norway, Spain, Sweden, and the United Kingdom) made special agreements relating to safety requirements for ro-ro ferries operating between their ports[24]. This development was a critical one for international regulation as it demonstrated that where full international agreement cannot be reached relating to safety provisions the IMO does have the flexibility, in very specific circumstances, to allow for the development of regional agreements.

One section of the industry that has learnt its lessons from past mistakes is the oil tanker segment. Major environmental disasters such as the *Torrey Canyon, Exxon Valdez* and *Amoco Cadiz* prompted politicians and the general public to call for serious action to prevent further ecological catastrophes. Since then, the oil tanker industry has done much to make that happen. Captain Rahul Khanna, AGCS Senior Risk Consultant – Marine, says: "A lot of credit should go to the oil majors and OCIMF (Oil Companies International Marine Forum) whose vetting programs, like SIRE (Ship Inspection Report Programme), have made tankers work in a much safer manner. Over the last few decades they have done a lot of work to improve safety, analyzing risks before they became an accident and taking proactive action." Jean-Pierre Ryckaert, AGCS Marine Technical Adviser, adds that vetting practiced by the oil industry has done much for "improving the safety standards on-board tankers".

And these superior standards for oil tankers have been a driver for further safety improvements elsewhere, according to Paul Newton, AGCS UK Head of Hull & Liability. "Some of the best owners with mixed fleets take the opportunity to run all vessels at the highest minimum best practice requirements. So if they run tankers, they have to run them to oil company vetting standards and they flow that down to every other vessel in their fleet regardless of whether it is in the dry market or any other market. In this respect, oil majors have set a precedent – they are notoriously difficult to please because they are out to protect their reputation and they want to operate with the best providers."

Not all Conventions and Codes are reactive at a regulatory level either, and one example of efforts to proactively regulate the activities of shipping in order to mitigate harmful impact on the environment can be seen in the development of a 'Polar Code'. Draft *'Guidelines for ships operating in Polar waters'* were agreed by the IMO in 2009, with the proposal to further develop the guidelines in the form of a Code for ships operating in Polar waters, which could, eventually, be made mandatory. While still in its infancy, this code is being molded in advance of widespread use of Arctic shipping lanes, focusing on issues relating to design, machinery, construction, search and rescue operations, and issues relating to the sensitive and important nature of the Arctic environment.

A cool attraction

Global climate change has brought about an unlikely benefit to future shipping: the advent of a new Arctic sea route. Models predict that a continuing decrease in Arctic sea ice coverage could lead to an entirely ice-free Arctic Ocean for a short period in the summer by 2040, if not sooner.

The possibility of a new sea route across the North Pole linking the North Atlantic and the North Pacific is an attractive proposition to an industry striving to reduce emissions, and improve on efficiency. But increasing maritime transport in Arctic waters presents environmental risks that must be mitigated with effective pollution control measures and adequate emergency response capacity. While the 'Polar Code' and IMO Guidelines go some way towards addressing the potential issues, further consideration needs to be given to wide-ranging concerns on extended Arctic and Antarctic shipping.

Ships operating in both regions are exposed to a number of unique and highly localized risks, such as poor weather conditions, a lack of good charts, and unreliable communication systems. Freezing temperatures may also pose ship operational challenges in Arctic waters, affecting the proper functioning of equipment and machinery onboard, including emergency equipment. Additional loads on the hull, propulsion system and appendages also pose potential challenges.

Other issues in need of further consideration include insurance implications, ice navigation experience, ice-specific training for crew and navigators, ice thickness modeling, emergency preparedness, search & rescue and emergency assistance, security issues in the Arctic, oil spills and marine pollution prevention, clean-up technologies, Arctic sea route optimizations and route planning, and risk management.

Kevin Whelan, AGCS's UK Marine Claims Manager (London) has over 30 years' experience in managing complex International Marine insurance claims and currently represents AGCS on the London Market Joint Marine Claims Committee.

"You must have local in-depth knowledge when it comes to ice shipping. Just because a Master has experience of ice in the Baltic area, it may mean nothing when it comes to the North East passage because the ice has a different technical make up and requires different navigational approaches."

Kevin Whelan, Manager, Marine Claims, Allianz Global Corporate & Specialty

And while the IMO has been, is and will continue to be a central force in the international regulation of shipping, other global and regional bodies also play important supporting roles. As an example, the International Labour Organisation spearheaded the Maritime Labour Convention – known as the "fourth pillar" in a maritime regulatory regime, along with SOLAS, MARPOL and the STCW conventions – which sets out minimum standards and fair working conditions for seafarers worldwide. And regional bodies such as the European Maritime Safety Agency have also played a part in raising international safety standards, supporting the European Commission and the Member States in maritime safety and prevention of pollution from ships.

Making the **connection**

Managing safety in shipping is today more important than ever

A combination of standardized training, regulations, and advancements in technology has undoubtedly enhanced safety in the maritime industry over the past 100 years. Tying these components together at an operational level, safety management systems have been just as instrumental. In recognition that a piecemeal approach to implementing safety measures was not the most effective, guidelines for safety management systems were introduced in the early 1990s and are widely regarded as having achieved a great deal in improving the safety of contemporary ships.

These steps were taken in line with similar approaches which had been widely adopted ashore and in response to damning safety management comments made in the course of inquiries into several high profile incidents. In one such incident, the tragedy of the *Herald of Free Enterprise* in which 193 people died on March 6, 1987, Lord Justice Sheen (presiding judge at the subsequent Court of Enquiry), made some stinging comments about management and suggested that "from top to bottom the body corporate was infected with the disease of sloppiness". While the investigation into the loss of the *Herald of Free Enterprise* attributed personal responsibility for the accident to several individual members of the ship's complement, it also charged management with significant negligence. The official report into the incident continued, "the failure on the part of the shore management to give proper and clear directions was a contributory cause of the disaster[25]".

The IMO soon responded with the inception of the International Safety Management (ISM) Code. Initial guidelines for the safe management of vessels were adopted by the IMO in October 1989. Subsequently, in 1993, the IMO adopted the ISM Code which was made mandatory in 1998 and further revised in 2000. The Code consists of two parts, one of which is mandatory and one of which is designated as guidance. Its stated purpose is "'to provide an international standard for the safe management and operation of ships and for pollution prevention[26]".

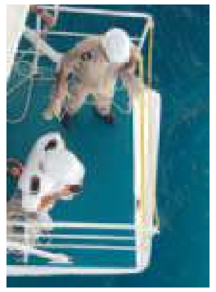
While initially it was met with some opposition, the code has come to be seen by many in the industry as an essential component of safe vessel management in the modern day context. The approach to implementation has been varied with some operators engaging operational and sea-staff to establish the safest practice on board, backing this up with appropriate documentation and training, while others have invested in safety management systems with appropriate software packages. Despite the associated increase in paperwork, seafarers generally recognize the improvements in safety associated with clear and well-designed safety management systems and consequently support their continued use.

Tim Donney, Global Head Marine Risk Engineering, Allianz Risk Consulting (New York), is a former US Merchant Marine officer with over 35 years' experience in loss control and marine risk engineering. He is Chairman of the American Institute of Marine Underwriters Technical Services Committee.

> "Safety management systems if completely embraced and applied correctly, can do a great deal for improving safety."
>
> Tim Donney, Global Head Marine Risk Engineering, Allianz Risk Consulting (ARC)

A helping hand

The monitors and enforcers of the international laws of shipping

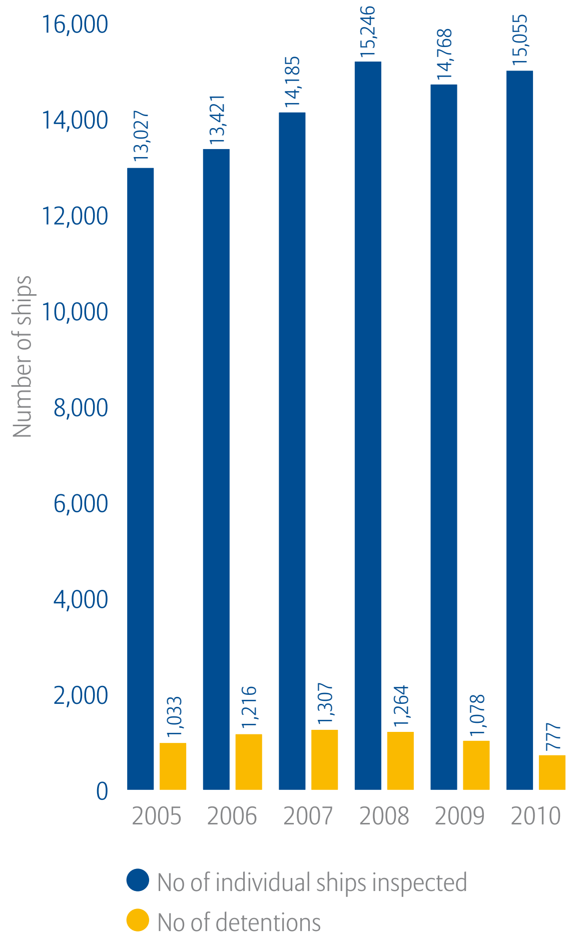


The importance of the International Maritime Organisation as an over-arching regulatory body cannot be overstated, but as it has no power to enforce its regulations it must rely on Member States for its codes and conventions to be really effective. In what has become a truly symbiotic relationship, Port State Controls' of Member States work tirelessly to check that ships calling at ports around the world are adhering to the codes and conventions that their country of registration has ratified.

The concept of Port State Control (PSC) was introduced by the IMO through its Standards of Training, Certification and Watchkeeping for Seafarers Convention in 1978. Article X of the STCW convention[27] requires that Parties to the agreement apply the STCW requirements to all ships calling at their ports so that there is no competitive disadvantage for ships flagged with states which are not Party to the convention. This principle now underpins much of the IMO's regulations and PSC has become a crucial element of the international enforcement of regulatory standards.

Today, PSC is a very powerful force which helps maintain safety standards throughout the industry. Many Port States publish details of detentions on the internet, which encourages ship-owners to remain proactive in their care of ships and crews. In a further boost to the hard-hitting effect of PSC, regional agreements on inspection regimes for ships entering into the waters of signatory states have been created and the resultant collaborations have had an even greater impact on safety. One such regional partnership is the Paris Memorandum of Understanding (Paris MoU), which combines the maritime administrations of 27 countries, covering the waters of the European coastal States and the North Atlantic basin from North America to Europe. In 2010, the Paris MoU conducted 24,058 ship inspections, resulting in 790 ship detentions across the Paris MoU region[28].

Number of ships inspected or detained: 2005-2010



Source: www.parismou.org

The Asia-Pacific PSC, also known as the Tokyo MoU, encompasses the 18 authorities of Australia, Canada, Chile, China, Fiji, Hong Kong, Indonesia, Japan, the Republic of Korea, Malaysia, New Zealand, Papua New Guinea, The Philippines, The Russian Federation, Singapore, Thailand, Vanuatu and Vietnam. In 2010, it inspected 25,762 ships, which led to 1,411 detentions[29]. Both of these regions have seen a dramatic improvement in the number of detentions despite a rise in the number of inspections (largely driven by increased trade). The number of inspections performed by Paris MoU Port State Controls has risen by 27% since 2001, but detentions over the same period have decreased by 54%. For the Asia-Pacific PSC, inspections rose by 48% from 2001-2010, but detentions dropped by 5%. Likewise, the US Coast Guard's Port State Control counted 18% more calls over the same period, but detained 9% fewer ships[30].

In the interest of transparency, some Port States display full details about a ship's detention with color photographs illustrating many of the identified deficiencies. This has created a market whereby potential ship-owners, ship managers, charterers and other interested parties can search the port state detention records for a named vessel to check on its seaworthiness and overall quality. This openness has underpinned the value of enforcement and inspection regimes, and has, in many parts of the world, created high degrees of compliance with international regulation, and safer shipping as a consequence. In the oil sector in particular, charterers have played an important role in pushing for higher safety standards making use of their own systems of inspection and auditing.

A thorough examination

Port State Controls (PSC) around the world use sophisticated databases to generate a list of ships to target for inspections on a daily basis. Ships may be targeted as a result of previous inspection findings, on a ship risk profile, or simply on the fact that an inspection is due. Once the ship has been targeted, the Port State Control (PSC) visit will normally begin with examination of documents, followed by a general inspection of the ship to verify that she complies with all relevant regulations. If she complies, and the statistics suggest that is frequently the case in modern day shipping, the PSC officer issues a 'clean' inspection report to the master. If deficiencies are identified, the inspection report will include a 'deficiencies found' report, which will give guidance on any follow-up actions that need to be taken to rectify the deficiencies. If deficiencies are found, they are normally required to be rectified before departure of the ship.

If more serious deficiencies are found – that might be hazardous to safety, health or the environment – the authorities will make sure that the hazard is rectified before the ship is allowed to proceed to sea and to ensure that outcome, may detain the ship. The operator of a ship does have the right of appeal against a detention, but an appeal will not lead to the immediate lifting of the detention.

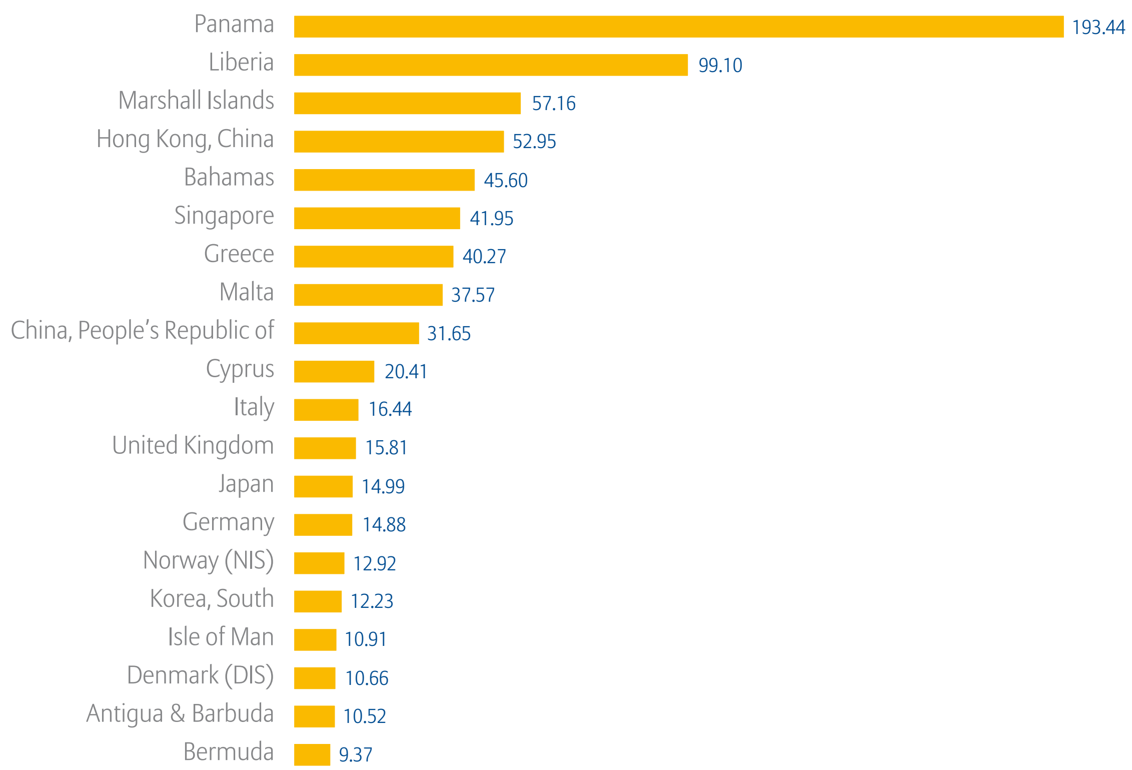
Whatever the outcome of a PSC inspection, the ship's data and the inspection result will be recorded on a central computer database for easy access to any concerned parties.

Flying the flag

National 'Flag States' also have a vital role to play in the monitoring and enforcement of international legislation. A Flag State is the administration or the government of the state whose flag the ship is entitled to fly. It is the Flag State that has overall responsibility for the implementation and enforcement of international maritime regulations for all ships that 'fly its flag'. In practice, each Flag State has a ship register in which all ships that sail under its flag need to be registered.

The importance of the Flag State is that it is considered the first line of defense against potentially unsafe or environmentally-damaging ship operations[31]. As well as enforcing IMO legislation that has been ratified by that nation, Flag States are also responsible for the implementation and enforcement of rules adopted by other intergovernmental bodies, such as the International Labour Organization and the International Oil Pollution Compensation (IOPC) Fund.

Top 20 Flag States



Millions of gross tonnes of shipping

Source: www.marisec.org

Since the 1950s, ship-owners have increasingly turned to open registries, dubbed "Flags of Convenience" (FoC), as an alternative to the traditional national Flag States. These FoCs allow ship-owners to register their ship in a different sovereign state to their own. Some of the benefits of this practice include tax incentives, and the ability to hire non-national crews. Panama's open ship register is by far the world's largest ship flag, with 193.44m gross tonnes of shipping on its register as at October 2010, equivalent to almost a quarter of the world's ocean-going tonnage. Second in the world ranking is Liberia at 99.10m tonnes, followed by Marshall Islands at 57.16m tonnes[32].

The popularity of FoCs has attracted criticism from both inside and outside the maritime industry as they are perceived to be tax havens that allow owners to employ cheaper and arguably less qualified staff. Whilst some commentators have pointed out that the IMO has only been able to ratify a number of conventions due to the support of dominant FoC countries such as Panama and Liberia, the performance of some open registries has been criticized for failing to operate at adequate internationally-accepted levels.

A classy affair

Closely aligned with the work of PSC and Flag States, Classification Societies develop and apply technical standards to the design, construction and assessment of ships (and other marine facilities) and carry out ship survey work. As independent, self-regulating, externally audited bodies, Classification Societies are expected to have no commercial interest in ship design, shipbuilding, ship ownership, ship operation, ship management, ship maintenance or repairs, insurance, or chartering. Flag States can also authorize Classification Societies to inspect their ships to verify compliance with international and/or national statutory regulations on behalf of the flag administrations.

Classification Societies can trace their origins back to a coffee house in the City of London, which proved a popular meeting place for merchants and shipowners in the late 1600s. The shipping community met at Lloyd's Coffee House to gossip about various voyages and make insurance deals. This unlikely beginning led to the birth of the Lloyd's of London underwriting market that is today synonymous with writing shipping risk.

The underwriters frequenting Edward Lloyd's coffee house realized that they needed to find an accurate way of assessing the quality of these ships. This led to the formation in 1760 of the Register Society who assembled a Register of Shipping, the first known register of its type attempting to classify the condition of a ship's hull and equipment. This marked the establishment of the world's first classification society, which subsequently became known as Lloyd's Register (LR).

These humble beginnings also led to the establishment of many more classification societies around the world. In Norway, the adoption of common rules for ship construction by Norwegian insurance societies in the late 1850s led to the establishment of Det Norske Veritas (DNV) in 1864. DNV was immediately tasked with the inspection and evaluation of the technical condition of Norwegian merchant vessels. In the United States, the American Bureau of Shipping (ABS) was first chartered in the state of New York in 1862, to certify ship captains and is today actively involved in the development and improvement of safety.

In Antwerp, underwriters Alexandre Delehaye and Louis van den Broek, and insurance broker, Auguste Morel, formed Bureau Veritas (BV) in 1828. Now based in France, BV has been listed on the Paris Stock Exchange since October 2007. Italy's Registro Italiano Navale (RINA) was founded in 1861 to meet the needs of Italian maritime operators. Six years later, Germany's Germanischer Lloyd (GL) was formed in 1867 to improve transparency, offering an independent evaluation of the quality of ships.

Hamburg, home of Germanischer Lloyd, one of the leading Classification Societies.

Almost all commercial ships are built to standards set by Classification Societies, which are issued by each society as published rules. Once a ship has been designed and built to the rules of a society, the owner can then apply for a certificate of classification from that society. While the rules of each society may differ, the goals remain the same: 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 in order to maintain essential services on board.

However, in the last decade, when a number of high profile shipping disasters were found to have technical failings that class would normally be expected to spot and action, the industry demanded a fresh look at the role and purpose of class. One such incident – the *Erika*, which broke in two on December 12, 1999, and sank, releasing thousands of tonnes of oil into the shores around Brittany, France – prompted EU legislation to deal with EU-recognized Classification Societies requiring assessment once every two years by the European Maritime Safety Agency on behalf of the European Commission.
Classification Societies themselves are clear on where the boundaries lie:

"Such a certificate does not imply, and should not be construed as, a warranty of safety, fitness for purpose or seaworthiness of the ship. It is an attestation only that the vessel is in compliance with the Rules that have been developed and published by the Society issuing the classification certificate. Further, Classification Societies are not guarantors of safety of life or property at sea or the seaworthiness of a vessel because the Classification Society has no control over how a vessel is manned, operated and maintained between the periodical surveys which it conducts." [33]

There are more than 50 organizations worldwide that define their activities as providing marine classification, 13 of which are members of the International Association of Classification Societies (IACS). While that number represents a small percentage of all societies, it is estimated that those 13 members collectively class over 90% of all commercial tonnage involved in international trade worldwide. One noteworthy progression that IACS and its members have made to ship safety is the introduction of 'Common Structural Rules for Tankers and Bulk Carriers'. Unanimously adopted by the IACS Council for implementation in 2006, these rules allow shipbuilders and designers to work with one common set of rules, instead of one set from each class society. This development has encouraged the design and construction of more robust ships and eliminated competition on scantlings, which determine structural strength.

Risk and reward

Marine insurers have an important contribution to make in improving accident rates and safety at sea. While it is generally not considered to be the role of insurers to police safety standards in shipping, insurers of all classes of vessel have a shared interest with crews, cargo owners and ship owners to reduce accidents across the industry. While anti-competition laws can place certain restrictions on the ability of insurers to cooperate in any pan-industry initiative, most major insurers can directly support clients by actively encouraging and recognizing best practice in their insured risks and, where necessary, declining coverage if circumstances justify this in a transparent underwriting assessment process. Furthermore, many larger insurers field specialist teams of marine risk consultants, often including highly experienced masters, to work with ship-owners to analyze and manage risk in advance. In this way, insurers can look beyond claims records to understand the risk management philosophy, training and team of each fleet.

But while organizations such as Classification Societies, Port State Control, and Flag States administrations are undeniably central figures in the shipping industry, they are just a handful of the bodies that steer the maritime safety regime on a day-to-day basis. Ship-owners, shipbuilders, underwriters, shipping financiers, charterers, and seafarers also have an important role to play in encouraging safer shipping in what is truly a shared undertaking.

Capt. Rahul Khanna, AGCS Senior Marine Risk Consultant (London), has over 19 years' experience in the shipping industry both as a master on large oil tankers and as a marine risk consultant including conducting casualty investigations into marine accidents.

> "Safety is a collective, not an individual responsibility."
>
> Captain Rahul Khanna, Senior Risk Consultant – Marine, AGCS

Professional seafaring remains comparatively dangerous, especially on fishing vessels. Photo: Getty Images (Christopher Pillitz)

Assessing the **risk**

The shipping industry remains alert to new challenges

The shipping industry has undergone considerable transformation over the past 100 years, particularly in its improving approach to safety. Despite this, not only do risks remain for the sector, there are also emergent risks which result, sometimes unpredictably, from changes in the industry itself and also from changes in the social, economic and political context of shipping.

For one, despite great strides in improving workplace safety, the industry remains a comparatively dangerous place to work[34]. A UK Maritime and Coastguard Agency commissioned and published report[35] calculated that the occupational fatality rate for seafarers is twelve times higher than for the general workforce in the UK, and that the rate of fatal accidents is two and a half times higher in shipping than in the construction sector, and eight and a half times higher than in manufacturing.

In fact, many of the current risks in shipping are generally associated with 'human element' issues or 'human factors'. In common with other industries, those risks can be associated with problems or failures in organizational management, mistakes on the part of individuals, and failures in the supply or recruitment of sufficiently competent workers.

One of the bigger causes for concern moving forward is the high number of marine casualties that are attributed, at least in part, to a degree of human error, recorded as 75%-96% in a recent analysis[36]. AGCS UK Marine Claims Manager, Kevin Whelan says that while the indicators are that, overall, shipping safety has improved, when incidents do occur it is primarily down to human error. "In fact," he adds, "going back over the years, the human error component is on the increase. So, while safety has improved overall, when there is a casualty the human error element is more likely to be the cause."

And of that percentage, a commonly identified cause of accidents involving human error is fatigue. This is a problem that has dogged the shipping industry with no signs of immediate improvement in light of the competitive forces driving down ship crewing levels, and pressure on turnaround time for ships in port. While steps have been taken in recent years to address fatigue on board, these are relatively easy to circumvent and have not been wholly successful in their introduction.

An analysis of accident investigation reports over a ten year period from 2002 to 2011 from the UK, Australia, US, and New Zealand, found that of 427 available reports fatigue was listed as the main cause of an accident in 3.7% cases and was further listed as a contributory cause in 5.2% of cases. This suggests that it remains a significant current risk to the safety of ships[37]. Further analysis has revealed that inadequate risk management is frequently identified in accident investigation reports as the main cause of an accident. Of the 427 accident reports analyzed, the Seafarers International Research Centre found that in 29.3% of cases inadequate risk management was the main cause of an accident and in 9.8% of cases this was identified as a contributory factor.

Plague of piracy

There is also rising global concern about the scourge of piracy on modern day shipping safety, especially in the Gulf of Aden region. Collectively, the industry has battled piracy with some success for many years, but the current situation in the Gulf of Aden is more difficult to address given the lack of an effective government in Somalia and the very low standards of living which means that incomes associated with ransom demands appear extremely attractive. For these reasons, piracy has become endemic off the coast of Somalia since 2008 and the levels of violence associated with pirate attacks have increased. According to the ICC International Maritime Bureau (IMB)[38], 28 ships were hijacked by pirates off the Somali coast in 2011 with 470 associated hostages. Fifteen people were killed in those attacks. Piracy also has a financial impact, with one estimate calculating that piracy cost the global economy $7bn in 2011[39]. For its part, the industry has not allowed the issue of piracy to go unnoticed, and the IMO together with a number of welfare organizations has kept the matter in the public eye. One campaign of note is Save Our Seafarers, which is aimed at raising awareness among the public of the impact of international maritime piracy and is attempting to encourage governments to increase their response to the situation[40].

Competing clash

Pressures of competition also pose a continuing safety risk to ships, seafarers and passengers. The loss of the *Herald of Free Enterprise* took place in the context of shore-based managers putting pressure on sea-staff to speed up their port turn around, a pressure that remains today. Likewise, the *Torrey Canyon* environmental disaster in 1967 has been attributed to a number of separate human errors[41]. The first saw management put pressure on the master to keep to a strict schedule, prompting the master to enter Milford Haven when the tides were waning to avoid a five day wait. The second was a poor decision by the master where he opted to go through the Scilly Islands without a copy of the Channel Pilot guide for that area, instead of around them as originally planned. And lastly, there was an equipment design error made by the equipment manufacturer which allowed the steering selector switch to be left on autopilot without any indication of the setting when at the helm. The consequence of these combined errors was that the *Torrey Canyon* ran around spilling some 120,000 tonnes of crude oil.

However, taken from a different angle, competition can also enhance safety. Paul Newton, UK Head of Hull & Liability, AGCS, says that competition prompts many charterers to look for the safest provider. "In this respect, charterers who have high ethical and high moral standards are in some ways pushing the safety culture," he says.

Technology concerns

The use of non-original parts for engine maintenance is also a potential safety issue for ships, in that these parts may not be tested or manufactured to the same standards as original parts and may become faulty. Non-Original Equipment Manufacturer (OEM) parts may also slip into the supply chain fraudulently and there is an additional question of whether OEM parts produced under license, are consistently of the same standard as OEM parts produced by the original manufacturers.

> "I've yet to meet an engineer that advocates the use of non-OEM parts because it is just not good practice."
>
> Paul Newton, UK Head of Hull & Liability, AGCS

From a more technical perspective, fire remains a major risk on board vessels with some ship types more at risk of combustion than others. For example, there are concerns that ro-ro vessels carrying vehicles present an increased risk partly because of their car and truck cargoes but also, and perhaps more importantly, because of the risk of fires rapidly spreading through the relatively large open spaces that constitute car decks aboard such ships. Likewise, mis-declaration of cargoes is also seen as a fire hazard to shipping, despite the implementation of the IMO's International Maritime Dangerous Goods (IMDG) Code regulating the safe stowage of hazardous cargoes. Where the contents of containers are not listed accurately, or are poorly understood they may inadvertently be stowed in unsuitable areas, posing an increased risk of a fire.

Safety first

While Safety Management Systems, introduced by the IMO's ISM Code, have certainly done much to improve shipping safety, they still offer scope for further progress. One negative is that by design, the ISM Code is written in general terminology because it has to be applied to all types of vessels and operations. This means that while company safety policies and procedures have to be written to a level of detail sufficient to control their specific operations, the definition of what is sufficient is left to the discretion of the SMS auditor, and not defined in the Code.

Tim Donney, Global Head Marine Risk Engineering, Allianz Risk Consulting (ARC), says: "I've seen great variances in companies with the application of their safety management systems. Some people really embrace it and get a lot out of the process, but others are just looking for any way they can gain compliance, get their certificates, and keep operating. They typically buy off-the-shelf programmes and just follow minimum guidelines – this is not pursuing SMS in the right way. If we could get more consistency and raise the standards overall, that would be a better way of improving safety. That said, I do believe that we are definitely on the right track with safety management systems, because they tie-in the responsibility for safe operations between shore-side management and the ship, focus on the human factors and require continuous improvement, and we should continue to pursue them."

Finally, it is fair to say that older tonnage is viewed as higher risk than newer tonnage, which will have been built to better construction rules and arguably in better condition. However, there do seem to be exceptions with regard to ship types and surprisingly some older ships (such as cement carriers and liquefied natural gas carriers) tend to be regarded by risk analysts as relatively 'safe'.

On the **horizon**

Making preparations for future challenges to shipping safety

The shipping industry is constantly looking at ways to further improve its safety record, and key in meeting that aim is determining future threats to operations. To that end, risk assessment specialists, academics and industry commentators all agree that the shrinking supply of a skilled workforce, both at sea and onshore, is a major risk factor on the horizon medium term.

Of particular concern is the move to source workers from emergent labor supply countries, the concern being that these nations may not have the necessary expertise or infrastructure to adequately train competent seafarers for a career in the maritime industry[42]. While the IMO has identified this problem and has attempted to address it by introducing standards for the training and certification of seafarers there is evidence that it is insufficiently able to enforce and monitor such standards[43]. And different standards of training are being compounded internationally by different methods and standards of seafarer assessment. This has produced an international system of certification whereby one certificate almost certainly does not carry the same meaning as one issued by a different Flag State[44]. The overriding fear is that such variations in standards could give rise to variations in seafarer competence which may in turn lead to poor navigational understanding and limited competence with regard to shipboard maintenance and emergency response.

Training more generally is considered a key challenge for the future. Kevin Whelan, UK Marine Claims Manager at AGCS, believes that training is a problem on two grounds: firstly, is there enough training available, and secondly, is it of the right standard?

"Attracting the right caliber of person seems to be a real challenge," he says. "It's a perennial problem and there is little sign of improvement unless the maritime industry itself can somehow make a career at sea more attractive. Some ship-owners are already offering higher salaries to attract the right staff, but with ship-owners today operating to the slenderest margin, any investment in training is a drain on the bottom line."

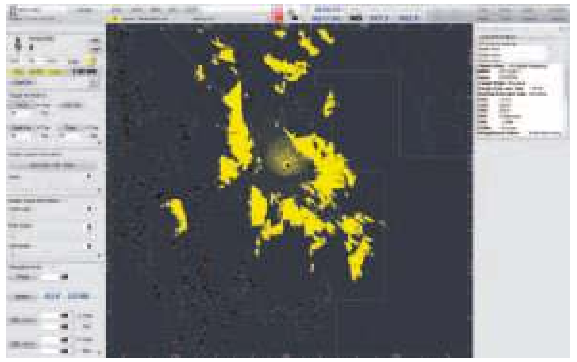
Paul Newton, UK Head of Hull & Liability, AGCS, agrees that the shipping industry has a major problem in getting people to come onboard. "A shipping career today is less glamorous than it used to be and, as with other industries, most companies want more people to do far more for far less."

Staying on the human front, Volker Dierks, AGCS Head of Marine Hull Germany, says crews are fed up with inspections. "They have vetting teams from oil majors, PSC, class societies, P&I clubs, hull underwriters and many more." The fundamental problem is that no one entity trusts the finding of another's. "It wouldn't cure all evils but if you could take oil major vetting, create something from that to apply to all industries, and have a centralized body to run it, shipping would probably be a far better place," suggests Mr Newton. As one of the most rigorous inspections, oil major vetting can take two-three days, including a ship vetting and an audit of the office. "They leave very few stones unturned," he says.

Technology overload?

A dependence on satellite positioning, especially GPS, is also singled-out as a threat to future shipping safety, especially in light of concerns about the reliability of available satellite-based systems and the potential threat to disruption to satellites by renegade groups or terrorists.

Allianz Risk Consulting (ARC) Global Head Marine Risk Engineering, Tim Donney gives the example of a cruise ship that ran aground in the US, near the Port of Boston. The bridge team was only using their satellite navigation system, but the wire connection from the satellite receiver on the ship to the actual receiver in the wheelhouse had become worn away and was no longer making a connection. With the signal lost, the satellite receiver had defaulted to dead reckoning positioning, based on last known position, course and speed. "That's all they were using and watching, so they were not taking into account currents, wind or other things that would cause them to drift," he says. "They ran aground on the North American continent. They had other means they could have used, such as radar, depth-finder and a lookout, but they were just relying on watching their satellite receiver box."



Ship's RADAR display (Photo Courtesy of Kongsberg Maritime)

Jean-Pierre Ryckaert, AGCS Marine Technical Adviser (Paris) holds a 1st class combined master/chief engineer licence and spent over 16 years at sea, as a Chief Engineer on a wide range of vessels. He was also a superintendent and fleet manager for 10 years for tanker companies and an ISM/ISO auditor.

Jean-Pierre Ryckaert, Marine Technical Adviser at AGCS France, gives another example of a grounding caused by over-reliance on GPS, where the GPS was giving a false position for many days as the ship approached shore. "The use of an echo sounder should have warned the Officer of the Watch (OOW) that something was going wrong." The OOW should never, he adds, rely on a single navigational help to get a fix and that a GPS position should always be confirmed by at least one other means.

One response to the dependence on GPS has been the UK Department for Transport's, via the General Lighthouse Authority (GLA), sanctioning of a 15-year contract to provide an enhanced long range navigation system, eLoran, to civilian mariners. The full eLoran system, due to come into service by 2022, aims to provide accuracy of 10 meters and will improve safety, security, and protection of the marine environment.

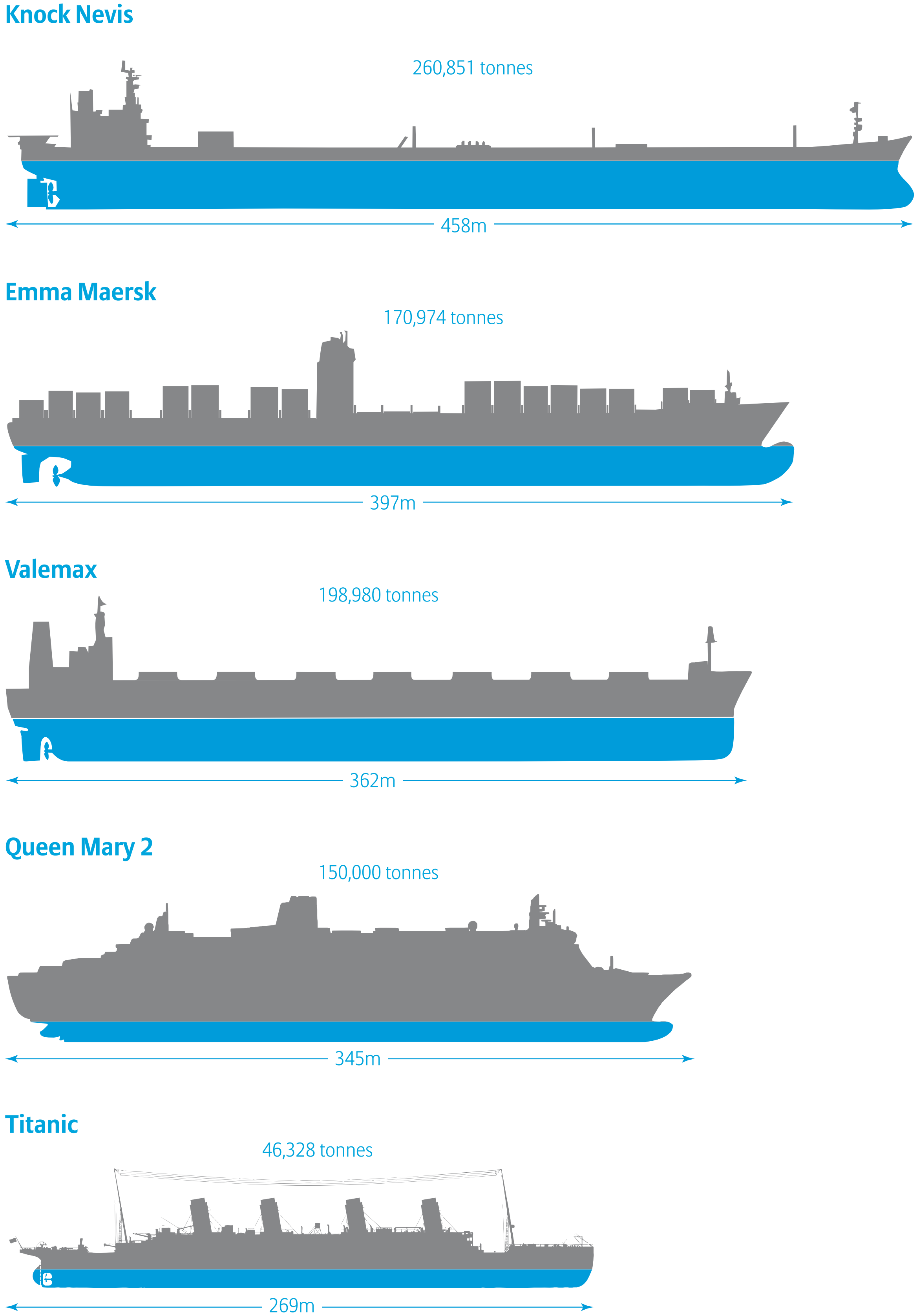
> "You can always train the technology of equipment, but not the human factors."
>
> Konstantin Boroffka,
> Marine Risk Control Manager Europe, AGCS

In terms of other technology, onboard computer-based navigation information system ECDIS is also earmarked as a concern for future safety by Mr Newton. "ECDIS is causing a lot of heartache over implementation and handover procedures between watches." Unlike a paper chart which has all of the hazards so marked, ECDIS is a visual computer display and not all of the underlying hazards are displayed in some settings. "There doesn't appear to be a standardized product or specification for the product and the underlying map data. Owners aren't being negligent; there's just so much disparity between implementation."

Pushing the design envelope

The modern shipping fleet is getting bigger, and not just in number of ships. Ever larger ships have tested design boundaries, maximizing cargo carriage and reducing average unit costs. In 1956, the *Spyros Niarchos* was the largest ship sailing and she had a deadweight of merely 46,000 tonnes. In the 1960s, the *Universe Apollo* marked the emergence of a new larger class of oil tanker with a deadweight of 100,000 tonnes. Today, very large crude carriers (VLCCs) of 300,000 deadweight tonnes or more are commonplace, and even larger ultra large crude carriers (ULCCs) of 550,000 deadweight tonnes are also in existence.

Comparing size of Titanic with other ships (gross tonnage)



Containerships have also been steadily increasing in size: the arrival of Maersk Line's *Emma Maersk* in 2006, set a new bar for containerships. At 397.7 meters long, with a beam of 56.4 meters, she was the largest of her type at the time. But advances in propulsion, and a drive to improve efficiency has led to the design of an even bigger model, known as the Maersk Triple-E class, scheduled for delivery in 2014. At 400 meters long, 59 meters wide and 73 meters high, the Triple-E will be the largest vessel of any type on the water. Its 18,000 twenty-foot container (TEU) capacity is 16% greater (2,500 containers) than the *Emma Maersk*.

A question of size

The Maersk Triple-E class[45] is so large that you can fit a basketball court, a full-sized American football stadium, and a spectator-packed ice hockey arena all below deck.

The 20-strong fleet will be able to carry as many as 3.64bn Apple iPads, enough for half the world's population.

And the 18,000 containers that one ship can carry would fill Times Square in New York City, towering over billboards, lights and many buildings. To carry all those containers a train would need to be 110 km long, and if those containers were stacked end to end on top of each other they would break through the earth's stratosphere.

The lure of China and its insatiable thirst for bulk commodities such as iron ore has driven other ship types to follow suit. In 2011, the first of a new generation of bulk vessels, known as very large ore carriers or VLOCs, was seen plying the trades between South America and China/Europe. With a deadweight of up to 400,000 tonnes and dedicated to carrying heavy cargoes, concerns have been raised about their structural integrity.

The drive to make ships bigger carries with it some emergent risks with regard to structural integrity and failure. Such incidents also give rise for concern over the current effectiveness of systems designed to maintain safe standards of vessel design. Mr Newton describes increasing ship size as a "major issue", raising particular concerns about the advent of project specific, supersize ships. Captain Rahul Khanna, AGCS's Senior Risk Consultant – Marine, adds that there is no reason to believe that larger ships should be any more dangerous, but the industry needs to understand and address the risks associated with larger ships and ensure that there are enough safety standards in place to prevent incidents. "And if something goes wrong with these larger ships we need to consider how we are going to address that," he says.

Image: Courtesy of Maersk

A new bulk scale

2011 witnessed the arrival of a new class of dry bulk carrier, the largest ever built and the longest ships in service. Valemaxes – named after the world's second biggest mining company Vale, who placed the original order – are 400,000 dwt very large ore carriers (VLOC). At 360 meters in length, these giants are longer than three UK football fields end to end.

The first Valemax vessel, *Vale Brasil*, was delivered in 2011 and a further 35 ships are expected to be in service by 2013. The emergence of such a huge bulk carrier has raised concerns about the structural integrity, concerns that were thought justified when on December 5, 2011, the *Vale Beijing*, operated by STX Pan Ocean, suffered structural damage during her first cargo loading and was in danger of sinking at the port of Ponta da Madeira in Brazil due to sea water entering ruptured ballast tanks and cargo holds.

However, post incident calculations performed by the ship's Classification Society, Det Norske Veritas found that the damage was not caused by global strength issues or single pass loading, but was assumed to be related to local buckling strength in some areas of the web frames in the aft ballast tanks. Investigations are ongoing, but whatever is found to be the cause, the incident demonstrates the unknowns that still exist in ship design as the industry continues to push construction boundaries.

Alongside a growth in the size of cargo ships over the last one hundred years, we have also seen a growth in the size, and passenger capacity, of cruise ships. While the *Titanic* was the largest passenger ship in her day, she would be dwarfed by the huge cruise liners in service today. At 46,328 gross tonnes, a length of 882.5 feet and a passenger carrying capacity of 3,000 people, the *Titanic* is just a fifth of the weight of the today's largest passenger ship, the *Allure of the Seas*, which can accommodate up to 6,360 people. The IMO has addressed this specifically through recent amendments to SOLAS, focusing on large passenger ships being built after July 1, 2010[46]. These new regulations respond to the challenges of this new generation of ultra-large passenger vessels, and place greater emphasis on reducing the chance of accidents occurring and on improved survivability, embracing the concept of the ship as 'its own best lifeboat' so that, in the event of a casualty, persons can stay safely on board, as the ship proceeds to port.

Fire in such vessels is an area of risk management focus with both the 'hotel' services and individual passengers considered as posing potential ignition risks. Indeed, the new SOLAS amendments address the need for improved fire prevention, detection and alarm systems and processes, the provision of safe areas and maintenance of essential systems after an incident, on-board safety centers for effective control of safety systems, as well as orderly evacuation and abandonment when necessary.

The IMO has also highlighted that one of the major concerns surrounding the growth of passenger ships is the challenge of successful search and rescue missions if a serious emergency occurs aboard such a vessel in a remote area where infrastructure may be limited, or involving large numbers of passengers of all ages and levels of fitness. Fortunately, despite high profile incidents such as that of the *Costa Concordia* in January 2012, the cruise industry has a good passenger safety record, and the great majority of cruises take place in less remote areas allowing for relatively easy access to emergency support and rescue services. Statistics from the Cruise Lines International Association state that in the five years prior to the *Costa Concordia* incident, 100 million passengers took part in a cruise holiday, with a total of 16 casualties[47]. Of greater concern is the continuing risk posed by some ferries and passenger vessels in developing regions – as shown by the *MV Rabaul Queen* loss in February 2012 off Papua New Guinea.

Capt. Konstantin Boroffka, sailed on container ships for many years and then worked in the global marine surveying and loss control industry. As Marine Risk Control Manager Europe at AGCS (Hamburg), he specializes in risk assessment for large cargo projects.

Basics of ship insurance

When it comes to insuring an ocean-going ship, there are a number of different coverages available. In general, the different aspects of a ship, its crew and its activities would be covered by the following types of insurance:

- Hull & Machinery - covers the physical damage of the ship and her propulsion systems
- Collision liability - includes usually the liability occurred as the result of a collision of the vessel with fixed and floating objects
- Protection & Indemnity (P&I) - covers any liability caused by other than vessel collision, e.g. by pollution, costs of wreck removal, as well as the liability caused by damage of carried goods and injury to crew. Coverage is traditionally provided by specialized P&I Clubs.
- Loss of Hire (comparable to business interruption insurance) covers loss of earnings which occur as the result of a damage to the vessel
- War insurance - covers material damage of the vessel caused by war and warlike events and nowadays also includes the risk of piracy.
- Freight, Demurrage & Defence - a specific legal protection insurance for ship-owners

Due to the high risks and large sums of money involved, ocean-going ships are usually insured on a subscription (or coinsurance) basis. This means that the risk is spread over a number of different insurers (in some cases, more than 20): each insurer only writes a certain percentage – or a line – of the total risk, thereby limiting the exposure for the individual companies.

Another layer of complexity is added when the ship carries cargo. The cargo itself is not insured by the ship owner, but by the owners of the cargo – which in the case of a big ocean-going cargo carrier can be quite a large number of parties with a variety of different insurers. Therefore maritime law has introduced the principle of general average which is particularly relevant for emergency situations when part of the ship or the cargo have to be sacrificed to save the whole. In that case and subject to the contract terms, all parties jointly share in the common loss incurred.

Breaking the ice

It is not only the introduction of larger ships that is a cause for concern among risk analysts; there are also new types of vessels being designed for use in specialized sectors which have yet to prove themselves on a safety front. One such sector that is piquing the interest of ship-owners is the opening up of the North East Passage, a sea route through the Arctic Ocean, connecting the Atlantic and Pacific Oceans. Until 2009, the Arctic pack ice prevented regular marine shipping throughout most of the year, but climate change has reduced the pack ice, and this shrinkage has made the waterways more navigable, bringing with it new ship design challenges. Other new types of vessels are appearing to service the burgeoning Renewables industry, especially for construction and servicing of wind farms installations.

Konstantin Boroffka, AGCS's Marine Risk Control Manager Europe, says that ships may be "technically capable" of going through ice areas safely, but to sail in these waters ship-owners need to consider the salvage and rescue opportunities if there is an incident. The quality and availability of supporting infrastructure must be considered, adds AGCS's Mr Dierks. "If a casualty occurs in Siberia, is the infrastructure – with icebreakers, with helicopter accessibility, with oil prevention measures at short notice – capable of supporting a shipping route through the North East passage?"

In respect of the highly sensitive nature of the Polar environment, Mr Newton advises that ship-owners have a complete operational readiness plan mapped out and that needs to take "more than just a passing view". "It needs thorough analysis and a careful review of pricing against risk. The challenges are immense and the insurance industry needs to carefully analyze the new risks so that everyone is getting a fair deal."

These new services and operations are inherently riskier as they are relatively untried and some risks associated with their operation may not be known for some time. And while the IMO is taking pre-emptive steps to mitigate potential risks, these new areas of operation may contain as yet unknown dangers.

Mr Newton also raises concerns of language barriers that might hinder safe operations in the Arctic. "The safest way to navigate the North East passage will be with a Russian pilot ship and a Russian icebreaker, but you almost need to employ a native Russian speaker on board your own ship to communicate directly with them," he says.

However, it is not just the Arctic environs that might suffer from poor communications; it's an industry-wide problem, according to Mr Whelan. "The language of the seas is English, but perhaps it is not always used because of a lack of fluency or otherwise in the English language. This is a problem for a master communicating with his crew, and for communications with another vessel or the coastguard. It could obviously compromise safety if the master or any of the other parties are not fluent in English."

Poor enforcement

Poor monitoring and enforcement of existing legislation is also cited as a risk to safety going forward. "Regulation should be better co-ordinated; there's enough of it, but monitoring and enforcement needs to be better," says Mr Whelan. "These disparate units [PSC, Class, IMO, Flag States] all have their values and are all pulling in the same direction, but the fact we have so many highlights the fact that a co-ordinated approach is lacking."

One key problem is that none of these so-called 'enforcers' will take responsibility for incidents, adds Mr Ryckaert. "Flag States will not take the blame and when the classification society delivers safety certificates on behalf of the Flag State, there is no reason for the society to take the blame as it is working on behalf of the Flag State. Classification societies themselves also have no "Police power" – that is to say that if the class considers a vessel unsafe with regards to classification, the only thing it can do is to suspend or withdraw the vessel's class, which will not prevent the ship from sailing."

Onboard challenges

Bureaucracy on board is also a worry. Says Mr Boroffka: "A real challenge to safety on board vessels today is the amount of bureaucracy burdened on crew. In earlier times, all ships had a radio officer who was responsible for communications and much of the paperwork onboard. Today, the master and crew are expected to deal with paperwork along with their other duties." Mr Boroffka suggests that the industry considers re-introducing a purser role, or introducing a new crew member dedicated to paperwork and relieved of watchkeeping duties. "This would be an improvement for safety and for the people on board," he says.

Complacency, as in so many long-serving industries, can also pose a safety risk. As Terry Campbell, AGCS's Marine Claims Head for the Americas, points out, "you get in your car and put your seat belt on 99% of the time, but sometimes you get in the car and you forget or you feel that it's only a short trip to the store so why bother. I really believe that complacency can be a challenge to any safety regulations or safeguards, whether that be in maritime, auto or any other industry."

Building blocks

Terry P. Campbell, AGCS Marine Claims Head – Americas (New York) has over 30 years' experience in the Marine insurance industry as an underwriting and claims expert.

Perhaps unsurprisingly, ship construction quality also has a bearing on safety. "Good quality ships which are built strongly and reliably are built for lasting work; poor quality ships will have more accidents because of mechanical breakdowns," says Mr Boroffka.

However, he adds that this is just as much a question of adequate supervision by classification societies and Flag States at construction stage as it is build quality. "The challenge for class and Flag States is to ensure that if the quality of newbuild ships is not sufficient that deficiencies are rectified." Mr Dierks agrees. "Shipyards will build whatever the shipowner asks them to build; however, the quality is a question of regulation and of classification society approval."

Green credentials

There have been numerous initiatives to improve the green credentials of shipping from the top down, including carbon disclosure, emissions control, and slow steaming – a practice of sailing at lower speeds to burn less fuel and to offset capacity stresses by using more vessels to make up for the longer sailing times. While, on the whole, steps taken to mitigate pollution by ocean going vessels are beneficial from a safe operations perspective, there are potential risks associated with some schemes. For example, under the IMO's ruling to force ships to switch to and from high and low sulfur fuels as they enter and depart from specified Emission Control Areas, there is a risk of changeovers not being correctly performed, which could damage engines.

And the introduction of greener fuels may also pose a threat to safety in the future. The first liquefied natural gas-fuelled ships will enter into service in 2013 and while they have been subjected to rigorous design testing, there may yet be some risks to be identified which will only become apparent once the ships enter service.

Meeting minimums

Chapter V of the IMO's SOLAS convention includes a "general obligation ... for Contracting Governments to ensure that all ships shall be sufficiently and efficiently manned from a safety point of view"[48], effectively setting safe minimum manning numbers. Nonetheless, it is argued that these minimum levels are too low and should be revised to maintain safe operations in the future.

ARC's Mr Donney explains that minimum crewing numbers assume that operations will always be 100% efficient and that when a crew is off watch, that there is nothing else on the ship that needs to be done. "But there are always repairs, maintenance, and training that need to be done and that takes people and time," he says. "That's not to mention weather factors, mechanical failures, or operational issues. A 100% perfect, theoretical operation doesn't happen. So the crew is under pressure to keep up with the demands of operations and the ship's tight schedule and doesn't have the time to spend on maintenance, repair, training or other issues."

Further, minimum crewing requirements take very little account of the geographical area the ship is sailing in, according to Mr Boroffka. "Crews can be exhausted in the Baltic as there are many port calls in a relatively short space of time. There can even be numerous loading and discharge berths within one port." Mr Boroffka gives the example of a ship that called at Hamburg to load at four different berths, proceeding on to Bremen, Antwerp and Felixstowe, all in one week. "The poor master had about two dozen berthing operations in one week. When is he able to sleep? This really isn't taken into account when crewing requirements are set. It should not be a one-size fits all."

Captain Khanna agrees that there is a serious shortage of skilled manpower on ships today. "There are just not enough people on board on some ships. A lot of responsibility is placed on the crew without realizing the workload and assessing whether that workload is reasonable. Consequently, crew fatigue is now a big problem." Mr Donney adds that with increasing economic pressure on operators and so much congestion in ports, crew are under tremendous pressure to be on time.

"Minimum crew numbers are inadequate – they do not leave any margin for safety, particularly in event of an emergency, or adequate consideration of crew fatigue."

Tim Donney, Global Head Marine Risk Engineering, Allianz Risk Consulting (ARC)

Class conflicts

Classification societies have evolved extensively from their humble beginnings as supporting bodies to underwriters, with quality certification of safety management systems and ship design services now just two of many additional services that are available today. However, not all of that evolution is necessarily viewed as beneficial by the industry. One particular issue raised is the potential for conflicts of interest that can arise with some of the extension of services that class now offer, especially when these services were originally intended to provide two independent safety nets. Mr Donney points out that critics of the ISM Code believe that IMO requirements should not allow the quality register – issuing the certificate for compliance of safety management systems – to be part of the same organization that issues and maintains the ship's Classification certificate. "If during the course of an ISM certification audit, issues are found that might question the classification society inspections and the ship's class certificate, would the auditors put that in their report if it would reflect badly on their own organization?" he asks. "The IMO and/or Flag States should require that separate organizations do the ship's classification and the issuance ship's Safety Management Certificate – they should not both issued by the same corporate organization."

Some Classification Societies are now also offering ship design services, which, as Allianz specialists point out, have attracted controversy. As a core service, Societies certify that ship builders' designs meet Classification Society construction rules for construction, for vessels of different types and trades. "If some Classification Societies are now also proposing to design the ships, they could be designing and certifying their own work, which has considerable potential for conflicts of interest," says Mr Donney. Nonetheless, as Sven Gerhard explains, many of the better known Societies have made significant design contributions to safety improvements: "Whilst Societies need to protect their independence, we can also see where safety improvements have come about directly through the design work of some of the better known Societies."

Mr Boroffka describes class as "an interesting market". "They are mostly organized as profit-making entities and they have a reputation to protect, but is a commercial entity really the right entity to enforce regulations?" he asks. Mr Dierks adds that there is a "grey area" under the current set-up, where classification is not independent of its customers. "If there was no relationship between classification surveyors and the owner, there might be more focus on safety," he says.

Key risks to the future safety of shipping

- Human error
- Competition
- Piracy
- Use of non-OEM parts
- Over-dependence on technology
- Lack of skilled workforce
- Increasing ship sizes
- Ice shipping
- Non-standardized training
- Poor monitoring and enforcement of regulation
- Complacency
- Non-sector specific Safety Management systems
- Reduced crewing numbers
- Crew fatigue
- Classification and Flag: potential for conflicts of interest
- Poor communications
- Operational pressures
- Bureaucracy onboard
- Build quality
- Inspections
- ECDIS implementation
- Commerciality of Class and flag

Rising to the challenge

While in combination, these current and future challenges to safety are extensive, they are not insurmountable. The shipping industry has proved that it can and will rise to safety challenges in any shape or form. And while there is no one answer to mitigating these emerging safety risks, the industry has a powerful selection of tools at its disposal to further improve safety records. Regulation (whether through regional, national and international legislation), sector-specific support from organizations, risk analysis, training, research and development in new technologies, computer modeling and more all work together to support the common goal of reducing safety risks and preventing accidents in shipping.

Since the tragic *Titanic* accident in 1912, maritime safety has improved greatly. One hundred years later, the industry is continuing to build on those improvements with a resolve that will likely be further strengthened by incidents such as the *Costa Concordia* grounding. This commitment to continual progress will undoubtedly lead the industry to celebrate further safety improvements 100 years from now, building on a reduction of incidents in the face of an ever-increasing number of ships servicing world trade.

As with other major accidents, the Costa Concordia incident of January 2012 is likely to trigger further improvements in marine safety regulations.

Photo: Getty Images

Acronyms

AIS	Automatic Identification System
ARPA	Automatic Radar Plotting Aid
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
ECDIS	Electronic Chart Display and Information System
EMSA	European Maritime Safety Agency
EPIRB	Emergency Position Indicating Radio Beacon
GLA	General Lighthouse Authority
GLONASS	Global Navigation Satellite System
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positioning System
IMDG	International Maritime Dangerous Goods
IMO	International Maritime Organization
ISM	International Safety Management
ISPS	International Ship and Port Facility
MAIB	Marine Accident Investigation Branch
MARPOL	International Convention for the Prevention of Pollution from Ships
OEM	Original Equipment Manufacturer
RADAR	Radio Detection and Ranging
SAR	Search and Rescue
SART	Search and Rescue Transponder
SMS	Safety Management Systems
SOLAS	International Convention for Safety of Life at Sea
STCW	Standards of Training, Certification and Watchkeeping
ULCC	Ultra Large Crude Carrier
UNCTAD	United Nations Conference on Trade and Development
VHF	Very High Frequency
VLCC	Very Large Crude Carrier
VLOC	Very Large Ore Carriers

Causes of loss – detailed descriptions

Collision	Includes ships lost as a result of striking or being struck by another ship, regardless of whether under way, anchored or moored.
Contact	Includes ships lost as a result of striking an external substance – but not another ship (see collision) or the sea bottom (see wrecked/stranded). This category includes striking drill rigs/platforms, regardless of whether in fixed position or in tow.
Foundered	Includes ships which sank as a result of heavy weather, springing of leaks, breaking in two etc., but not as a consequence of categories listed elsewhere.
Missing	After a reasonable period of time, no news having been received of a ship and its fate being therefore undetermined, the ship is posted as 'missing' and is included in the missing category.
Fire/ Explosion	Includes ships lost as a result of fire and/or explosion where it is the first event reported. It therefore follows that casualties including fires and/or explosions after collisions, strandings etc., would be categorized under 'collision' or 'wrecked/stranded'.
Wrecked/Stranded	Includes ships lost as a result of touching the sea bottom, sandbanks or seashore, etc., as well as entanglement on underwater wrecks.
Hull/ Machinery	Hull/machinery damage or failure which is not attributed to any other category.
Other	Includes war loss (and encompassing loss occasioned to ships by hostile acts) and losses which, for want of a sufficient reason, cannot be classified.

Source: Lloyd's Register World Fleet Statistics

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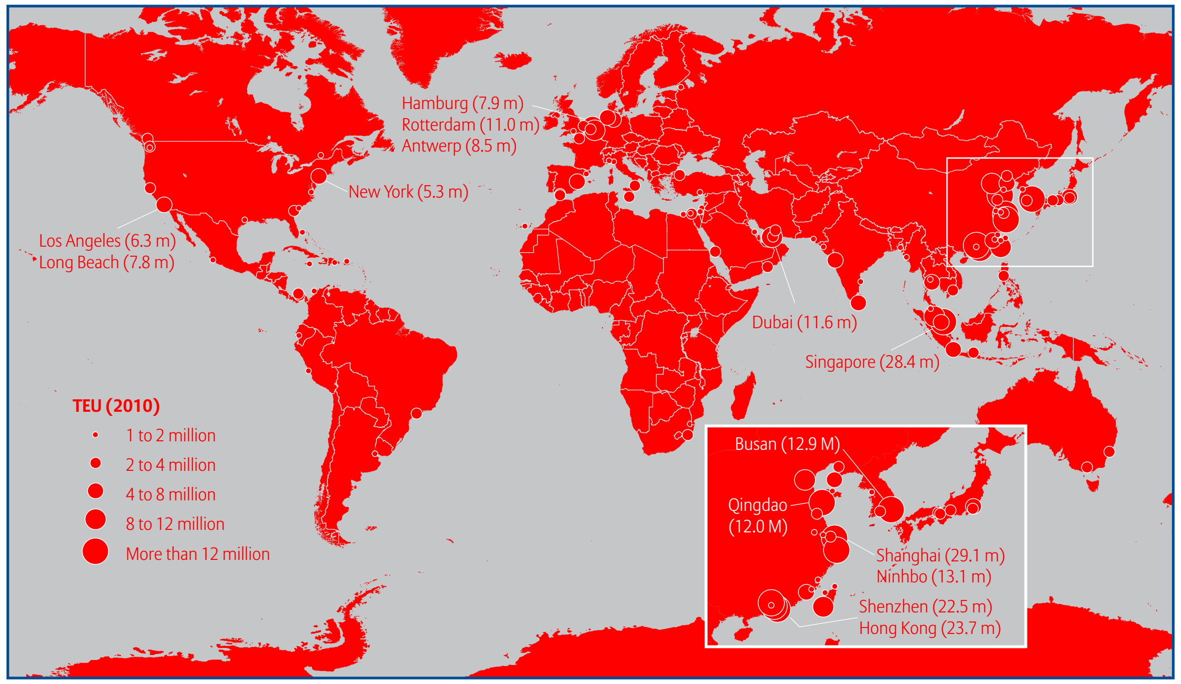
Appendix: Major Container Ports 2010



Source: Dr. Jean-Paul Rodrigue, Dept. of Global Studies & Geography, Hofstra University.
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Acknowledgements & Credits

We would like to thank all the Allianz Global Corporate & Specialty Marine experts for their time and valuable input, and Dr. Jean-Paul Rodrigue, Dept. of Global Studies & Geography, Hofstra University for mapping and trade flow information.

Special thanks also go to Professor Helen Sampson, Mr Neil Ellis, Dr Elizabeth Gould, Dr Lijun Tang, Dr Nelson Turgo, and Dr Zhiwei Zhao at the Seafarers International Research Centre (SIRC), Cardiff University, for their original research on marine safety on which this report draws.

Seafarers International Research Centre (SIRC),
Cardiff University, 52 Park Place, Cardiff, CF10 3AT

Tel: +44 (0)29 2087 4620
Fax: +44 (0)29 2087 4619

sirc@cardiff.ac.uk
www.sirc.cf.ac.uk

Editor: Carly Fields. Carly is a freelance specialist maritime Editor with an industry-specific degree and 12 years' journalism experience. She is the Editor of Mercator Media's Port Strategy magazine and the Institute of Chartered Shipbrokers' Shipping Network magazine.

Design and layouts: Mediadesign (Wales).

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Allianz Global Corporate & Specialty AG, Fritz-Schaeffer-Strasse 9, 81737 Munich, Germany
Allianz Global Corporate & Specialty AG, (London office) 60 Gracechurch Street, London EC3V 0HR

Contact us

For more information, please contact your local Allianz Global Corporate & Specialty Communications team.

London

Hugo Kidston
hugo.kidston@allianz.com
+44 (0)203 451 3891

Jonathan Tilburn
jonathan.tilburn@allianz.com
+44 (0)203 451 3128

Munich

Heidi Polke
heidi.polke@allianz.com
+49 89 3800 14303

Singapore

Wendy Koh
wendy.koh@allianz.com
+65 6395 3796

Paris

Isabelle Caminade
isabelle.caminade@allianz.com
+33 (0) 1 58 85 97 22

New York

Jacqueline Maher
jacqueline.maher@agcs.allianz.com
+1 646 472 1479

www.agcs.allianz.com

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