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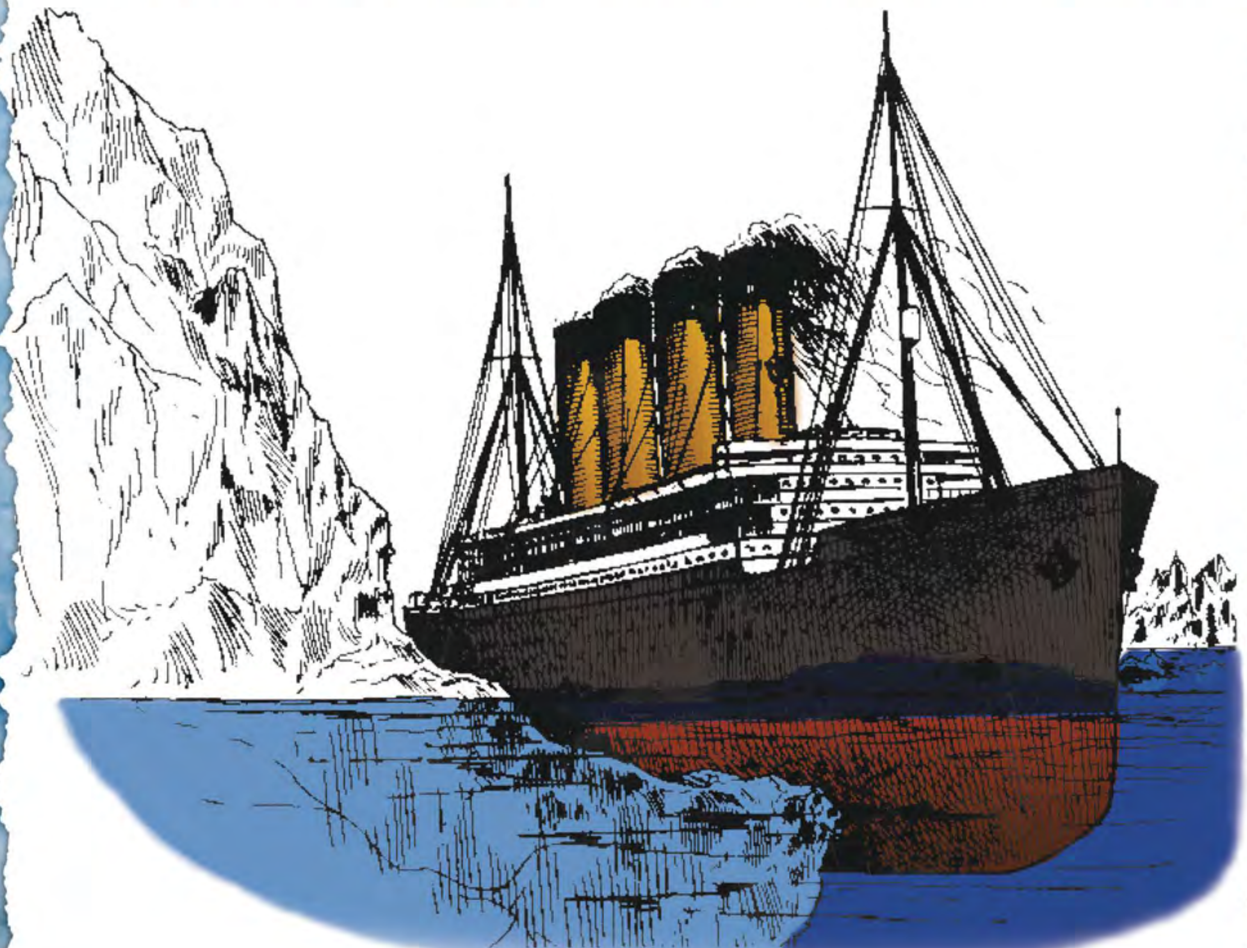

100 Years of Marine Safety

PROCEEDINGS

Summer 2012

Vol. 69, Number 2

Titanic Response

Titanic Response

Evolution of Standards

Evolution of Standards

Industry's Safety Contributions

Special: *Titanic* Investigation

Pictured on the cover: Artist rendition of RMS *Titanic* colliding with iceberg. USCG +LVWRULDQ¶V2I¿FH

Director's Perspective

by Mr. Jeffrey G. Lantz
Director, U.S. Coast Guard
Commercial Regulations and Standards

Practically Unsinkable

In 1911, *Shipbuilder* magazine published an article describing the *Titanic's* construction, declaring that the ship would be "practically unsinkable" when its watertight doors were closed. We all know that statement was wrong.

The loss of the *Titanic,* and the resultant loss of more than 1,500 people, was a tragedy that changed the way the world approached maritime safety. At the time, there were no international standards and relatively little government oversight for ship construction, equipment, maintenance, or operation.

This incident was a tipping point—the catalyst for governments to come together and create an international body, now known as the International Maritime Organization (IMO), dedicated to maritime safety, security, and environmental protection. In doing so, these governments crafted the most important treaty on ship safety the world has known: the International Convention for the Safety of Life at Sea (SOLAS), which stands today as the global standard for marine safety. In fact, many of today's requirements for stability, watertight subdivision, lifesaving equipment, and radio telecommunications can be traced back to the lessons learned from the *Titanic* disaster.

IMO has followed SOLAS with other important international treaties and codes, including the International Convention for the Prevention of Marine Pollution from Ships; Standards for Training, Certification and Watchkeeping for Seafarers; and the International Ship and Port Facility Security Code. The maritime community takes pride in how it has become a safer, more secure and environmentally friendly mode of transportation over the last century.

This has been no easy task. Globalization, the economies of scale, and customer demand have led to larger, fancier, and faster vessels, with capability unthinkable 100 years ago. Additionally, the demand for bigger, better, and faster ships has been accompanied by society's decreased acceptance of risk.

This presents a huge challenge to the maritime industry. Too often, quantum leaps in safety improvement were triggered by a catastrophic incident. And, despite the tremendous improvements in maritime safety, we all—shipbuilders, owners, government authorities, ships' officers and crew—must be constantly vigilant and strive for even safer vessels and maritime operations. Our goal must be safety perfection. Although we may never attain that perfect state, we must never be content with the status quo.

We have only to look to the recent *Costa Concordia* grounding to realize that, despite the many improvements in maritime safety over the past 100 years, ships are still not unsinkable. Let us never cease our quest to ensure that "better" ships are always "safer" ships.

Champion's Point of View

by Mr. Francis J. Sturm
Deputy Director, U.S. Coast Guard
Commercial Regulations and Standards

In 1912, there was no international maritime safety organization and little in the way of international safety standards. Then the RMS *Titanic* sank, and that changed.

My overall vision for this edition is to provide the reader with information about the *Titanic* itself, and the impact of its sinking on the state of maritime safety—in the short term and over the past 100 years.

The first section of the magazine has a short history of the ship and its fateful maiden voyage. There are several articles about the International Ice Patrol, created to patrol the North Atlantic and report iceberg locations to the shipping community. There is also information on the world's first international intergovernmental body for marine safety, now called the International Maritime Organization, and how the most important treaty on ship safety, the Safety of Life at Sea (SOLAS) Convention, came to exist.

Following this section is a collection of articles that describe the evolution of SOLAS requirements. Experts in ship stability, structural design, lifesaving, fire protection equipment, and maritime distress and radio telecommunications equipment explain the evolution of today's current ship design and equipment safety standards. Search and rescue experts also lay out modern techniques for response to marine safety incidents. Other articles look beyond safety regulations for large passenger vessels and traditional cargo ships to explain the relatively recent evolution of specialized standards for vessels designed for offshore oil development and for hazardous materials carriage. There is also an article in this section about the Coast Guard program specifically focused on approval of the design and equipment on cruise ships operating out of the United States.

We also present a group of articles that focus on the vital services provided by industry standards organizations, ship classification societies, ship management companies as well as the role of protection and indemnity clubs (ship insurers) in marine safety.

Those who read *Proceedings* on a regular basis know that each issue usually contains articles on lessons learned from Coast Guard casualty investigations. This issue features a special pair of such articles. The first article poses stimulating questions about decisions made surrounding the *Titanic* and the events leading up to her sinking. Following this is an article about the U.S. Senate investigation that focused specifically on this tragedy.

This year, people have placed much focus on the 100th anniversary of the *Titanic's* sinking. I hope these articles give you a better understanding of some of the shortcomings that led to the loss of this majestic vessel and a greater appreciation of the efforts to improve marine safety over the last century.

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The Short Life and Tragic End of RMS *Titanic*

by Mr. Christopher B. Havern, Sr.
Staff Historian
U.S. Coast Guard Historian's Office

At 11:40 p.m. on April 14, 1912, Royal Mail Steamer (RMS) *Titanic* collided with an iceberg. Two hours and 40 minutes later, the pride of the White Star Line, a testament to technology and the achievement of men, began her two-mile plunge to the bottom of the North Atlantic. Of the 2,224 passengers and crew aboard, only 710 survived.[1] While there were other incidents that produced greater losses of life,[2] the sinking of *Titanic* is arguably the most famous and far-reaching maritime disaster in history.

Captain Edward John Smith, 62, joined White Star as a fourth officer in 1880. He gained his first command, SS *Republic,* in 1887. A year later, Smith earned his extra master's certificate and joined the Royal Naval Reserve. Smith, assuming command of *Titanic,* had a reputation as one of the world's most experienced sea captains. The ship's senior officers were also all experienced seamen.

On April 2, 1912, *Titanic* completed sea trials, during which the crew started and stopped her engines and practiced port and starboard turns, turning a full circle, and running at different speeds. Only one day was devoted to trials, so the ship could meet her appointed departure. She arrived at the White Star dock in Southampton shortly after midnight on April 4.

The Voyage Begins

At 5:18 a.m. the crew and passengers began boarding, and at noon the ship was underway. Ominously, *Titanic* nearly collided with SS *New York* as she left Southampton. *Titanic* made two stops before departing for her ultimate destination, New York. The first was at Cherbourg, France, to take on additional passengers, luggage, and mail. Her second stop was at Queenstown (now Cobh), Ireland, on April 11. Having completed her business, *Titanic* set sail for New York. This was the last time the ship would see land.

The first two days of the trip were largely uneventful, though several eastbound ships gave warnings of ice in the sea lanes. Captain Smith, in response, altered his course southerly. On Sunday, April 14, White Star policy called for conducting lifeboat drills after religious services. However, Captain Smith cancelled them, a move that would prove fateful. *Titanic* received no less than six warnings of icebergs and pack ice as the day wore on.

At 10 p.m. there was the regular change of watch, and the crew on the forward watch was warned to look out for small icebergs or "growlers," but they didn't have binoculars. Given the clear weather conditions and the very calm seas, it was still difficult to identify icebergs at a distance, especially without binoculars. The ship was running somewhere between 21 and 22 knots, less than her maximum speed of 23 knots.

The Iceberg

At 11:39 p.m. the lookouts spotted an iceberg. They immediately rang the warning bell and telephoned the bridge, "Iceberg, right ahead!" The first officer ordered, "Stop! Full speed astern!" to the engine room and "Hard a'starboard!" to the quartermaster, who turned the ship's wheel hard over.[3] At 11:40 p.m., *Titanic* collided with the iceberg. According to the British inquiry, "The collision with the iceberg … caused damage to the bottom of the starboard side of the vessel at about 10 feet above the level of the keel, but there was no damage above this height."[4] The damage extended about 300 feet.[5] *Titanic* was mortally wounded.

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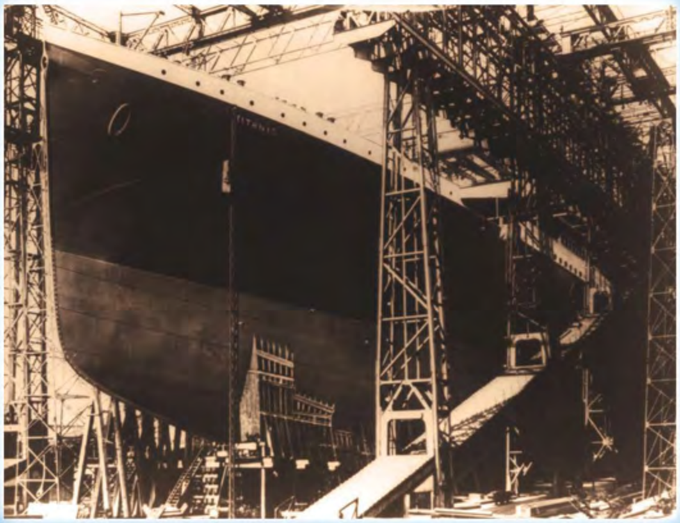
March 31, 1912
RMS *Titanic* launched.



RMS *Titanic* XQGHUFRQVWUXFWLRQ8 6&* +LVWRULDQ¶V2 I¿FH

Titanic prior to launch, May 31, 1912. George Grantham Bain Collection Prints & Photographs Division, Library of Congress LC-USZ62-34781.

Titanic GHSDUWV8 6&* +LVWRULDQ¶V2 I¿FH

April 2, 1912
RMS *Titanic* sea trials completed.

Smith ordered the engines stopped and an inspection conducted. He also directed the wireless operators to prepare a distress call. Inspections determined that 14 feet of water had entered the first five compartments in less than 10 minutes. The sixth compartment was being pumped, but it was only a matter of time before the level in the first five would rise to the point where water would lap over the top of the watertight bulkhead. This process would be repeated from compartment to compartment. Thomas Andrews, the ship's constructor, estimated that the ship would stay afloat about two hours. *Titanic* was doomed.

Abandon Ship

At 12:05 a.m. the wireless operator issued the call for assistance. Captain Smith also ordered the lifeboat covers removed and crewmen dispatched to awaken the passengers, have them dress, and put on life belts.

Information on the true extent of *Titanic's* tragedy emerged slowly. This New York newspaper's front page, issued the day after the collision, lacks many details including the staggering number of casualties. Image produced by the Library of Congress as part of the Chronicling America project and reprinted with permission.

LINERS TAKE OFF PASSENGERS;
TITANIC IS REPORTED SINKING

FINAL EDITION

FINAL EDITION.

The Evening Edition World.

"Circulation Books Open to All."

PRICE ONE CENT. NEW YORK, MONDAY, APRIL 15, 1912. 16 PAGES PRICE ONE CENT.

MANY NOTABLES IN FIRST CABIN OF GREAT LINER

Col. John Jacob Astor, His Bride and Alfred G. Vanderbilt Among Them.

RELATIVES ARE ANXIOUS.

Crowd the Offices of the White Star Line Anxiously Awaiting News.

Gigantic Bow of the Titanic Crumpled by Collision With Iceberg

THE TITANIC'S BOW

SHE CANNOT SINK, SAYS OFFICIAL OF WHITE STAR LINE

"Absolutely No Fear Is Entertained for the Safety of the Passengers."

DISABLED SHIP UNDER TOW AFTER HITTING BIG ICEBERG

Wireless Brings Steamships to Scene of Disaster, and Passengers, Including Many Notables, Are Transferred to Carpathia and Parisian.

World's Biggest Ship Reported in Bad Shape After Collision at Night and Now Being Towed to Halifax by the Allen Liner Virginian.

LATEST BULLETIN.

HALIFAX, N. S., April 15.—The Canadian Government Marine Agency here at 4.15 P. M. received a wireless despatch that the Titanic is sinking. The message came via the cable ship Minia off Cape Race.

It said that the steamers towing the Titanic were endeavoring to get her into shoal water near Cape Race for the purpose of beaching her.

It was said at the White Star line's offices at 4 o'clock this afternoon that a despatch had been received from a Canadian news agency that the Titanic was in a sinking condition. No confirmation of this report had been received.

From another source it was reported to the line late this afternoon that all the disabled vessel's passengers had been put aboard the Carpathia, Parisian and Virginian.

LINERS TAKING OFF PASSENGERS.

NATIONAL LEAGUE.

AMERICAN LEAGUE.

SAY PASSENGERS WERE TAKEN OFF.

BALTIC SPEEDING TO RESCUE.

LINERS RACE TO THE RESCUE.

At 12:25 a.m. Smith ordered the lifeboats swung out to load passengers. Venting steam from the engines made orders inaudible and confused passengers mingled on the deck. It was not until 12:45 a.m. that the first lifeboat launched. It was around this time that the first of eight signal rockets was fired.

The remaining regular lifeboats and one of the collapsible boats were launched over the next 70 minutes; the last at 1:55 a.m. Those still aboard struggled to launch the remaining collapsible lifeboats. At 2:05 a.m. collapsible lifeboat "D" was the last boat launched from the davits. At this time, Captain Smith told the wireless operators to stop transmitting, though both stayed on duty for another 12 minutes.

At 2:15 a.m. as the stern rose higher into the air and the last two collapsible boats went into the water, one was inverted and people clambered onto it. The other went in upright, but the wave caused by the collapsed forward funnel swamped it and pushed it away from the ship. Eventually, a number of people were able to climb aboard. At 2:18 a.m. the electric lights flickered and were extinguished.[6] At 2:20 a.m. the stern went nearly vertical and then slipped into the deep. *Titanic* was gone.

With the ship sunk, there was only the cold, starlight, and the screams of those in the water. Eventually, the screams subsided as the frigid water claimed its victims. Though some went back in the hope of rescuing survivors, most of those on lifeboats just rowed away or stood off for fear of being capsized.

At 3:30 a.m. rockets from RMS *Carpathia* were spotted. Forty minutes later, the vessel began picking up survivors. By 8:30 a.m. the last survivors were taken aboard. And, at 8:50 a.m., *Carpathia* Captain Arthur Henry Rostron decided to return to New York. Along with the survivors, Rostron had 13 lifeboats hauled onto his ship—that was all that remained of RMS *Titanic.*

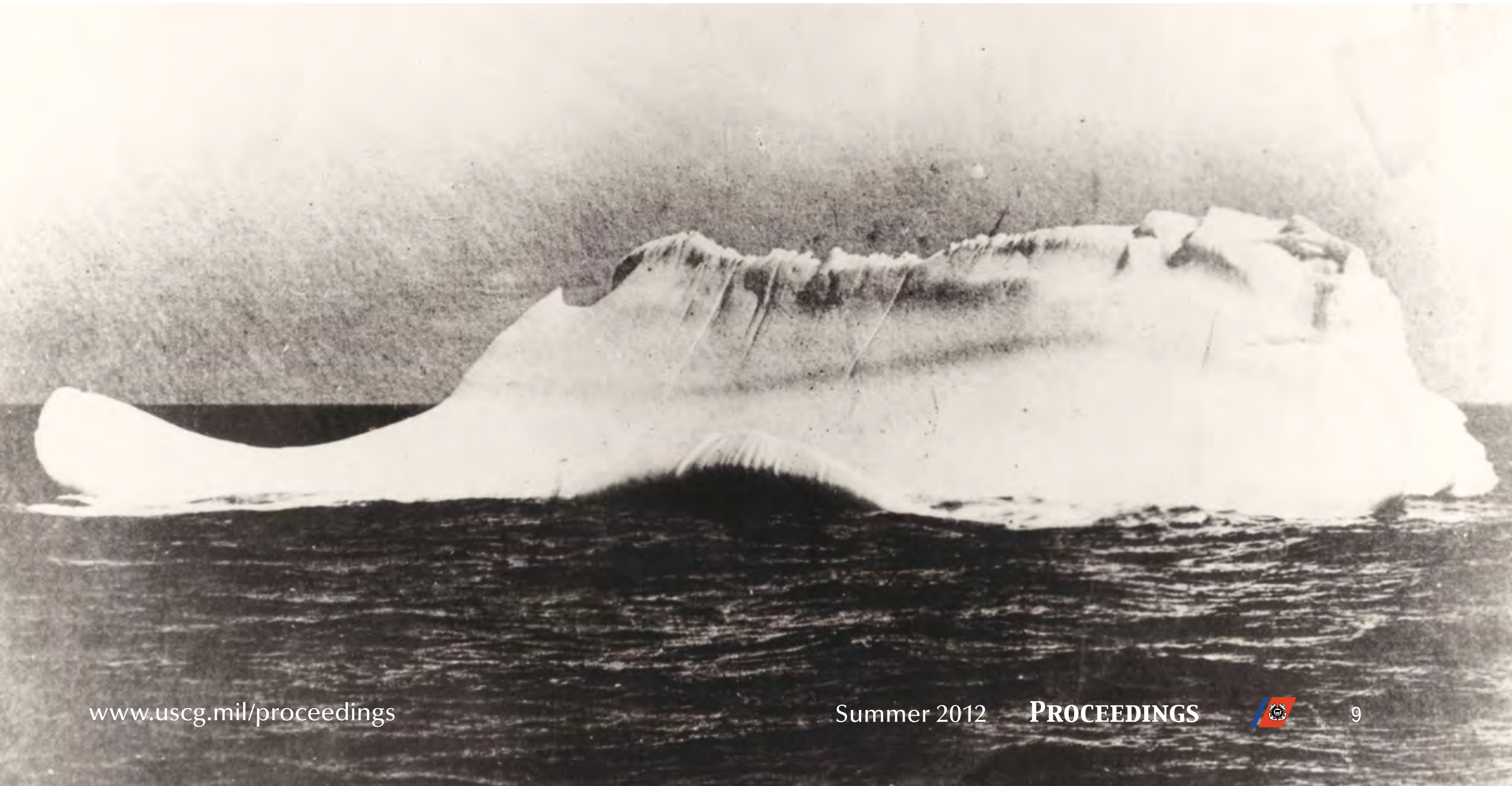
The Aftermath

Initial reports mistakenly related that *Titanic* was safe and under tow. Crowds gathered at White Star's offices in search of news. On April 17, however, the sinking was confirmed in a message from *Carpathia.* The next day, the ship pulled into New York as reporters in boats shouted questions to the survivors. The story was front-page news around the world.

With the initial reports of trouble, President William Howard Taft appointed Senator William Alden Smith, chair of the Senate's investigation. The committee hearings convened even before *Carpathia* made port. The Senate committee questioned 82 witnesses[7] and issued its report on May 28, 1912.

continued on page 12

Iceberg purported to be that which caused devastating damage to RMS *Titanic.* 86&* +LVWRULDQ¶V2I¿FH



Unsinkable?

The construction of *Titanic* and her sister ships stemmed from the rivalry between the White Star Line and Cunard Line.[1] White Star planned to build magnificent ships that were fast, luxurious, and with large steerage capacity. The intent was to attract wealthy trans-Atlantic travelers and poor immigrants traveling to America.

Designed by Thomas Andrews and Alexander Carlisle, the ship had a double-bottom.[2] She had 15 transverse bulkheads, creating 16 watertight compartments. These bulkheads, however, did not extend all the way to the top deck. There were 14 watertight doors that were designed to close automatically when the water level rose above six inches in a compartment. These doors could also be closed electrically from the bridge or manually by a member of the crew. All these features gave rise to the belief that the ship was "unsinkable."

The Construction

The keel plate for *Titanic* was laid at the Harland and Wolff Yard in Belfast, Ireland, on March 31, 1909. More than 15,000 Irish workers labored five and a half days a week to build her. Launched on March 31, 1911, the interior construction continued until March 31, 1912.

When completed, *Titanic* displaced 52,310 tons and had a draft of 34 feet, seven inches. She was 882 feet nine inches in length, with a beam of 92 feet, and a height of 175 feet from keel to the top of the funnels. Her cruising speed was 21 knots with a maximum speed of 23 knots. Fully loaded, *Titanic* had a capacity of 3,547 passengers and crew.

Amenities

The ship had 840 staterooms (416 first class, 162 second class, and 262 third class) plus 40 open berthing areas. Her amenities included a shipboard telephone system, a lending library, a barbershop, and a grand center stair case. First-class passengers had the use of a swimming pool, a gymnasium, a squash court, and a Turkish bath. It even included what was known as an "electric bath," the 1912 equivalent of a tanning bed.

Steam-driven generators powered the four electric elevators and the electric lights found throughout. *Titanic* was also equipped with Marconi wireless sets manned by Marconi Company operators.

Lifeboats

While the ship was clearly well appointed in luxury items, it proved deficient in at least one important item: lifeboats. Despite the fact that *Titanic's* Welin davits had the capability to carry 64 wooden lifeboats, the ship was only intended to carry 32. This number, however, was halved to 16.

Instead of carrying the additional lifeboats, White Star's head, J. Bruce Ismay, decided to add more first class cabins and suites. In addition to the 16 lifeboats, *Titanic* carried four "collapsible" lifeboats. All told, the lifeboat capacity of the 20 boats was 1,178.

In retrospect, Ismay's decision seems irresponsible at best and criminal at worst, but it was well within the British Board of Trade guidelines. Established in 1894, the regulations only required vessels more than 10,000 tons to carry 16 lifeboats plus enough capacity in rafts and floats for 75 percent of that in the lifeboats (50 percent for vessels with watertight bulkheads).

White Star would have only been required to provide capacity for 756 persons had they applied the bulkhead exception. White Star Line, therefore, provided much more lifeboat accommodation than was required. Additionally, in the event of the ship sinking, it was believed that the lifeboats could be used to ferry passengers to rescuing vessels. It was expected that *Titanic's* watertight compartments and pumps would keep her afloat long enough to make ferrying passengers possible.

Though they would prove of little use in the frigid North Atlantic, *Titanic* also carried 3,500 life belts and 48 life rings.

Endnotes:

1. The Blue Riband was the trophy for the fastest crossing of the Atlantic Ocean in regular service. The Cunarders RMS *Lusitania* and RMS *Mauretania* both claimed it in 1907.
2. A double bottom is a construction in which the lowest part of the hull was formed not by a single layer of steel plating, but by a heavily reinforced structure with the vertical keel as its backbone and the outer bottom plating forming the "skin" of the ship.

710 survived

Rescued passengers aboard RMS *Carpathia*. National Archives.

RMS *Titanic* Memorial in Washington, ' & 86&* +LVWRULDQ¶V2 I¿FH

Political cartoon after *Titanic's* sinking. Prints & Photographs Division, Library of Congress LC-USZ62-121019. Created in 1912 by artist William Allen Rogers.

Numbers of Passengers and Crew

Passenger Category	Number Aboard	Number Saved	Number Lost	Percent Saved	Percent Lost
Children, First Class	6	5	1	83%	17%
Children, Second Class	24	24	0	100%	0%
Children, Third Class	79	27	52	34%	66%
Men, Crew	885	192	693	22%	78%
Men, First Class	175	57	118	33%	67%
Men, Second Class	168	14	154	8%	92%
Men, Third Class	462	75	387	16%	84%
Women, Crew	23	20	3	87%	13%
Women, First Class	144	140	4	97%	3%
Women, Second Class	93	80	13	86%	14%
Women, Third Class	165	76	89	46%	54%
Total	**2,224**	**710**	**1,514**	**32%**	**68%**

1,514 perished

As the ship was British-flagged, the British Board of Trade also conducted its own hearings to determine what caused the disaster. The British report concluded that the ship was travelling too fast for the icy conditions and lacked a "proper" watch.

The Worldwide Response

The American inquiry resulted in new legislation requiring all U.S.-flagged ships and those bound for American ports to carry sufficient lifeboats for all, be adequately manned with trained crewmen, and mandated that lifeboat drills be conducted on every voyage. There would also be requirements for all passenger liners to be equipped with wireless sets that are manned 24 hours a day.

Senate committee hearings. National Archives.

After *Titanic's* loss, the U.S. Navy assigned the scout cruisers *Chester* and *Birmingham* to patrol the Grand Banks for the remainder of 1912. In 1913 the Navy could not spare the ships, so the Revenue Cutter Service assumed responsibility, assigning the cutters *Seneca* and *Miami* to conduct the patrol.

The Ice Patrol

At the first International Conference on the Safety of Life at Sea, convened in London on November 12, 1913, the subject of patrolling the ice regions was discussed. The convention signed on January 30, 1914, provided for an international derelict-destruction, ice observation, and ice patrol service, consisting of vessels that should patrol the ice regions during iceberg season and attempt to keep the trans-Atlantic lanes clear of derelicts during the remainder of the year.

The U.S. government was invited to undertake the management of the triple service due primarily to the experience gained in 1912 and 1913. Each year since then, with exception of the wartime years, the U.S. Coast Guard has maintained a patrol.

While there have been major memorials erected to mark the sinking of RMS *Titanic,* the greatest memorial to those lost were the subsequent actions and regulatory changes undertaken so that such a tragedy never happened again.

About the author:
Mr. Christopher B. Havern, Sr. has been on staff in the USCG Historian's Office since 1997. He is a former infantry officer in the U.S. Army. He earned his B.A. in history with honors from the Pennsylvania State University and his M.A. in history from the University of Maryland-College Park.

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United States Senate. *Report of the Committee on Commerce, United States Senate Pursuant to Senate Resolution 283 Directing the Committee on Commerce to Investigate the Causes Leading to the Wreck of the White Star Liner* "Titanic." 62d Congress, 2d Session, Report No. 806. Washington, DC: Government Printing Office, 1912.

Endnotes:

1. There are some discrepancies among sources regarding the actual numbers involved with the sinking of RMS *Titanic.* Unless otherwise noted, this article references the U.S. Senate's investigation of the sinking for all statistics, information, and the account of the voyage. See United States Senate, *Report of the Committee on Commerce, United States Senate Pursuant to Senate Resolution 283 Directing the Committee on Commerce to Investigate the Causes Leading to the Wreck of the White Star Liner* "Titanic," 62d Congress, 2d Session, Report No. 806. Washington, DC: Government Printing Office, 1912.
2. Two of the best examples are the torpedoing of MV *Wilhelm Gustloff* by a Soviet submarine in the Baltic Sea on January 30, 1945, which resulted in the loss of an estimated 9,400 lives. See A.V. Sellwood, *The Damned Don't Drown: The Sinking of the* Wilhelm Gustloff. (Annapolis, MD: Naval Institute Press, 1996). Another was SS *Mont Blanc,* a French cargo ship loaded with ammunition that collided with the Norwegian ship SS *Imo* in the narrows of Halifax Harbor, NS, Canada on December 6, 1917. The resulting fire ignited an explosion, which was the largest non-nuclear detonation of ammunition in history and resulted in approximately 2,000 deaths and more than 9,000 injuries. See Robert M. Browning Jr. *Captains of the Port.* Washington, DC: US Coast Guard Historian's Office, 1993.
3. According to nautical practice in 1912, the order "hard a starboard" (right) actually meant to turn the ship to port (left). "Hard over" means all the way to one side.
4. *British Wreck Commissioner's Inquiry.* London: Board of Trade's Administration, July 30, 1912.
5. While it was long assumed that the iceberg simply gashed the hull, sonar analysis conducted since the ship's discovery indicates otherwise. Scientists now believe that the hull plates buckled upon striking the iceberg. This created gaps in the steel plating and enabled water to rush into the ship's forward compartments.
6. The lights had continued to operate through the efforts of the engineering crew. All 35 engineers went down with the ship.
7. Among these were the two surviving wireless operators, Harold Thomas Cottam and Harold Sidney Bride. Their testimony provided much of the chronology regarding the final moments of the ship.

The International Ice Patrol

Safeguarding life and property at sea.

by Dr. Donald L. Murphy
Chief Scientist
U.S. Coast Guard International Ice Patrol

LCDR Jacob L. Cass
Information Officer
U.S. Coast Guard International Ice Patrol

The iceberg menace to safe navigation in the western North Atlantic was well known long before RMS *Titanic* struck an iceberg and sank in 1912. As early as 1909, the U.S. Hydrographic Office published a study showing the extent of the iceberg distribution for the previous 10 years, which demonstrated that icebergs were seen in established shipping lanes. The Hydrographic Office also published monthly pilot charts showing ice conditions and a weekly Hydrographic Bulletin, which reported ship iceberg observations from the previous week.

In those days, ice warnings were also passed from ship to ship using newly invented radio communications. Despite knowledge of the looming iceberg threat and the informal warning system, many ships struck icebergs during the two decades bracketing the beginning of the 20th century. Ships were becoming bigger and faster, resulting in a smaller margin for error, consequently setting the stage for disaster.

Catastrophe

All too frequently, it takes a disaster to galvanize the nations of the world. The magnitude of the loss of life due to the sinking of the *Titanic* resulted in an international uproar and a universal demand for action.

In the weeks following the disaster, the U.S. Hydrographic Office recommended an ice patrol be established in the steamer lanes. Shortly thereafter, the U.S. Navy assigned two scout cruisers, USS *Birmingham* and *Chester,* to conduct patrols of the danger area and warn passing ships of the location of menacing icebergs.

In 1913, the U.S. Navy was unable to provide ships, so the Revenue Cutter Service (RCS) assigned U.S. Revenue Cutters *Seneca* and *Miami* to the ice patrol task. In addition, the British Board of Trade and shipping interests chartered the S.S. *Scotia* to study ice and meteorological conditions.

SOLAS

Meanwhile, plans were being made to hold an international convention on Safety of Life at Sea (SOLAS) in London. Captain Commandant Ellsworth P. Bertholf, RCS, was chosen as one of the U.S. convention delegates, due in part to the success the RCS vessels had in conducting the ice patrol in 1913.

The SOLAS Convention, signed January 20, 1914, provided for an international derelict destruction, ice observation, and ice patrol service, with each of the 13 nations party to the treaty agreeing to pay its proportionate part of the expense. The U.S. government was invited to undertake the management of the three services.

The primary of the three services was an ice patrol, which was tasked with monitoring the ice conditions nearest the transatlantic shipping lanes and providing warnings of the ice danger to mariners. The service for the study and observation of ice was conducted in conjunction with the patrols during the ice season and during the rest of the year. The last of the three services was charged with destroying abandoned vessels drifting in the North Atlantic Ocean.

The International Ice Patrol

The SOLAS agreement didn't go into effect until July 1, 1915. As a result, Great Britain, on behalf of several nations, asked the United States to conduct patrols in 1914 and 1915. President Woodrow Wilson agreed, and on February 7, 1914, he directed the Revenue Cutter Service (forerunner of the U.S. Coast Guard) to conduct the patrols. On February 11, 1914, *Seneca* was ordered to fit out for the duty, and, eight days later, sailed for the Grand Banks.

Early Operations

Cutters *Seneca* and *Miami* took turns conducting the ice patrol, with each ship spending 15 days on station, patrolling in the North Atlantic, six days transit to and from the patrol area, and nine days in Halifax for repairs and resupply.

In addition to the primary duty of scouting for icebergs and warning the steamers of the ice limits, the crews were directed to study the ice, currents, and to gather other information that would be helpful to mariners.

Suspension for WWI, WWII

The Ice Observation and Ice Patrol Service in the North Atlantic was suspended in 1917, due to the raging war in Europe. By 1918, the U.S. was fully engaged in the war, and the patrol ships were sent to European waters. The *Miami*, renamed *Tampa*, and *Seneca* served on convoy duty between Gibraltar and Britain. In September 1918, a U-boat torpedo sank *Tampa*, with all hands.

After the war, plans were made to re-establish the ice patrol for the 1919 iceberg season, and cutters *Androscoggin* and *Tallapoosa* conducted the 1919 patrols. Similarly, WWII forced the suspension of the International Ice Patrol (IIP) for the 1942 to 1945 seasons.

Post-WWII Era

The improvements of long-range aircraft during WWII had a profound effect on IIP operations and ushered in the era of aerial ice reconnaissance, which continues to this day. It also initiated the long and enormously successful partnership between IIP and USCG Air Station Elizabeth City, the primary base of the aircraft used for iceberg reconnaissance.

At first, aircraft were considered supplemental to the iceberg scouting ships. In the early post-war years, the aircraft conducted early season searches when visibility was more likely to be good. Surface patrols were

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"Iceberg" Smith

In 1922, the International Ice Patrol began the practice of leaving an ice observation officer at sea for the entire iceberg season to facilitate the effort among the participating ships. The first ice observation officer was LTJG Edward H. Smith, who later became better known by his nickname "Iceberg" Smith.

The length of time the ice observation officers and their assistants spent continuously at sea depended on the severity of the iceberg season. In some years, it extended from early March to late July. This practice continued until World War II.

During WWII

The war effort took great advantage of IIP's unique expertise with Arctic ice and its knowledge of Greenland and surrounding waters. The Greenland Patrol, formed in 1941, was placed under the command of then CDR Edward H. Smith. Among the many missions of the Greenland Patrol were rescuing survivors from torpedoed vessels, finding and destroying enemy weather stations, and escorting ships. In 1943, the Greenland Patrol included 37 vessels, which were mainly Coast Guard vessels transferred to the Navy with crews that had ice patrol experience.

In 1942, Floyd M. Soule, IIP's senior physical oceanographer, accepted a commission as a LCDR in the Coast Guard Reserve and served as "Iceberg" Smith's operations officer. In 1945, CDR Soule received a Bronze Star for his wartime service.

Edward H. "Iceberg" Smith. U.S. Coast Guard photo.

By the end of WWII, Edward Smith had been promoted to the rank of Rear Admiral. He was awarded the Distinguished Service Medal for exceptionally meritorious service as commander of the Greenland Patrol.

Oceanographic Observations

The Secretary of the Treasury and Captain Commandant Bertholf made it clear from the beginning that scientific investigations conducted as part of the ice observation service were secondary missions of the patrol vessels. However, it was also clear that the significance of such work was recognized early in IIP's history. In 1913, ships' officers and crews made the first observations of the ocean currents and the physical properties of ice.[1]

Captain Commandant Ellsworth P. Bertholf, Revenue Cutter Service, was one of the U.S. representatives at the first SOLAS Convention. U.S. Coast Guard photo.

By the following year, the Secretary of the Treasury arranged for scientists and equipment from the Bureau of Standards and Bureau of Fisheries to accompany *Seneca* on ice patrols.

Ice Observation Cruises

In July 1914, *Seneca* undertook a special ice observation cruise to Labrador, Canada, and Greenland, after the conclusion of the regular ice patrol season, specifically to study oceanography and meteorology. This was the first of many oceanographic cruises conducted in support of the International Ice Patrol.

By far, the most famous was the summer 1928 survey of the waters between North America and Greenland. The 73-day, 8,100-nautical-mile expedition, led by then LCDR Edward "Iceberg" Smith, studied the origins of the icebergs that menace the shipping lanes each year and the currents that brought them there. Reports from this cruise are still referenced in scientific literature.

Evergreen maneuvers in rough seas during the 1951 iceberg season. U.S. Coast Guard photo.

Seneca on patrol in the North Atlantic in 1914. U.S. Coast Guard photo.

Service in War and Peace

The cutter *General Greene* was the ice observation and oceanographic vessel from 1931 to WWII. Staffed with the senior Ice Patrol Oceanographer Olav Mosby in 1931 and 1932, and thereafter with Floyd Soule and several assistants, the vessel conducted monthly oceanographic surveys near the Grand Banks.

Soule used the survey results to create a current map that was delivered to the patrol vessel to plan iceberg searches. While on patrol, the oceanographic vessel saved the survivors of the steamer *Marconi,* which had been sunk by German forces.

In 1948, *Evergreen* began service as IIP's oceanographic vessel, continuing the work of mapping the ocean currents near the Grand Banks. *Evergreen* served in that capacity until 1978. In 1979, IIP began using satellite-tracked oceanographic drifters to determine the currents and no longer had need for an oceanographic vessel to conduct surveys in support of operations.

Endnote:

1. *International Ice Observation and Ice Patrol Service in the North Atlantic Ocean.* International Ice Patrol. Bulletin No. 3, p. 78. Washington, DC: United States Coast Guard, February to August 1914.

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reserved for the months when fog was most prevalent, typically from May to July.

The International Ice Patrol gained more confidence throughout the 1950s due to the aerial reconnaissance; and, as a result, surface patrols were limited to the severe iceberg years. While the aircraft bore the load of the reconnaissance operations, the ships focused on obtaining ocean current data.

Bases of Operations

IIP's operations and its forward operating bases have moved several times. Prior to WWII, the patrol vessels served both as the center of ice reconnaissance and product distribution. In most cases, Halifax, Nova Scotia, was the forward operating base, since this was where the patrol vessels were provisioned. The actual operations center was on the vessel on patrol.

After WWII, the IIP aircraft were assigned to Coast Guard Air Detachment Argentia, which was located at U.S. Navy Air Station Argentia, in Newfoundland, Canada. The U.S. Naval station served as a base for the IIP ship operations, IIP offices, and as a radio station that broadcasted ice bulletins twice a day.

After the 1966 iceberg season, the IIP offices were moved from Argentia to Governor's Island, N.Y. Commander, Coast Guard Eastern Area (later Commander, Atlantic Area) assumed responsibility as Commander, International Ice Patrol. He assigned an officer on his staff to oversee the Ice Patrol mission.

IIP's aircraft continued to operate as an ice reconnaissance detachment (IRD) based at the U.S. Navy Air Station Argentia, until 1970. Since then, the base of International Ice Patrol's IRD has moved several times, first to Summerside, Prince Edward Island, and later to Gander and St. John's, Newfoundland.

In 1983, IIP became an independent unit of Atlantic Area and moved its operations center to the offices of the U.S. Coast Guard Research and Development Center (RDC) in Groton, Conn. In 2009, IIP became a unit of the First Coast Guard District, and then moved with the RDC to another facility at Fort Trumbull, in New London, Conn. Currently, IIP's Ice Reconnaissance Detachment is based once again out of St. John's.

The Ongoing Mission

Today, the essential elements of IIP's mission have changed little since the first patrol vessel steamed into the Grand Banks fog in 1913. While technology has continually evolved over the decades, IIP has carried out its mission. To date, no ship that has heeded International Ice Patrol warnings has struck an iceberg.

About the authors:

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LCDR Jacob L. Cass is the information officer of the U.S. Coast Guard International Ice Patrol. Prior to this assignment, he served aboard the Coast Guard Cutters Rush, Chase, *and* Midgett *and within the enforcement branch of the Fourteenth Coast Guard District. He earned an M.S. in physical oceanography from the University of Hawaii at Manoa.*

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From Sea to Air to Space

A century of iceberg tracking technology.

by LT Erin Christensen
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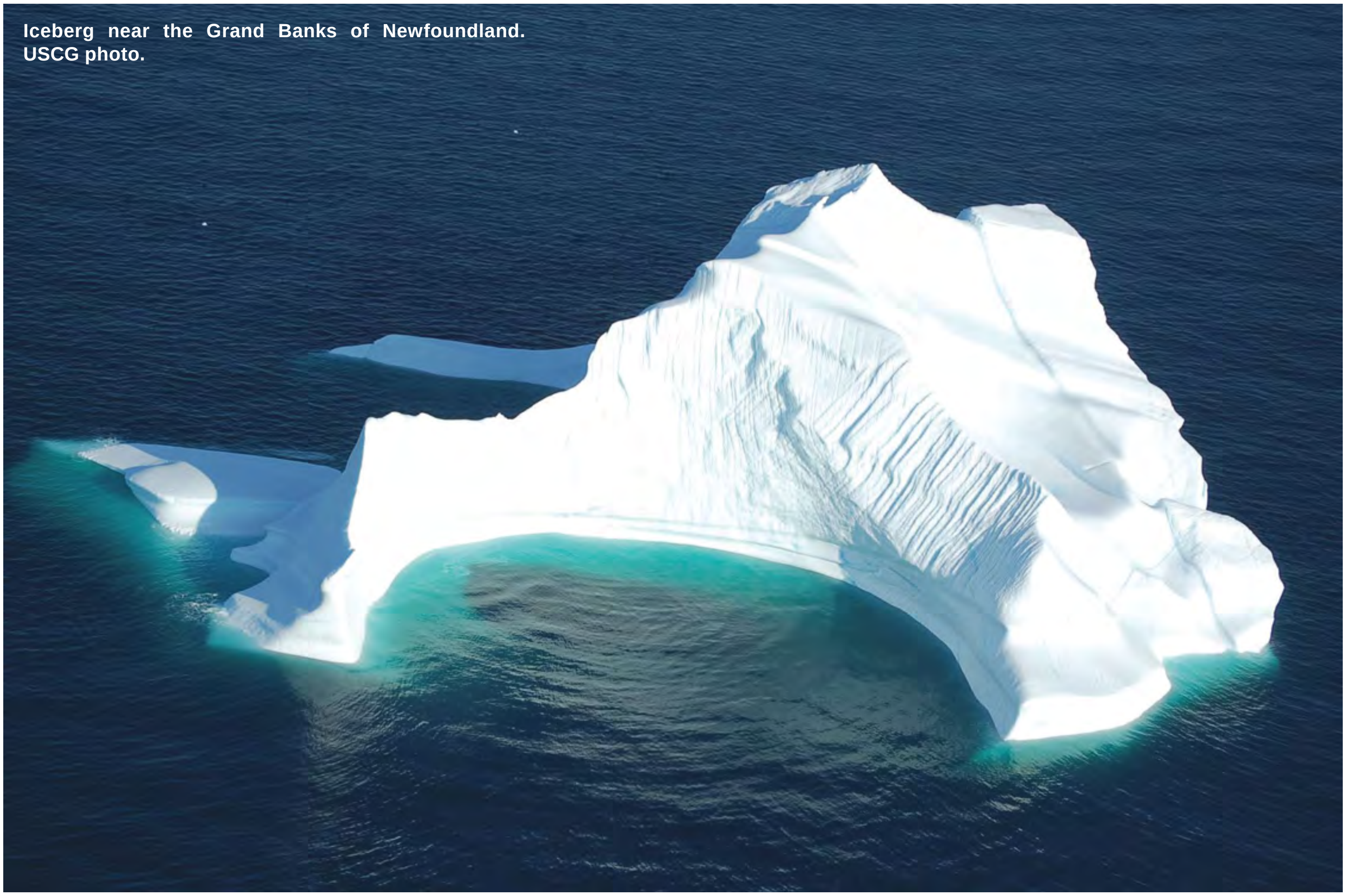
The formation of the International Ice Patrol (IIP), shortly after the 1912 sinking of RMS *Titanic*, provided mariners a source of information they needed to navigate safely. Over its nearly 100-year history, IIP has aggressively pursued the latest technology to assist in gathering, analyzing, and distributing maritime safety information.


Iceberg near the Grand Banks of Newfoundland. USCG photo.

USCGC *Androscoggin* crewman gathers information on an iceberg near the Grand Banks of Newfoundland. USCG photo.

What started as an undertaking of ships without radars or precise navigation is becoming an advanced operation that fuses information from satellite-based radars with data from automated ship tracking systems, using vastly improved numerical models of iceberg drift and deterioration, to provide a comprehensive picture of the iceberg distribution.

By Sea: *Titanic* to World War II

The first International Ice Patrol ships U.S. Revenue Cutters *Seneca* and *Miami*, conducted reconnaissance using lookouts. To enhance the lookouts' abilities, they experimented with several ways to find icebergs. At night, they experimented with the searchlight, but found they could see farther at night with the naked eye and binoculars.

Ice Blink and Indirect Detection

They also observed the characteristics of ice and investigated events such as "ice blink" to determine if there were better ways to spot icebergs. On clear nights, especially when the moon was visible, the sky along the horizon in the direction of an ice field was markedly lighter than the rest of the horizon. This ice blink effect could be noted before the ice was sighted. Unfortunately, while ice blink was useful for detecting the presence of sea ice, it was not helpful for detecting icebergs.

In 1913, the crews of the ice patrol vessels tried using the ship's steam whistle to detect icebergs with little success. The conclusion: While an echo means an obstruction, its absence proves nothing. They also tried to determine if an iceberg was near, by measuring the sea and air temperature. They found that a sudden decrease in the temperature of the water means nothing as far as icebergs are concerned, as seawater temps are variable. Also, they found that if a ship was close enough to feel the cooler air in the vicinity of an iceberg, it was too close to the iceberg and was in danger of collision.

Ultimately, standing at the highest point of the vessel above water and using the naked eye and binoculars was the primary method of iceberg detection. In addition, it should be noted that from the earliest days of the ice patrol, ships transiting the area have reported ice and weather information and continue to do so today.

Radars

In a more promising 1914 effort, Professor Reginald Fessenden of the Submarine Signal Company used a "submarine electric oscillator" to detect icebergs—using the propagation of sound through the water. He was able to detect an iceberg 0.5 to 2.5 miles away. He also successfully used this technology to determine the depth of the water, which later led to the invention of the fathometer.

With the advent of shipboard radars during World War II, in 1946, U.S. Coast Guard Cutter *Mojave* was equipped with a 10-cm radar and 3-cm radar. (The numbers refer to the wavelength of the microwaves the radar transmits.) In general, longer wavelength radars have poorer resolution than short wavelength radars, but are less affected by sea clutter.

Radar operator aboard the USCG R5D-3 aircraft. USCG photo.


IIP's primary aerial reconnaissance platform is the C-130J, shown here in St John's, Newfoundland. USCG photo by PAC Robert Laura.

The *Mojave* crew faced several challenges when evaluating radar detection of icebergs. For example, the weather on the Grand Banks frequently made *Mojave* pitch and roll, putting the radar equipment through heavy vibrations, which influenced radar calibration and ability. It was also a challenge to conduct necessary maintenance on the radar equipment, since the equipment had to be turned off for repair. The radars were regularly operated for 24 hours a day to augment navigation during periods of reduced visibility.

At the end of the 1946 season, IIP determined that smaller sea chop seemed to have a greater radar return than larger sea swells. A study found that radar "sea clutter" could mask medium-sized icebergs. In addition, when using radar alone, there was no way to differentiate between an iceberg and a vessel. Ultimately, it was concluded that the heavier the sea state (sea clutter) and winds, the greater the chance that a radar would miss an iceberg.

In 1959, IIP conducted a more extensive study of shipboard radar iceberg detection, but by then it was becoming clear that aircraft had replaced ships as the preferred platform for iceberg reconnaissance.

By Air: World War II to Present

Patrol Aircraft

Immediately following WWII, the International Ice Patrol began to use aircraft for iceberg reconnaissance, since aircraft could cover a much larger area in a fraction of the time of seagoing counterparts. In 1946, the first aircraft used were the "Catalina" flying boat and the "Liberator," better known as the B-24. By the end of the 1946 season, the first "Flying Fortress" was introduced into the ice patrol aircraft inventory. This airplane, famous for its WWII bombing missions, was to become the workhorse of IIP aerial reconnaissance for the next 12 years.

The patrol aircraft were equipped with Loran for navigation and radar that augmented ice observers' visual sightings. In 1946, the aircraft flew an average of 7.7 hours per flight at 25-nautical mile track spacing.

Iceberg-Spotting Challenges Continue

Similar to shipboard radars, sea state and clutter like sea ice presented target-identification challenges. Because the aircraft moved so quickly over the surveillance area, there was no accurate way to estimate the speed of a radar target to determine if it might be a vessel or an iceberg. Icebergs and the wooden baroques commonly used for fishing near the Grand Banks presented similar radar returns. Additionally, small dories around a larger fishing schooner presented similar radar returns as an iceberg surrounded by growlers (smaller pieces of ice).

However, the 1946 IIP annual report notes that steel vessels "give a somewhat sharper and brighter echo

Ice Observations

The early ice patrol cutters carried oceanographers who conducted hydrographic surveys near the Grand Banks, collecting a wide range of data, including:

- **water depth,**
- **salinity,**
- **water temperature,**
- **water samples,**
- **water movement.**

In 1920, scientific observer Albert L. Thuras noted that icebergs were carried south along the coast of Labrador, Canada, by the Labrador Current until it mingled with the north-flowing Gulf Stream. The icebergs generally remained in the mixed waters of the two currents until they melted.

He also noted that the area of "mixed waters" was usually very foggy, held icebergs, and was extremely dangerous for vessels. These early observations laid the framework for newer data collection and forecasting technologies in iceberg tracking.

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than do icebergs." The IIP concluded that aircraft-based radars were useful tools to determine a target's existence, but the targets had to be visually confirmed as ice.

Initially, the ice patrol considered aircraft to be a supplement rather than a replacement for surface patrol vessels, since aircraft personnel had difficulty distinguishing between icebergs and vessels when visibility was poor. As a result, aerial reconnaissance missions were scheduled during late winter and early spring when visibility was more likely to be good.

Surface patrol vessels were deployed later in the spring when fog is typically more prevalent near the Grand Banks. As the IIP gained more confidence in aerial reconnaissance throughout the 1950s, this attitude reversed. Aircraft became the primary reconnaissance platform and surface patrols were used only in severe iceberg seasons.

Side-Looking, Forward-Looking, and Multi-Mode Radar

In 1963, International Ice Patrol began using the HC-130B Hercules based out of the Coast Guard Air Station in Elizabeth City, N.C., for iceberg reconnaissance. As the airframes improved, so did the radar systems; however, until 1983, the primary method of locating icebergs remained visual detection. This severely limited the number of days a patrol could be conducted because of the requirement for reasonably good visibility conditions in the planned search area.

All that changed in 1983, when IIP began using side-looking airborne radar (SLAR) that had the ability to cover a wide area on each side of the aircraft. It recorded a radar image on film, in its early days. In later years, images were recorded digitally.

Careful analysis of the radar image allowed an experienced operator to distinguish between an iceberg and a vessel. This system provided IIP with near all-weather reconnaissance capability; and, in many cases, IIP could distinguish between ships and icebergs without visual confirmation. In some cases, however, making the distinction was difficult and the aircraft had to descend beneath the clouds to visually confirm a radar target.

The ability to distinguish between an iceberg and a ship using radar alone took another major step forward with the introduction of forward-looking airborne radar (FLAR) in 1993. This system, used in conjunction with the SLAR, had an inverse synthetic

An ice observer records iceberg sighting information. USCG photo by PAC Robert Laura.

aperture radar (ISAR) mode, which created a Doppler image of a target that an experienced operator could use to identify the object without visual confirmation. IIP has used this combination of equipment effectively for more than two decades.

In 2009, IIP began using the HC-130J with the multi-mode radar for iceberg reconnaissance. The ice patrol uses the radar's search mode, which scans 360 degrees, for detection and its ISAR mode for identification.

Finally, IIP is in the early stages of testing the Coast Guard's newest airframe, the Ocean Sentry, equipped with a multi-mode radar for iceberg reconnaissance.

By Space: Into the Future

The first efforts at detecting icebergs using satellites were met with little success. The sensors on the early satellites were visual and infrared, neither of which can reliably detect objects through clouds. In addition, the sensors were designed to monitor large-scale weather systems, so they were incapable of detecting anything but the largest icebergs.

By the mid-1990s, satellites with synthetic aperture radars (SAR) were able to detect targets regardless of cloud cover. Newer SARs have improved resolution and varying beam modes that provide additional characteristics for each target.

The International Ice Patrol is evaluating the effectiveness of using other maritime domain awareness data to resolve target ambiguity.

Several challenges must be surmounted before satellites can contribute significantly to IIP's reconnaissance. For example, users must receive satellite information that:

- reliably distinguishes ships and icebergs,
- helps locate smaller icebergs.

Aerial deployment of a World Ocean Circulation Experiment buoy, used to monitor ocean currents responsible for iceberg transport. USCG photo.

Currently, there is no single SAR-equipped satellite or constellation of satellites that can provide complete and frequent high-resolution coverage over the IIP's 450,000 square nautical mile area of operations.

Forecasting

Iceberg tracking combines detection and forecasting. Forecasting, the process of estimating changes in the iceberg's location and size, helps determine if a reported iceberg is new or already in the database. Second, it allows IIP to estimate where an iceberg will be in the future and how much it will have melted.

When the first International Ice Patrol vessels patrolled the vicinity of the Grand Banks, personnel knew little about the currents, so most iceberg reports were viewed as new observations. There was little effort to estimate where an iceberg would drift. By the early

1930s, International Ice Patrol oceanographers were routinely conducting oceanographic surveys and using those results to calculate the ocean currents to search for icebergs near the transatlantic shipping lanes. By the late 1940s, the IIP oceanographic vessel was providing monthly maps of the ocean currents and sea surface temperature. These oceanographic surveys continued until 1979 when IIP began using satellite-tracked oceanographic buoys to provide ocean current information.

In 1979, IIP began using a computer model to predict iceberg movement. The model was enhanced in 1983 to include predictions of iceberg melt, and thus predict the sizes of sighted icebergs over time. It also allows personnel to estimate the movement and deterioration of icebergs using environmental data such as winds, waves, currents, and sea surface temperature.

The Vision for the Future

Twenty years from now, how IIP tracks icebergs will be drastically different. We envision a modeling system that can:

- differentiate between icebergs, vessels, and industry platforms to precisely determine the iceberg limit,
- automatically apply environmental data to predict how the icebergs will move.

What will not change is the International Ice Patrol's mission to monitor the iceberg danger near the Grand Banks of Newfoundland, Canada, and provide the iceberg limit to the maritime community. The IIP is proud to say no vessel that has heeded the ice patrol's published iceberg limit has collided with an iceberg.

About the authors:

LT Erin Christensen is the International Ice Patrol operations officer. She previously served at the Valdez Marine Safety Unit.

MSTCS John Luzader has served in the Coast Guard for more than 21 years. He has 12 years of experience responding to oil spills, hazardous materials releases, and natural disasters and seven years of experience tracking icebergs.

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International Maritime Organization

100 years after the Titanic.

by Mr. Koji Sekimizu
Secretary-General
International Maritime Organization

Many ships have sunk; in fact, too many, but few have had the impact of the seemingly invulnerable White Star Line's RMS *Titanic* that collided with an iceberg on the night of April 14, 1912. In a few short hours, the passenger vessel was transformed from the world's most celebrated ship to a name forever synonymous with disaster.

IMO Secretary-General Koji Sekimizu

But the legacy of that tragedy, in which more than 1,500 people perished in the freezing waters of the North Atlantic, is actually a very positive one. It prompted the major shipping nations of the day to take decisive action to address maritime safety, and led to the adoption of the first International Safety of Life at Sea (SOLAS) Convention in 1914.

Today, updated and revised, SOLAS is still the most important international treaty addressing maritime safety. And, as 2012 marks the 100th year since that ill-fated ship foundered, the International Maritime Organization council decided that the World Maritime Day theme for 2012 should be, "IMO: 100 Years after the *Titanic*." The theme was chosen to give the organization the opportunity to take stock of the developments in maritime safety since that disaster, and to examine which areas of ship safety should be given priority in the years to come.

IMO Origins

Since the adoption of the first SOLAS Convention in 1914, it has been recognized that the best way to improve safety at sea is through international regulations that apply to all shipping nations. During the first half of the last century, several countries proposed that a permanent international body should be established to promote maritime safety more effectively, but it was not until the establishment of the United Nations itself that these hopes were realized.

In 1948, an international conference adopted a convention formally establishing IMO (the original name was the Inter-Governmental Maritime Consultative Organization, or IMCO, but the name was changed to International Maritime Organization in 1982). The IMO convention entered into force on March 17, 1958, and the new organization met for the first time the following year.

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The 1948 IMO council. All photos courtesy of the International Maritime Organization.

Important Marine Conventions

Notable IMO conventions

- ★ International Convention for the Safety of Life at Sea, 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.
- ★ International Convention on Standards of Training, Certification and Watchkeeping for Seafarers as amended, including the 1995 and 2010 Manila Amendments.

Maritime safety and security and ship/port interface conventions

- ★ Convention on the International Regulations for Preventing Collisions at Sea, 1972.
- ★ Convention on Facilitation of International Maritime Traffic, 1965.
- ★ International Convention on Load Lines, 1966.
- ★ International Convention on Maritime Search and Rescue, 1979.
- ★ Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation, 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, 1972.
- ★ Convention on the International Maritime Satellite Organization, 1976.
- ★ The Torremolinos International Convention for the Safety of Fishing Vessels, 1977.
- ★ International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel, 1995.
- ★ Special Trade Passenger Ships Agreement, 1971, and Protocol on Space Requirements for Special Trade Passenger Ships, 1973.

Conventions relating to prevention of marine pollution

- ★ International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969.
- ★ Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (and the 1996 London Protocol).
- ★ International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990.
- ★ Protocol on Preparedness, Response and Cooperation to pollution Incidents by Hazardous and Noxious Substances, 2000.
- ★ International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001.
- ★ International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004.
- ★ The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009.

Conventions covering liability and compensation

- ★ International Convention on Civil Liability for Oil Pollution Damage, 1969.
- ★ Protocol to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992.
- ★ Convention relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material, 1971.
- ★ Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974.
- ★ Convention on Limitation of Liability for Maritime Claims, 1976.
- ★ International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, 1996 (and its 2010 Protocol).
- ★ International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001.
- ★ Nairobi International Convention on the Removal of Wrecks, 2007.

Other subjects

- ★ International Convention on Tonnage Measurement of Ships, 1969.
- ★ International Convention on Salvage, 1989.

The 1959 IMO assembly.

Today's IMO is very different from the organization envisaged in 1948, but so is the world of merchant shipping. Without amendments to the IMO convention, the organization would not have been able to evolve and respond to changes that have taken place outside it during the past 60 years. IMO membership now stands at 170 nations, which collectively control more than 98 percent of world merchant marine tonnage. More importantly, the maritime industry has enjoyed a consistent overall reduction of lives lost at sea due to the rigorous enforcement of IMO measures.

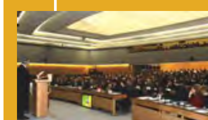
Presently, IMO develops and maintains a comprehensive regulatory framework for shipping, including safety, environmental protection, legal matters, technical cooperation, maritime security, and shipping efficiency (see sidebar).

Effectiveness

All too often, regulatory policy is dictated by events. If the *Titanic* spurred the SOLAS Convention, other disasters have also made their mark. Many can still recall the *Torrey Canyon* spilling oil in the English Channel in 1967 and subsequent environmental disasters caused by the grounding of the *Argo Merchant* off Nantucket and the *Amoco Cadiz* grounding off the coast of France in the 1970s. The losses of the *Derbyshire* in 1981, the *Herald of Free Enterprise* in 1987, the *Exxon Valdez* in 1989, the *Scandinavian Star* in 1990, the *Estonia* in 1994, the *Erika* in 1999, and the *Al-Salam Boccaccio* in 2006 all resulted in either a heavy loss of life or a significant impact to the marine environment.[1]

These, along with other major casualties, have not only made headlines but have also had a major impact on IMO's work. Governments turned to the organization to find solutions to the technical and political problems these incidents raised, and there is no doubt that the IMO's actions as a result of these and other incidents have helped to make shipping safer and to reduce pollution.

Adopting international treaties and standards is only part of the story. Effective implementation and enforcement is also required. For this, states need efficient maritime administrations staffed by trained and experienced personnel. That is why IMO's sphere of activities also includes technical cooperation. Many of today's shipping nations did not even exist when IMO started functioning in 1959, and the expectation is that still more countries will expand their shipping activities in the years to come. For many, a lack of experience and resources will be a handicap. IMO has recognized this and has done a great deal to overcome this problem by building capacity in these newly emerging shipping nations.



Engagement Efforts

The World Maritime University, the IMO International Maritime Law Institute, and the IMO International Maritime Academy were set up in the 1980s to help developing countries to acquire necessary knowledge and skills. Today, IMO has identified a funding requirement of more than $24 million to cover the planned technical cooperation activities for 2012 to 2013.

IMO conventions and protocols must be applied and enforced in a uniform and fair manner to be effective. Since its establishment, IMO has kept the regulations under its purview up to date and will continue to do so to keep pace with the rapid pace of technological change within the shipping industry.

The first few decades of IMO's existence focused on laying foundations. IMO has adopted more than 50 different conventions and protocols—the majority dealing with maritime safety and preventing marine pollution. This process was essential. In many areas, there was no international standard, and, in others, the regulations that did exist needed modification or replacement.

The world has changed so much in the past decade. I firmly believe we are now entering a new era in maritime safety. That is why it is now imperative for the organization to look at the future and decide whether the prescriptive regulatory framework that traces its

origins back to 1914 is still the best model for addressing tomorrow's maritime safety issues.

In recognition of this rapidly changing world, this year's World Maritime Day theme, in addition to paying tribute to the memory of those who lost their lives on April 15, 1912, will provide the organization with an opportunity to:

- review the history and past achievements made in maritime safety,
- consider the present challenges facing IMO and the maritime community,
- contemplate the future of ship safety.

IMO Ship Safety Symposium

That is why I have decided to hold a two-day symposium on ship safety at IMO headquarters, in conjunction with a future World Maritime Day celebration. The symposium will address IMO's history and achievements in developing maritime safety regulations and explore the future of maritime safety. Resultant recommendations will be presented to the Maritime Safety Committee.

These are exciting times for the maritime community. We have the privilege of being at the forefront of a new era in maritime safety. An event of this kind is important to support universally accepted improvements in maritime safety, security, and environmental protection.

It is also important since it brings together widespread technical expertise from every corner of the globe, provides a chance for common issues and problems to be discussed from a wider perspective, and for shared solutions to emerge. This is the real strength of IMO, in that it also provides a unique forum for the world's experts to come together to work out comprehensive solutions to problems and to agree on universal standards that are fair, practicable, and effective.

No one can predict exactly what the future holds, but I am certain that the symposium will play a pivotal role in the development of IMO's regulatory framework and reinforce the organization's unrelenting commitment to ensuring that the sacrifice of the many passengers and crew of the *Titanic* has not been in vain.

About the author:
Mr. Koji Sekimizu joined IMO in 1989 and became the Secretary-General in 2012. He initially worked as a ship inspector at the Ministry of Transport of Japan, and has been involved in the development of many important conventions and codes, with responsibility for maritime safety, security, anti-piracy measures, and marine environment issues. He studied naval architecture at Osaka University, where he obtained a master's degree in engineering.

Endnote:

1. In 1967, the *Torrey Canyon* ran aground off the shore of England, releasing more than 500,000 barrels of oil. The tanker *Argo Merchant*, carrying more than 100,000 barrels of fuel oil, went aground in 1976 near Nantucket Island, Mass. In 1978, *Amoco Cadiz* grounded off the coast of Brittany, spilling more than 1,000,000 barrels of oil. The M/V *Derbyshire* went down with all hands in 1980. In 1987, the *Herald of Free Enterprise* capsized; nearly 200 passengers died. The *Exxon Valdez* ran aground in Prince William Sound in 1989, spilling hundreds of thousands of barrels of crude oil. In 1990, the *Scandinavian Star* passenger ferry caught fire, killing more than 150. MS *Estonia* sank in the Baltic Sea in 1994, killing more than 800. The tanker *Erika* sank off the coast of France in 1999, causing major environmental damage. In 2006, the *Al-Salam Boccaccio* ferry sank in the Red Sea, killing an estimated 1,000.

The International Conference on Safety of Life at Sea, 1914

The history and the ongoing mission.

by LCDR Catherine Phillips
Staff Engineer
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Mr. Jaideep Sirkar
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The first International Conference for the Safety of Life at Sea (SOLAS) convened in London from November 23, 1913 to January 20, 1914, in response to the RMS *Titanic* disaster. The conference was comprised of more than 100 representatives from various maritime countries, including Germany, Austria-Hungary, Belgium, Denmark, Spain, the United States, France, Great Britain, Italy, Norway, Netherlands, Russia, Sweden, Australia, Canada, and New Zealand.

To address the complex safety concerns, the conference work was divided among six committees:

- safety of navigation,
- construction,
- certificates,
- radiotelegraphy,
- lifesaving appliances,
- revision.

Each committee consisted of one or more delegates from each of the participating countries. Captain E. P. Bertholf, of the Revenue Cutter Service (later to become the Commandant of the U.S. Coast Guard), participated as a U.S. representative.

After an unremitting seven weeks, 13 countries signed the 1914 SOLAS Convention on January 20, 1914. However, it was ratified by only five nations: Great Britain, Netherlands, Norway, Spain, and Sweden. For many countries, including the United States, ratification initiatives were suspended due to the outbreak of World War I. As a consequence, the 1914 SOLAS Convention never did enter into force as planned on July 1, 1915.

The Ice Patrol

The SOLAS 1914 convention introduced many new international standards for vessel construction and operation, such as uniform requirements for watertight bulkheads, lifesaving equipment, fire prevention, radiotelegraph equipment, and the safety of navigation. In addition, the conference also agreed to establish the North Atlantic ice patrol.

Even though the 1914 SOLAS Convention never entered into force, several articles contained within the safety of navigation chapter were immediately implemented. On January 31, 1914, the government of Great Britain, on behalf of several nations, requested that the United States immediately assume the responsibility for the North Atlantic ice patrol, with the costs being divided among 13 maritime nations. On February 17, 1914, U.S. President Woodrow Wilson assigned the task of the International Ice Observation and Ice Patrol Service to the Revenue Cutter Service. Since then, the U.S. Coast Guard has conducted the ice patrol mission.

THE 1914 SOLAS CONVENTION

Chapter I: Safety of Life at Sea (Article 1)—signatory parties agreed to support the convention.

Chapter II: Ships to which this Convention applies (Articles 2-4) specified that the convention applied to mechanically propelled merchant ships carrying more than 12 passengers on an international voyage.

Chapter III: Safety of Navigation (Articles 5-15) included provisions for derelict destruction, ice observation, and North Atlantic ice patrol service.

Chapter IV: Construction (Articles 16-30) included requirements for watertight bulkheads, subdivisions, and openings in the vessel's side.

Chapter V: Radiotelegraphy (Articles 31-38) included a requirement for a continuous communication watch on vessels equipped with radio equipment.

Chapter VI: Life-saving Appliances and Fire Protection (Articles 39-56) required every vessel to carry a sufficient number of lifeboats for all passengers, required lifejackets for every person on board (including children), required emergency lighting to be provided on ships, set regulations to conduct emergency drills, and for certificated lifeboatmen to man lifeboats.

Chapter VII: Safety Certification (Articles 57-63) required flag states to issue ships a safety certificate. Signatory nations agreed to accept international standards of safety for ocean travel and accepted the good faith of other nations to uphold those standards. By issuing this certificate, the nation certified that the vessel complied with the requirements of the convention. In every case, the government that issues the safety certificate is bound by the convention to guarantee the completeness of the inspection and survey.

Chapter VIII: General (Articles 64-74) included entry into force requirements and laid out technical regulations for lifeboats, davits, lifejackets, and life buoys.

The Continuing Mission

Many of the safety requirements contained in the 1914 SOLAS Convention were later incorporated into the 1929 SOLAS Convention, which entered into force in 1933. Since then, there have been three subsequent versions of SOLAS:

- The third, adopted in 1948, entered into force in 1952.
- The fourth, adopted in 1960, entered into force in 1965.
- The present version, adopted in 1974, entered into force in 1980, and has been amended and updated many times.

Even though the 1914 SOLAS Convention was never entered into force, it was a major milestone in maritime history that ultimately led to standardized international regulations for the Safety of Life at Sea.

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Secretary-General of IMO, Koji Sekimizu, addresses Marine Environment Protection Committee delegates in February 2012.

Ship Stability

The evolution of stability requirements.

by LCDR Ron Caputo
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For more than 100 years, vessel stability has been defined in a most basic way: the tendency of a vessel floating in water to return to the upright position after it is inclined away from that position by an external force. There are, in fact, as many types of ship stability as there are ranges of motion a vessel experiences.

Stability Measures

Ship designers typically focus on changes in draft, list, and trim. Not surprisingly, these considerations, which are combined in longitudinal and transverse stability, are also those for which international regulations have been developed—all to help ensure the vessel returns to that all-important upright position. The regulations are broken down into two basic forms relating to the material condition of the vessel:

- intact stability,
- damage stability.

Intact stability refers to the ability of an undamaged vessel to return to its initial upright position after an outside force, such as wind or a wave, is applied to it. Damage stability refers to the residual buoyancy of the vessel after external damage to the hull. Further, two geometric measures also relate to vessel stability:

- longitudinal stability,
- transverse stability.

A ship's longitudinal stability describes its resistance to forces that can cause changes in draft at the bow and stern, also called "trim." For example, the *Titanic* sank after a loss of longitudinal stability. Watertight compartments symmetrically flooded to the point where the vessel sank uniformly, with only a little list. (This is also known as a total loss of buoyancy.) Transverse stability describes a ship's resistance to forces that can cause changes in the ship's list or heel angle; the loss of transverse stability results in capsize.

From Deterministic to "Probabilistic"

Over the last century, stability regulations have evolved from a deterministic engineering approach applicable to all ships to that of a complete performance–based analysis on each individual ship. In

Floodable Length

The concept of "floodable length" is used to describe the segregation of compartments using watertight bulkheads that extend the entire breadth of the vessel. This watertight subdivision is incorporated into a ship design and provides for its survivability in the event of internal flooding caused by damage to the hull.

A ship is described as being a one-, two-, or even a three-compartment ship when it is designed to float with that number of adjacent compartments flooded.

Because the decision regarding a ship's arrangement of key structure, like watertight bulkheads, is necessary early in the ship design process, the regulations that govern ship subdivision apply at this stage.

The M/V *Cosco Busan*. U.S. Coast Guard photo.

other words, the original stability requirements were defined by regulators and required the designer to conduct a very prescriptive series of calculations based on a vessel's length, volumes, capacity, and service type to evaluate and demonstrate ship stability compliance. Current stability criteria are defined by the designer's evaluation of the probability of numerous failure modes. This is known as "probabilistic" stability criteria. The history behind this shift follows.

The SOLAS 1929 "Compromise"

In 1929, the United Kingdom hosted an international conference to update the 1914 SOLAS Convention. While the United States and other countries advocated incorporating a damage stability standard in SOLAS, there was little support for specific proposals, and this matter was dropped from SOLAS 1929. However, a concept governing the system of ship subdivision regulation obtained wide support in the SOLAS regulation, namely:

"Ships shall be as efficiently subdivided as possible having regard to the nature of the service for which they are intended. The degree of subdivision shall vary with the length of the ship and with the service, in such manner that the highest degree of subdivision corresponds with the ships of greatest length, primarily engaged in the carriage of passengers."

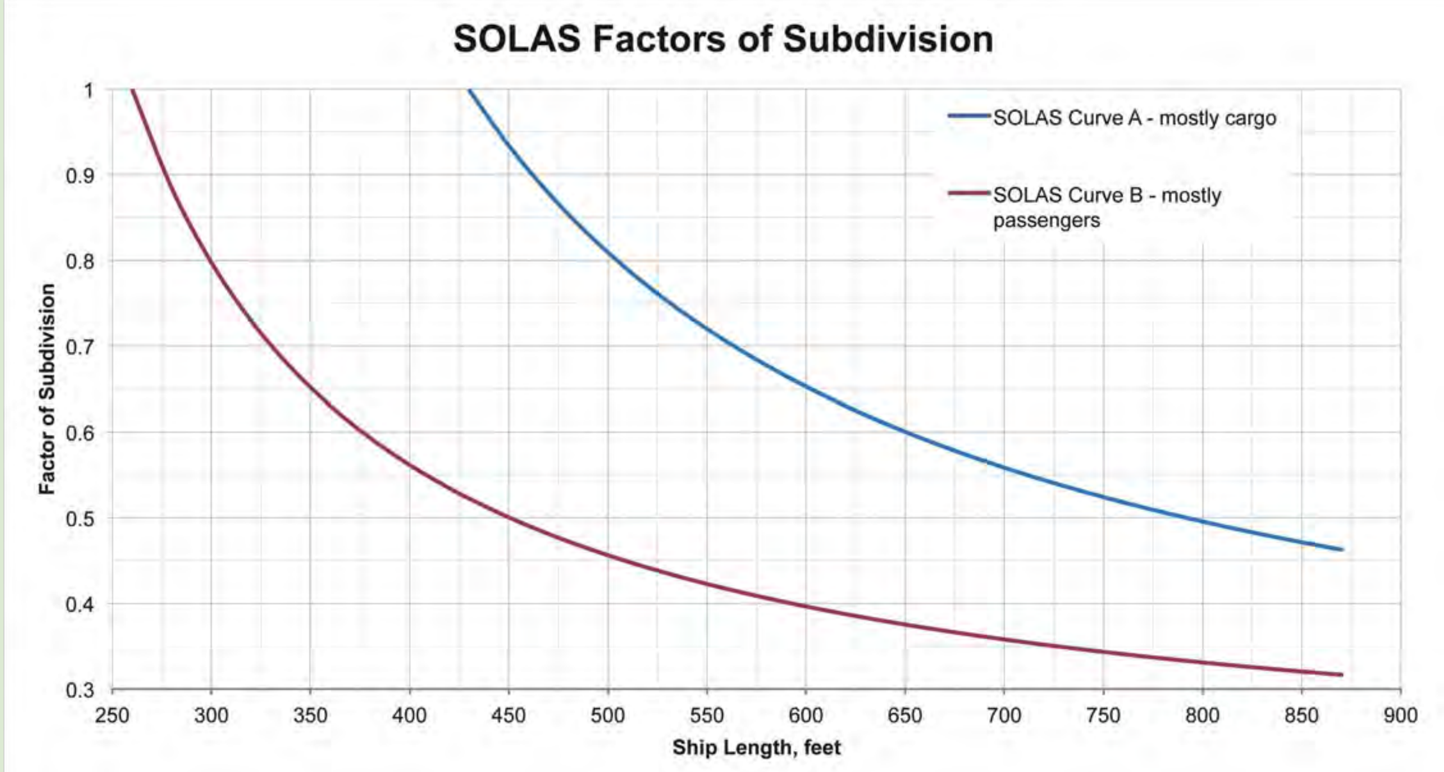
To accomplish this, the 1929 conference delegates decided to adopt the regulatory subdivision scheme included in SOLAS 1914, which was a compromise

SOLAS Factors of Subdivision

The formulas are often depicted as two curves, each of which, for a certain ship length, gives a factor of subdivision that is multiplied by the floodable length to determine the maximum permissible compartment length.

Curve A was for ships carrying mostly cargo and Curve B for ships carrying mostly passengers.

To determine whether one used Curve A, Curve B, or something in between, a criterion of service numeral, Cs, devised by the British, was adopted to categorize a ship as "mostly passenger" if the volume of space in the hull below the margin line was mostly devoted to passenger spaces (passenger spaces above this line were not accounted for). If Cs was less than 23, the ship was deemed to be carrying mostly cargo, and Curve A was used; if greater than 123, the ship was carrying mostly passengers, and, if in between, an interpolated factor of subdivision between the two curves was calculated.



based on the fixed permeabilities proposed by the British, the fixed margin line proposed by the Germans, and a factorial system proposed by the French.

Early 20th century ships were designed to carry a mix of passengers and cargo and all generally had the same hull form. Even the *Titanic* was designed to carry cargo, and a factorial system using two simple formulas was set up to reflect this (see graph).

Another Tragedy Highlights Stability Regulations

The 1929 conference officially ratified the original international maritime regulations, and became SOLAS 1929. Even though SOLAS 1929 entered into force in 1931, only after the *Mohawk* collision[1] and subsequent sinking, in which nearly 50 people lost their lives, did the U.S. ratify SOLAS 1929, in 1936, and establish required subdivision regulations.

SOLAS 1929 also introduced requirements for watertight construction as well as assigning and marking a subdivision load line on the hull at the maximum draft, used to determine the permissible compartment length. This last requirement ensured the subdivision requirement was met and maintained for simple visual inspection.

SOLAS 1948 Adds Requirements for Stability After Damage

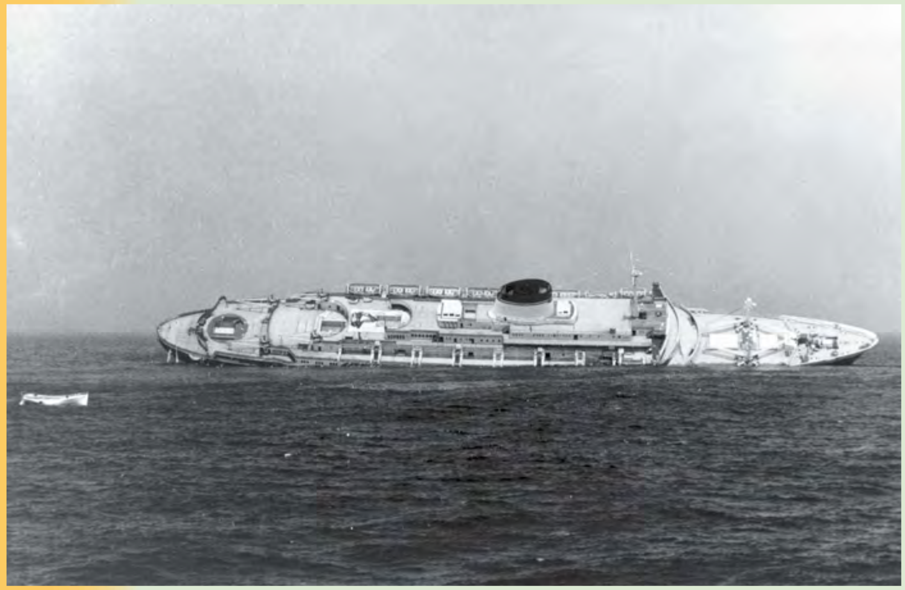
The same deterministic methodology was applied in developing SOLAS 1948. Additional "factors of subdivision" were introduced to compute A and B curves, depending on vessel length and the same criterion of service numeral calculated under SOLAS 1929. These additional factors mark where vessel design began to make a distinction between a dedicated passenger vessel and a dedicated cargo vessel.

The most significant change in 1948 was the introduction of the first requirements for stability after damage (this term normally implies internal flooding caused by damage). These standards ensured that vessels can survive a minimum extent of damage in the longitudinal, transverse, and vertical directions, and mandated minimum residual conditions after damage, including:

- positive metacentric height (denoted "GM," the initial measurement of stability, where a negative value represents an unstable condition);
- minimum angle of heel;
- non-submergence of the margin line.

SOLAS 1960: Tragedy Strikes Again and the Industry Responds

The collision and sinking of the *Andrea Doria* in 1956,[2] in which more than 40 people perished and half the lifeboats were rendered useless due to severe vessel list, prompted the convening the first SOLAS conference under the auspices of the Inter-Governmental Maritime Consultative Organization (IMCO) in 1960.



The *Andrea Doria.* 3KRWR FRXUWHV\ RI WKH 86&* +LVWRULDQ¶V 2I¿FH

There are few changes to stability requirements in SOLAS 1960. They include the vertical extent of damage to include double bottoms, minimum required equilibrium GM > 0.05m after damage, amplifying cross-flooding arrangements, and the need for developing residual stability criteria.

Additionally, the convention recognized that the deterministic methods in the 1929 and 1948 conventions were based on older vessel designs common to that era. Therefore, conference leaders recommended studies of subdivision, considering the relative merits of the existing criteria in comparison to other proposals. Other recommended studies included: proposals for intact stability standards for passenger ships, cargo ships, and fishing vessels to damage stability and standards for cargo ships. This laid the groundwork for developing a probabilistic approach to the evaluation of subdivision and damage stability for passenger and cargo ships.

SOLAS 1974: The "Last" SOLAS Convention

The 1974 SOLAS Convention also contained very few changes to the international stability regulations. The most significant development in international stability criteria originated a year earlier, in the form of passenger ship damage stability regulations based on the probabilistic concept of survivability that was the product of the 1960 SOLAS conference recommended studies.

The regulations, contained in IMCO Resolution A.265 (VIII), were only included in SOLAS 1974 as an equivalent to the old 1929 SOLAS factorial subdivision system. This resolution would remain only an equivalent alternative until 2009, when both it and the old factorial subdivision system were replaced by new harmonized probabilistic damage stability regulations for passenger and cargo ships.

The tacit acceptance process adopted in 1974 ensured constant updates could be made to the convention without the need for majority vote by the contracting governments. This process change ensured the SOLAS Convention remained accurate to developing marine technologies and methodologies. Accordingly, all following consolidated editions to SOLAS are referred to as "amendments" to SOLAS 1974. The 1973 and 1978 Protocol to the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) included within it a similar tacit acceptance procedure for amending that convention and also incorporated deterministic intact and damage stability requirements for oil tankers.

The 1980s: IMO Develops Stability Criteria

The IMO work of the 1980s included recommending a severe wind and rolling criterion for passenger and cargo ships and fishing vessels. In 1983, amendments created the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk, and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, for tank vessels carrying chemicals and liquid gas, respectively.

The stability regulations contained within these codes utilize a strictly deterministic approach to damage criteria. Following a series of roll-on, roll-off (ro-ro) passenger ship casualties, including the 1987 incident in which the *Herald of Free Enterprise*[3] flooded through its cargo doors and capsized, revised residual damage stability requirements were incorporated into the 1988 amendments to the SOLAS damage stability regulations.

The result: The minimum range of stability with positive righting arm was increased to 15 degrees, and an associated minimum amount of energy to right the vessel was quantified. Further, the new requirements accounted for passenger crowding, launching life rafts and lifeboats, and the effects of wind for the required calculated heel angles. In addition, cargo-loading doors on all vessels were required to be locked prior to getting underway.

The 1990s: Focus on Ro-Ro Passenger Vessels and Stability Standards

On September 28, 1994, the M/V *Estonia* sank, carrying more than 900 passengers when significant flooding occurred through the bow doors.[4] Additionally, the effect caused by the water on the vehicle deck produced a 90-degree list to starboard within 30 minutes. Subsequently, the 1990s saw continued refinement of ro-ro vessel survivability requirements, particularly in developing regional water-on-deck requirements, in what has become known as the "Stockholm Agreement."

Not only were ro-ro passenger vessels required to meet the SOLAS 1990 amendments, but also the Stockholm Agreement required additional analyses to evaluate the free surface effect of a minimum depth of 0.5 meters of flood water on the vehicle deck of these ferries.

Other significant amendments to SOLAS 1974 included the 1990 amendments regarding probabilistic damage stability requirements for dry cargo vessels, completing part of the work of the 1960 SOLAS recommendation. Many other changes were rapidly made to SOLAS 1974; however, the most important was the new damage stability standard to supersede the outdated deterministic factor of subdivision system still being applied. Finally, in 1993, IMO adopted the Intact Stability Code that co-located all intact stability recommendations.

The 2000s: Improving International Regulatory Instruments

The amendments of the early 21st century further improved the international regulatory instruments created in the 1990s. IMO-sponsored research committees harmonized stability regulations within SOLAS 1974. The most noteworthy was the "harmonization of rules and design rationale," known as the HARDER Project, which the European Union commissioned, to fully explore the probabilistic approach to assessing a vessel's damage stability.

Essentially, the new performance-based method adopted the basic approach that required the designer to establish the stability standard for the vessel by calculating a required subdivision index, "R," and the attained subdivision index, "A," where $A \geq R$. R is a value based on the length of the vessel and the number of passengers carried, similar to the aim of the old 1929 subdivision standard. The subdivision index "A" is attained by a rigorous summation of numerous probabilities that account for the likelihood of flooding one or multiple compartments, and the likelihood that the vessel will survive that flooding. The results were quite impressive, proving applicable to all vessels. IMO adopted this model in Resolution MSC.216 (82) in December 2006, and it entered into force in 2009 for passenger and cargo ships.

The second milestone reached during the 2000s was the restructuring and revision of the 1993 Intact Stability Code that resulted in the Code on Intact Stability, 2008, which entered into force in 2010 and is comprised of mandatory and recommended provisions establishing the intact stability criteria that will significantly impact new ship designs and overall safety.

A History of Innovation

International subdivision and stability regulations have developed significantly since the *Titanic* sank a century ago. The most complex and accurate of which—the probabilistic stability approach—took more than 30 years to gain international acceptance and an additional 20 years to develop.

Stability requirements that began as a simple deterministic, plug-and-chug analysis have now progressed to evaluating performance-based secondary and tertiary reactions to ship motions. Not only are ship owners and shipbuilders obligated to prove that a ship's initial measures of stability are met, but developing international requirements will direct that operational stability risks are more fully considered; quite possibly enhancing ship safety to a level never envisioned in 1929 and certainly not in 1914.

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LCDR Ron Caputo has served in the U.S. Coast Guard for 12 years. He is a graduate from the Massachusetts Institute of Technology with an M.S. in naval architecture and marine engineering, and an M.S. in mechanical engineering. He has served in many capacities, most notably as a naval architect and marine inspector.

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2. Two great ocean liners, *Andrea Doria* and *Stockholm*, collided near Nantucket, Massachusetts. Available at www.thegreatoceanliners.com/andreadoria.html.
3. A full report is available at www.maib.gov.uk/publications/investigation_reports/herald_of_free_enterprise.cfm.
4. The *Estonia* was a cruise ferry that sank in the Baltic Sea in 1994. A case report is available at www.springerlink.com/content/vj55ma1ftndjpwn0/fulltext.pdf.

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International Requirements for Ship Structures

Protecting ships from the sea and the sea from ships.

by Mr. Charles Rawson
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The function and purpose of a ship's hull structure is to protect the vessel from the sea and vice versa. This is why ship designers and owners have an inherent incentive to provide adequate structure that will ensure the continued functionality of the vessel over its lifespan, regardless of any national or international design requirements.

Nevertheless, whenever there is economic benefit to be gained from operating a ship, there is also motivation to increase profit by minimizing initial capital costs, reducing weight, or postponing regular maintenance. This is why ship structural requirements have been imposed in various forms by various entities. Unlike other safety systems, such as lifesaving requirements, structural requirements are as rooted in maintaining an owner's profitability as they are in ensuring the mariner's safety and preserving the environment.

From Wood to Steel

The transition of ships from wood to iron and steel in the second half of the 19th century came in a time when the engineering profession was rapidly expanding. Strength requirements at this time prevented only the most basic of structural failures, such as water coming into the vessel or cargo escaping from it. During this transition, however, processes and designs that had been developed through personal experience were yielding to a regimen of analysis and application of scientific and physical principles.

While the new building materials weighed significantly more than the wood that had been the shipbuilder's staple, they offset that disadvantage by being able to be constructed with much thinner units. They also permitted increased length of structural members; and, consequently, longer ships, because iron and steel joints (even in the time of rivets) were much stronger than wood joints.

Efforts to determine the longitudinal strength of ships in a seaway resulted in modeling the ship as a beam, either supported singly amidships and resulting in a hog condition or doubly supported at the ends, resulting in a sag condition.[1] This beam theory allows engineers to use mathematical formulae to analyze ship structures and make a prediction of whether the ship would have adequate structural strength for its expected operating conditions.

Classification Society Standards

Classification societies provided assurances to owners and investors that a ship would be suitable for its given assignment, based upon a comprehensive series of surveys of the ship and review of its construction. This system kept enough ships from experiencing structural failures. When the first international safety conventions were held, immediately prior to World War I, development of specific structural strength standards was not a primary concern.

Consequently, drafters of the International Load Lines Convention of 1930 (1930 ILLC) were content with the continued use of class society standards.

David Arnott, a contemporary naval architect, noted "as a standard of longitudinal strength, [the ILLC] is admittedly quite inadequate, but the provision of a complete standard would mean embodying in the freeboard regulations the construction rules of a class society or their equivalent."[2]

For vessels not complying with classification society rules, the 1930 ILLC provided guidance by offering two measures of structural adequacy:

- The first measured longitudinal strength, and the requirement increased with the ship's draft and breadth and the square of the vessel's length.
- The other measured frame (rib) strength, and increased with frame spacing and the square of the vessel's depth.

Such minimal guidance relied on the assumption the measures would be intelligently used and the hull material properly distributed, as non-functional designs meeting these criteria could easily be proposed.

WWII-Era Innovations, Challenges

While classification societies remained the primary ship structural standards developers, the introduction of welded steel construction during World War II revealed new structural problems beyond basic dimensional considerations. Welded merchant vessels experienced a series of mysterious structural failures—hull fractures that could not be explained. The fractures, in many cases, manifested themselves with explosive suddenness and exhibited a quality of brittleness that was not ordinarily associated with the behavior of a normally ductile material such as ship steel.

It was evident that the implications of these failures on welded ships might be far-reaching and have a significant effect upon the war effort. In 1943, the Secretary of the Navy, James Forrestal, established a board of investigation to inquire into the design and methods of construction of welded steel merchant vessels. One of the board's recommendations: Establish an organization to formulate and coordinate research in matters pertaining to ship structure. The Ship Structure Committee, created later that year, is still in existence today; it is an interagency organization consisting of technical experts from the U.S. Coast Guard, U.S. Navy, U.S. Army, the Maritime Administration, the American Bureau of Shipping, and other government agencies. Since its inception, the committee has promoted technological and educational advancements in marine transportation.

Post-War Efforts

Similarly, the International Ship and Offshore Structures Congress, a group of experts from dozens of countries, has met regularly every three years since 1961. Its main functions:

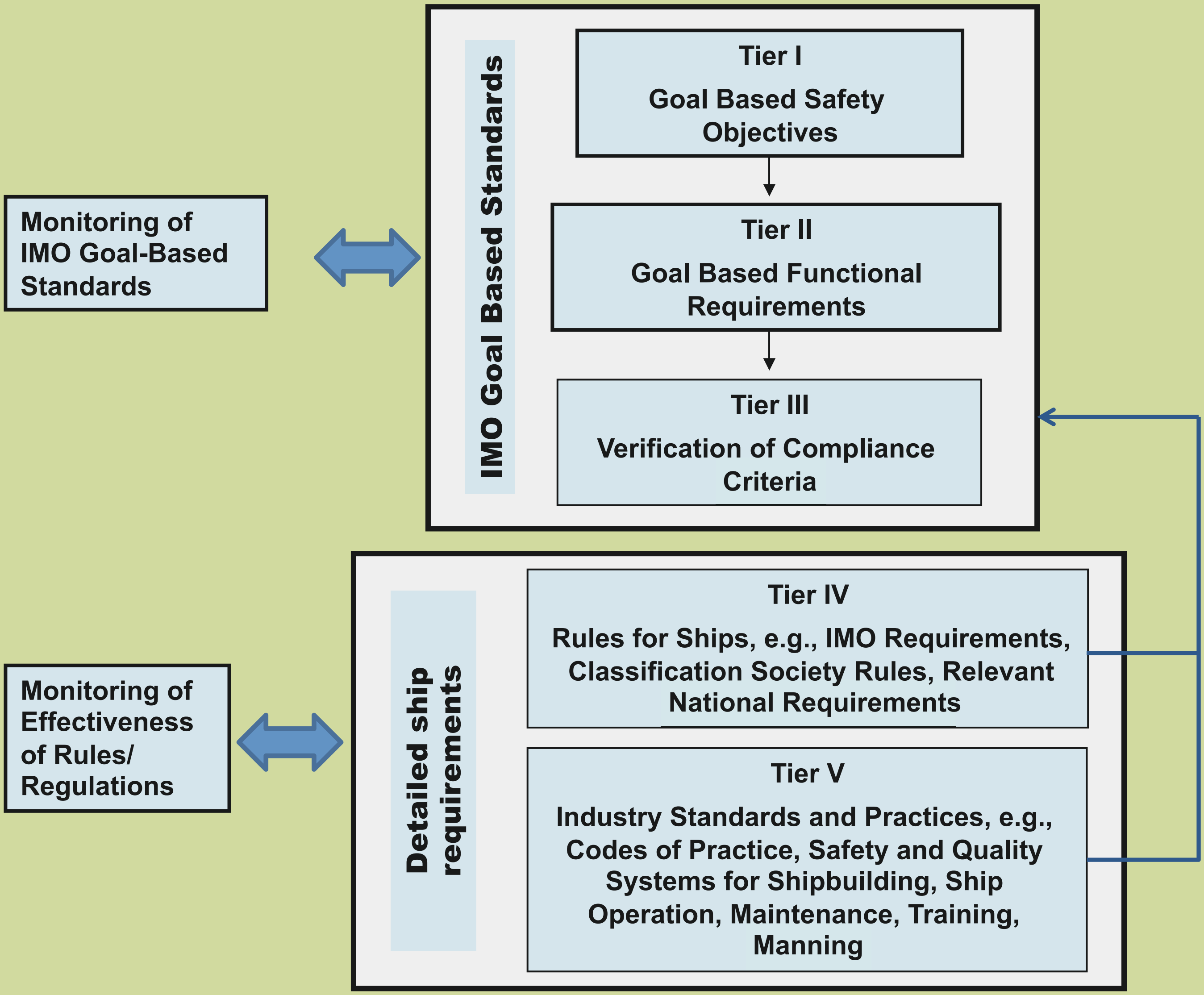
- promote relevant research regarding ship structures;
- recommend improvements in design, production, and operational procedures;
- review relevant research;
- evaluate and disseminate results from recent investigations;
- identify areas for future research, especially that involving cooperation among countries.

The host country for each congress is responsible for the specific organization, but there can be at most 12 technical committees and 10 specialist committees. In this way, the congress efficiently evolves to keep up with advancements in the industry and take advantage of new technologies or applications. Committee mandates have included fatigue and fracture control methods; ocean wave, current, wind, and temperature statistics; and the impact of dynamic response of offshore structures on safety, serviceability, and naval ship designs.

Environmental Standards

Regarding the second part of our initial equation—protecting the sea from ships—a ship's structure is also intended to maintain an impervious boundary for its cargo, especially in the case of liquid cargoes. Increasing focus on the negative impact of cargoes being discharged into the sea following marine casualties led to numerous efforts to construct ships that are more crash-worthy.

The Oil Pollution Act of 1990, enacted in the wake of the *Exxon Valdez* casualty, mandated that tank vessels plying the waters of the United States be constructed with a double hull. Other structural or operational tank vessel requirements that would provide equal protection to the marine environment were also considered. For example, the Coast Guard asked the National Research Council (NRC) to assess whether alternative tank vessel designs would improve maritime safety and environmental protection. The NRC convened a committee, composed of members with expertise in tank vessel design and construction, tank vessel operation, maritime salvage, maritime safety, vehicle dynamics, structural engineering, economic analysis, risk assessment and management, and envi-



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ronmental and maritime law. This committee recommended that there needed to be a greater understanding of structural behavior of tank vessels, and more accurate modeling of the performance of a ship's structure in the event of a collision or grounding.

Numerous subsequent research projects attempted to refine the extent of damage assumptions used in the hypothetical oil outflow calculations to predict specific structures' performance following a grounding or collision. While the Coast Guard was able to define and promulgate an evaluation tool using the accumulated research on tank vessel structures, the comparison methodologies used to compare a tanker's oil outflow performance do not consider the effect of structural design or crashworthiness.

International Engagement

In 1996, following a period of significant competition among the classification societies, SOLAS was amended to formalize the longstanding practice memorialized in the load lines conventions that detailed structural requirements should be determined, implemented, and verified by the classification societies. This was enacted by adding into Chapter II–1 a new Part A–1, titled "Structure of Ships." One of the two regulations in this new part, Regulation 3–1, required ships to be designed, constructed, and maintained in compliance with the structural requirements of a recognized classification society or with applicable requirements of the administration. (The other regulation dealt with ballast tank corrosion prevention.)

The classification societies themselves worked to improve the situation of unhealthy competition by initiating a project to establish common structural rules that would constitute a single set of globally applied standards that would result in stronger, more durable ships that were built in a more efficient and cost-effective manner. In 2006, after years of development and verification, the International Association of Classification Societies adopted the first set of rules, which was applicable to tankers and bulk carriers.

While the classification societies were developing the common structural rules, IMO became focused on providing goal-based construction standards after representatives from the governments of the Bahamas and Greece put forth the notion of a new and transparent goal-based regulatory framework for hull structures.

This effort represented a significant change from the existing complex system of largely prescriptive statutory international and national regulations, classification rules, and industry standards. The basic principle was to establish clear, demonstrable, and verifiable goals to the effect that a properly built, operated, and maintained ship should provide minimal risk to its cargo, crew, and to the environment for a specified operational life. This goal-based approach moved the regulatory framework from a culture of compliance, governed by prescriptive rules, to a culture of benchmarking, backed by functional risk-based requirements.

The evolution of international requirements for ship structures reflects the numerous directional changes that have influenced shipbuilding since the beginning of the 20th century. The requirements have evolved from the experience-based decisions of individual designers and shipbuilders; to private rule-based systems with input from shipbuilders, academia, and other experts; to the current rise of a transparent, performance-based method of developing standards responsive to all stakeholders involved with international shipping.

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For more INFORMATION:

The Ship Structure Committee

Information regarding the committee and the reports of its research projects are available online at **www.shipstructure.org**.

International Ship and Offshore Structures Congress

More information regarding the International Ship and Offshore Structures Congress is available at **www.issc2012.org**.

Forensic Analysis of the RMS *Titanic*

Unraveling the mysteries of the world's most famous sinking.

by Mr. Brian Thomas
Assistant Team Leader
U.S. Coast Guard Salvage Engineering Response Team

Mr. Jaideep Sirkar
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U.S. Coast Guard Office of Design and Engineering Standards

The RMS *Titanic* has captured the interest of many in the 100 years since her tragic sinking. Although formal investigations into the accident were carried out immediately, hobbyists and engineers have continued to study the disaster, attempting to shed light on the events of that fateful evening when the passenger liner struck an iceberg off southern Newfoundland.

The *Titanic* was the second of the Olympic class of ocean liners. Its hull was constructed with overlapped steel strakes fastened with steel and wrought iron rivets, and was subdivided into 16 watertight sections with transverse watertight bulkheads extending more than 12 feet above the waterline, which was consistent with shipbuilding methods of its era.

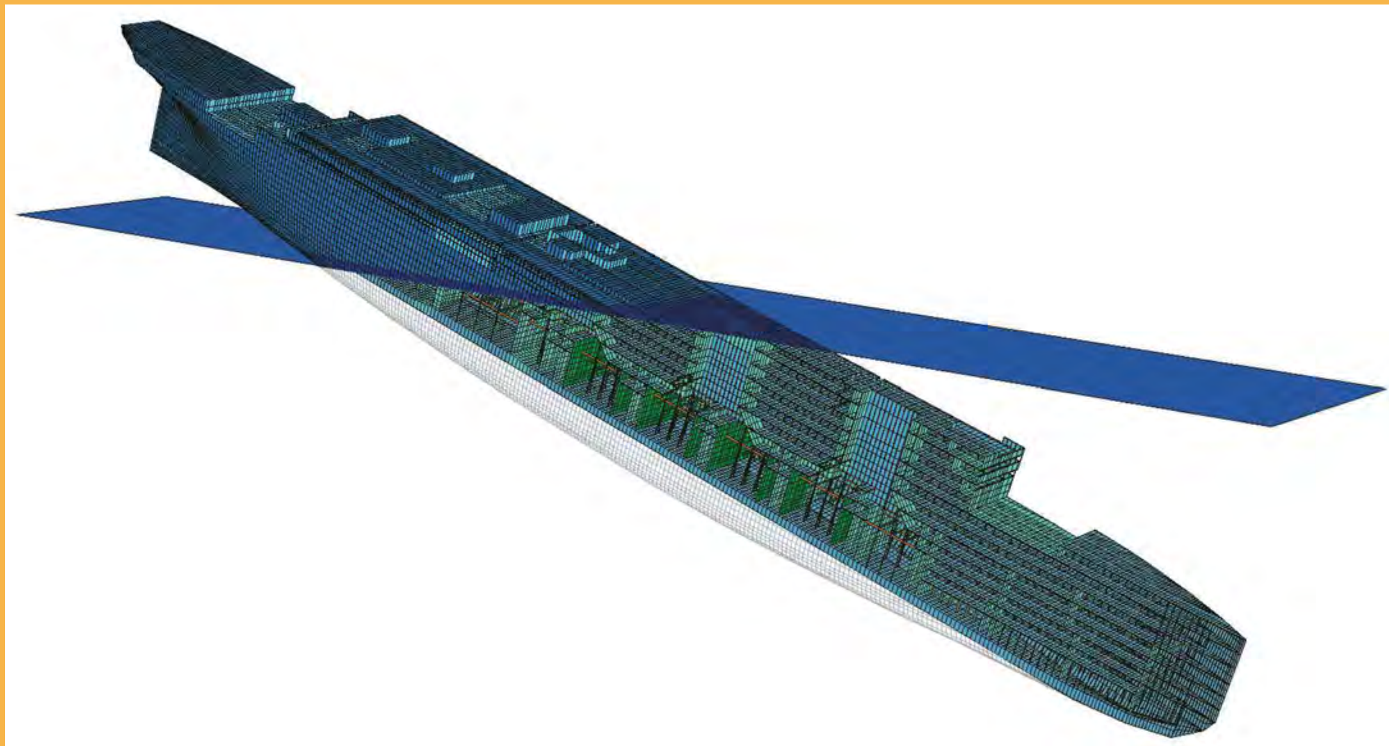
Contemporaneous Investigations

The primary formal inquiry into the sinking of the *Titanic* was conducted for the British Board of Trade and led by Lord Mersey. As wreck commissioner, he and his assessors were tasked with investigating matters ranging from construction and lifesaving arrangements to watchstanding and conduct of the crew during the casualty. The testimony of naval architect Edward Wilding is of particular interest to engineers who study the sinking. Wilding provided an estimate of the drafts, trim, and stability at the time of collision, based on the known sailing drafts from Southampton. Wilding also estimated, as a result of the collision, the combined area of all the hull breaches was approximately 12 square feet spread over six compartments, spanning the forward 300 feet of the ship.

In addition to the British inquiry, the U.S. Senate also conducted an investigation headed by Sen. William Smith of Michigan. In the course of that investigation, Smith interviewed dozens of witnesses and completed an extensive report on the accident. Both investigations ultimately called for sufficient lifeboat capacity for 100 percent of the passengers and crew as well as changes in hull subdivision requirements. Notably, witness testimony pointed to catastrophic structural failures, but neither investigation addressed the *Titanic's* break-up.

New Mysteries and New Answers

The 1985 discovery of the wreck of the *Titanic* sparked a new round of forensic investigation. The bow section was found largely intact with the stern section in hundreds of pieces approximately 2,000 feet away. The realization that *Titanic's* hull had broken at some point during the sinking added a new mystery to the already famous disaster. Fortunately, the discovery of the wreck also provided new forensic evidence in the form of recovered artifacts and detailed surveys. It was these new clues and advances in computer-driven engineering tools that dawned a new era of investigation.



Finite element model of the *Titanic* showing the orientation when break-up could have occurred. Graphics courtesy of Cmdr. Jeff Stettler, USN.

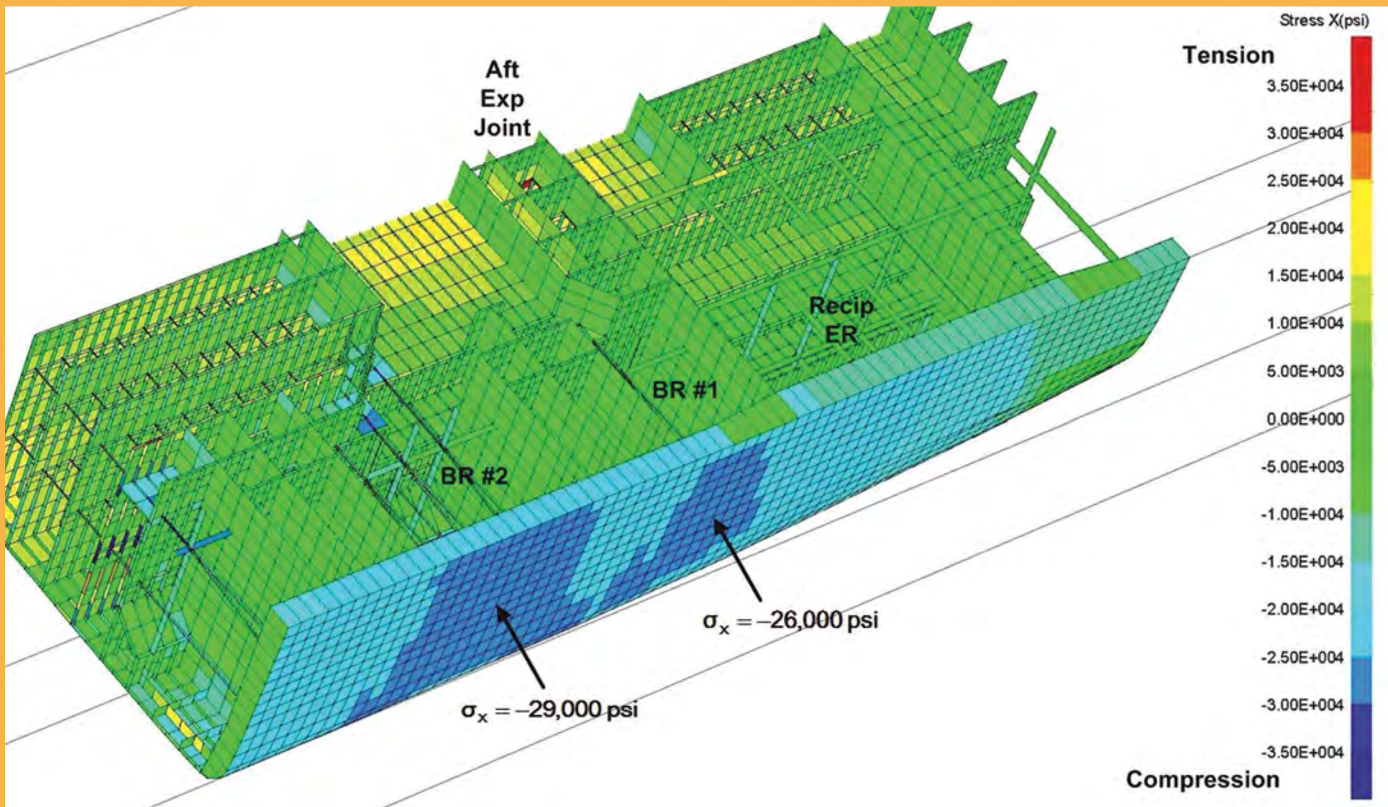
In 1996, naval architects Chris Hackett and John Bedford published a landmark paper that provided the first simulation of the sinking of the *Titanic* using modern hydrostatics tools. These tools could recalculate the estimates presented by Wilding in 1912, simulate the early stages of flooding, and assess *Titanic's* compliance with International Convention for the Safety of Life at Sea (SOLAS) standards for damage stability. Their analysis confirmed Wilding's estimate of a total hull breach area of approximately 12 square feet. Remarkably, they also found that the *Titanic* nearly met SOLAS damage stability requirements when two adjacent watertight compartments are breached.

In the mid-nineties, the Marine Forensics Panel (now the Marine Forensics Committee) of the Society of Naval Architects and Marine Engineers conducted analyses of the incident. Members of the panel joined a group of explorers in investigating the wreck site. The investigation included attempts to better understand several aspects of the incident prior to her collision with the iceberg, including the effect of a coal fire in the ship's bunkers. Regarding the coal fire: The analysis concluded that the steel watertight bulkhead between two boiler rooms may have been damaged metallurgically and structurally, compromising the bulkhead's watertight integrity.

Investigators reached several conclusions by combining sonar images, survivor narratives, metallurgical testing of the ship's steel hull and wrought iron rivets, and visual examination of the wreck and the debris field:

- The hull steel was the best available of the era, but the combination of the steel metallurgy with the wrought iron rivets had contributed significantly to the failure of the riveted seams in the collision with the iceberg.
- Brittle fracture contributed to subsequent hull failure even though it was not a factor in the initial damage propagation.
- Assisted by finite element analyses, the area of initial hull breaches was confirmed to be less than 13 square feet.
- Subsequent hull failures were the result of progressive flooding and steel metallurgy.

In 2003, Dr. Jennifer Hooper published a study that shed new light on the metallurgy of the hull steel and the wrought iron rivets, and their role in the sinking. Hooper and her co-authors were able to obtain wrought iron from the *Titanic,* as well as wrought iron samples from the same era used for other applications.



Finite element model of the *Titanic* shows stress in the bottom plating.

Combining metallurgical analysis, compositional analysis, mechanical testing, and computer modeling, the variations in mechanical properties of the rivets were determined. The authors concluded that there was a high degree of variability in the slag content and geometry within the rivets. These variations contributed to compromised rivet tensile strength, which could have accelerated riveted seam failure.

In 2009, Roy Mengot and Richard Woytowich conducted a structural analysis of Hackett's and Bedford's progressive flooding scenarios to identify potential causes of initial hull girder failure. Combining finite element analysis with possible flooding scenarios, the study identified likely locations for initial failure and subsequent propagation. However, the authors readily admit that, while the initial failure most likely occurred in the bottom structure, uncertainties associated with this mode of failure prevent a definitive conclusion.

In 2012, Cmdr. Jeff Stettler, U.S. Navy, and Mr. Brian Thomas, co-author of this article, presented a paper at the International Marine Forensics Symposium, which sought to use the *Titanic* as a test case to integrate cutting-edge techniques in hydrostatics with the finite element analysis. They created a three-hour simulation of the progression of floodwater through *Titanic's* compartments, which allowed investigation of multiple flooding pathways and examination of intermediate stages of flooding at 10-second intervals. A clear peak in the hull girder loads was apparent from the detailed flooding timeline.

They also used a complete ship finite element model to identify high stress areas and identified that the bottom plating just aft of amidships would have likely been the first area of structure to fail catastrophically.

The Common Threads

Each investigation of the *Titanic* has sought to establish the truth behind one of the most significant peacetime maritime disasters. There have been some remarkable similarities in the findings. And, although today's engineering tools are far more sophisticated than those available to Wilding, the basic problem of incomplete information prevents investigators from pinpointing the source of structural failure or developing a precise flooding timeline.

Notably, the flooding timeline presented by Wilding in 1912 is fundamentally the same as those presented 100 years later. Each study concluded that it took a breach of the hull amounting to roughly 12 square feet to sink the largest passenger liner of her time. In contrast, the early investigations overlooked the strong likelihood that the *Titanic* broke in half while still on the surface.

As the wreck of the *Titanic* quietly disintegrates on the bottom of the ocean, the promise of new forensic evidence fades along with it. Despite the impassioned efforts of the marine forensics experts, some truths about the *Titanic* may never be known.

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If the *Titanic* Sank Today

The evolution of lifesaving equipment.

by Mr. Kurt J. Heinz, P.E.
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On the cold, calm, moonless night of April 14, 1912, the passenger ship RMS *Titanic* was en route from Queenstown, Ireland, to New York, on her maiden transatlantic voyage with more than 2,000 passengers and crew aboard. She sliced steadily through the frigid North Atlantic off the coast of Newfoundland, Canada, despite periodic radio warnings of ice in the area. For the largest ship in the world at the time, a little ice might not have seemed like a major worry.

At about midnight, the lookouts shouted to the bridge that there was an iceberg dead ahead. Efforts to avoid it were unsuccessful, and the iceberg went grinding down the starboard side and popped a number of rivets below the waterline, initiating the inflow of frigid water into forward compartments. This was the beginning of a chain of events that ultimately sealed the fate of the "unsinkable" ship, with the tragic loss of more than 1,500 passengers and crew.

An Alternate History

Extensive improvements have been made in lifesaving capabilities since this tragic incident. So many, in fact, an argument could be made that the events leading to the loss of so many individuals might have played out much differently back then if the White Star liner was outfitted according to modern-day lifesaving equipment standards.

Therefore, I present "The 2012 *Titanic* Story," an alternative narrative of the sinking as it might have happened today.

As documented, the *Titanic* took more than two hours to sink from the time of the initial iceberg impact. That being said, in 2012, this would be more than enough time for a trained crew to prepare and execute a successful abandonment, one done in an organized manner with the benefit of improved equipment and safety protocols.

Changes in Launch Standards

In 1914, maritime nations gathered to develop international ship safety regulations following the loss of the *Titanic* two years earlier. This first international conference on marine safety negotiated (or drafted) the 1914 Safety of Life at Sea (SOLAS) Convention. Although this first SOLAS Convention unfortunately never entered into force due to World War I, it was an important start to international cooperation on marine safety.

SOLAS has been revised and updated many times since this initial gathering. In 1983, the International Maritime Organization (IMO) adopted a revised Chapter III, which entered into force in 1986, increasing the number of regulations. Among the more important changes were those covering lifesaving appliances and procedures for abandoning ship.

SOLAS required all lifeboats and life rafts on a passenger ship to be capable of being launched in less than 30 minutes from the time of the order to abandon ship. To meet this standard, modern ship designers must consider the layout of the ship, escape routes, and locations of muster and embarkation stations.

SOLAS also included requirements for each lifeboat to be attached to its own set of davits (a structure used to launch a lifeboat over the side of a ship). This is a very significant difference from the 1912 *Titanic*, which utilized "nested" lifeboats as well as some "collapsible" lifeboats stowed away from the davits, which would have had to be dragged down across decks to launch.

Nested lifeboats came with their own set of problems. For one, they had to be launched individually, which considerably extended the time required to abandon ship. In addition, any problems or equipment malfunctions with a launching appliance would affect more than one lifeboat. By contrast, the lifeboats on a modern-day *Titanic* would each be stowed ready for launching, attached to individual davits and wire rope falls.

Chapter VI of SOLAS 1914 addressed the problem of insufficient numbers of lifeboats onboard the *Titanic.* Article 40 prescribed:

> *"At no moment of its voyage may a ship have on board a total number of persons greater than that for whom accommodation is provided in the lifeboats and the pontoon lifeboat on board."*[1]

The *Titanic* had lifeboat capacity for only about half the persons aboard. Today, a *Titanic* would carry lifeboats and inflatable life rafts for 100 percent of the persons aboard, plus at least an additional 25 percent capacity in reserve.

Dry-Shod Boarding

A basic principle of SOLAS for modern passenger ships is dry-shod boarding. For the primary lifesaving capacity (survival craft for 100 percent of the persons aboard), both lifeboats and inflatable life rafts are generally boarded from deck, and are lowered into the water via davits and wire rope falls. Since the 1960 SOLAS, davit-launched inflatable life rafts have been accepted to provide no more than 25 percent of the survival craft capacity on passenger ships. The 1983 SOLAS amendments further expanded their use, permitting inflatable life rafts to serve no more than 70 percent of the persons aboard for so-called "short" international voyages.

It's permissible for a single davit to serve multiple life rafts; however, life raft davits are limited in the size of rafts they can serve, and the number of rafts that can be launched within the 30-minute time allotted. Further, each life raft requires an experienced crew member aboard to manage the passengers, and others to supervise raft launching and embarkation.

Marine Evacuation Systems

The "marine evacuation system" is a relatively recent development used for a quick evacuation. This may be in the form of an inflatable slide (similar to an aircraft evacuation slide) or a vertical fabric chute (like those used by firefighters to evacuate tall buildings). They provide fast access to an open inflatable platform at the waterline, from which multiple rafts may be quickly boarded.

Current marine evacuation systems can be used with rafts of up to 150-person capacity, reducing the number of crew needed. This system can also be much more efficient than davit launching—some systems are approved for capacities in excess of 400 persons in 30 minutes. However, this system does have its cons—it can be intimidating for untrained individuals since it requires entry into a fabric chute or an inclined open slide at a great height. Thus, this kind of evacuation system is better suited for the crew.

Improvements in Emergency Protocol

There are many improvements in emergency protocol since the days of the *Titanic.* In an emergency, the first obligation of a master is to establish whether abandonment is necessary. If so, the master then prepares all passengers and crew for muster at their prearranged assembly stations. Once the master gives the order to abandon ship, the passengers and crew assigned to each survival craft would proceed to their assigned embarkation stations with their lifejackets and commence boarding as directed by the crew.

Although launching techniques have evolved quite a bit since 1912, up until fairly recently, launching lifeboats could be a laborious task, requiring a substantial number of crew. Current SOLAS requirements mandate that launching appliances rely only on gravity or stored mechanical power to launch the lifeboat. In general, modern lifeboats are launched by the simple release of a brake, which can be accomplished either from the deck or from within the boat (providing for

the safe evacuation of the "last man" on the ship). This allows for much quicker launching, and requires substantially less labor.

Unlike the open, oar-propelled lifeboats on the 1912 *Titanic,* most modern lifeboats are self-righting and propelled by diesel engines. To help prevent hypothermia, which claimed the lives of many aboard the fabled *Titanic,* modern lifeboats are either totally enclosed, or at least partially enclosed by rigid fiberglass canopies; modern inflatable life rafts feature insulated floors and canopies.

Assuming all else went reasonably according to plan; the sinking of the 2012 *Titanic* would leave no one in the water, with all the persons aboard some kind of enclosed survival craft. In addition to the warmth provided by numerous people in an enclosed space, modern lifeboats and life rafts are equipped with thermal protective aids, which are essentially enclosed "space blankets" with sleeves. Crew members requiring more robust thermal protection, such as those supervising marine evacuation systems or crewing rescue boats, are typically provided with thermal protective immersion suits or anti-exposure suits.

Once the survival craft are launched, another modern appliance, the dedicated rescue boat, is provided on our 2012 *Titanic* to "marshal" any inflatable life rafts, (pull them together and away from the ship to prevent them from being affected by the sinking of the ship and/or scattering across the sea); and to recover any persons who, despite the various means provided to prevent it, may find themselves in the water.

Less "Search," More "Rescue"

Today, a distressed vessel would draw a variety of rescue assets, including potential assistance from Good Samaritans. Also, the advent of modern satellite communications tools, such as the Global Maritime Distress and Safety System and GPS-guided alerting via Electronic Position Indicating Radio Beacons have resulted in less "search" and more "rescue" efforts than in the 1912 *Titanic's* day.

However, mass recovery of persons from survival craft (and possibly from the water) is a problem not easily addressed—especially in remote areas such as the Arctic, where search and rescue assets may be few and far between. Also, mariners willing to undertake heroic efforts to rescue a person in distress may fall short in cases where their vessel is not well equipped for a water recovery mission. Fortunately, the International Maritime Organization's Ship Design and Equipment Sub-Committee is addressing these concerns by working to improve the capability of commercial ships to assist in operations to recover people in the water.

Thousands of lives have been saved in adverse conditions and remote areas, thanks to lifeboats and other survival equipment. With that being said, it cannot be determined whether lifeboats or life rafts will eventually become a thing of the past. However, one thing is for certain, 100 years after the *Titanic* disaster, they are still an essential piece of survival equipment.

Also, despite the common moniker often associated with the 1912 *Titanic,* one fact still remains … we have yet to develop ships that are "unsinkable."

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100 Years of Fire Safety Progress

The evolution of SOLAS fire protection requirements.

by LCDR John H. Miller
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U.S. Coast Guard Office of Design and Engineering Standards

Since the 1914 Safety of Life at Sea (SOLAS) conference, held in the wake of the *Titanic* tragedy, SOLAS requirements have evolved in the hope of preventing future loss of life. While ongoing SOLAS Conventions have dealt with many safety issues, this article relates to fire safety. As such, many of the changes that have occurred in SOLAS fire protection requirements over the past 100 years involve noncombustible construction, automatic firefighting and fire-detection systems, the Fire Safety Systems Code, the Fire Test Procedures Code, safe return to port regulations, and performance-based alternative arrangements.

1910 to 1930

The 1914 convention introduced new international requirements dealing with fire-resistant bulkheads, fire prevention appliances, and firefighting equipment on passenger ships. By 1927, proposals were made for another conference, which was held in 1929. Representatives from 18 countries attended the conference, where many of the basic fire safety requirements were carried over from the 1914 convention. The evolution of SOLAS fire protection requirements had begun.

1930 to 1960

In 1934, more than 100 people died in a fire on board the passenger ship *Morro Castle*.[1] The investigation of the fire incident, and the lessons learned from it, played a major part in developing noncombustible construction regulations. In addition to the regulations resulting from this disaster, many advances in maritime technology were made during World War II and were subsequently incorporated into the 1948 SOLAS Convention.

As a result of these maritime technological advances, a greater emphasis was placed on fire safety on ships; in fact, three new parts (D, E, and F) were added to Chapter II of the 1948 SOLAS Convention, which was exclusively dedicated to fire safety. In addition, the 1948 requirements were applied to passenger and cargo ships, including establishing three methods of construction for passenger ships and basic fire protection requirements for cargo ships. The 1960 updates include applying certain passenger ship fire safety requirements to cargo ships.

continued on page 47

The S.S. *Morro Castle*, ablaze off the coast of New Jersey. Photo courtesy of Maritime Industry Museum at Historic Fort Schuyler.

Recent Passenger Vessel Fires

Over the previous few decades, a number of major fires occurred on passenger ships, some of which contributed to the total loss of the vessel. Examples include the 1980 fire on (and subsequent sinking of) the *Prinsendam* in 1980 in Alaskan waters and the 1994 *Achille Lauro* fire. Both these incidents involved fires in the engine room that spread to the accommodation areas.[1]

Safety Improvements

The use of structural fire protection, safety areas, fire-resistant materials, detection systems, and fixed firefighting installations have contributed in a positive way in preventing and containing fires on modern vessels, especially as the requirements of SOLAS Chapter II-2 have become progressively more rigorous.

SOLAS Fire Safety Revision

Some major incidents have still occurred on passenger ships recently and these have led to further improvements.

One such incident occurred in 1998 when the cruise ship *Ecstasy* had just departed Miami for Key West and a fire started in the laundry room at the stern of the vessel.

The fire migrated through the ventilation system to the aft mooring deck where the mooring lines caught fire, producing intense heat and large amounts of smoke. An investigation concluded that the spread of smoke through ventilation ducts could have been mitigated, and the extensive fire damage caused could have been reduced by an automatic fire suppression system on the mooring deck.[2]

In response to the *Ecstasy* fire and others, the IMO adopted a completely revised SOLAS Chapter II-2 in December 2000, which entered into force on July 1, 2002. The new chapter structure focused on the fire scenario process rather than on the type of ship. The new layout also reorganized the chapter into separate parts including prevention, detection, suppression, escape, operational requirements, and alternative design and arrangements.[3]

In fact, risk-based design is an increasingly important element in modern fire safety design. SOLAS Chapter II-2 contains regulations that are mainly prescriptive in nature, but the December 2000 amendments incorporated a new regulation that allowed for alternative design and arrangements, provided that these were subject to a thorough engineering analysis. Guidelines on the requirements of the engineering analysis, based on risk-based methodology, were published in IMO's MSC Circular 1002.

To make the revised SOLAS Chapter II-2 more user-friendly, specific system-related technical requirements were moved to a new International Fire Safety Systems (FSS) code, where each regulation lists a purpose statement and functional requirements. The reasoning: to separate carriage and other statutory requirements, which belong in the convention and were meant for the administration, from purely technical provisions, which were better suited for the FSS code and could be applied in a more user-friendly manner.[4]

New Regulations for External Deck Areas

A more recent fire that caused particular concern within the cruise ship industry occurred on the *Star Princess* off the coast of Jamaica in 2006. This incident was caused by a discarded cigarette that ignited combustible materials on a stateroom balcony.

7KHDIWHUPDWKRIWKH¿UHRQWKH *Star Princess* in 2006. Courtesy of the UK Marine Accident Investigation Branch.

The flames were spread by the wind, and fire accompanied by intense black smoke spread quickly along neighboring balconies. Fortunately, the fixed firefighting system in the staterooms themselves, coupled with the restricted combustibility of their contents and the presence of structural fire protection, prevented the spread of fire within the vessel.

However, the heat from the fire shattered the glass in several balcony doors and smoke spread into the cabins and alleyways. One passenger died and others were treated for the effects of smoke inhalation.[5]

Until this incident, few authorities had fully considered the fire risks present on external deck areas, and it came as a surprise to them. IMO very quickly issued an MSC safety circular reinforcing the need to take fire precautions in light of this incident.

December 2006 amendments to SOLAS II-2 introduced regulations for new ships requiring non-combustible materials for cabin balconies and partitions. As a retrofit on existing vessels that became effective July 1, 2008, balcony furniture was to be of restricted fire risk unless fixed water sprinkler and detection and alarm systems were fitted.[6]

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1960 to 1990

Unfortunately, fires continued on passenger ships in the early 1960s, including an incident on the *Lakonia,* in which more than 100 people died due to a fire that started in the hairdresser's salon, as well as the smoke that resulted from it.[2] Lessons learned from this and other incidents helped inform the 1974 convention, which incorporated amendments including detailed fire safety provisions for passenger ships, tankers, and combination carriers. These provisions were based on the following principles:

- dividing the ship into main vertical zones via thermal and structural boundaries,
- separating accommodation spaces from the remainder of the ship via thermal and structural boundaries,
- restricting use of combustible materials,
- detecting the zone of origin for any fire,
- containing and extinguishing any fire in the space of origin,
- protecting the means of escape or of access for firefighting purposes,
- creating readily available fire-extinguishing appliances,
- minimizing possible ignition of flammable cargo vapors.

The 1981 amendments, which entered into force in September 1984, completely revised SOLAS Chapter II-2, and incorporated provisions for halogenated hydrocarbon extinguishing systems and a new regulation on inert gas systems.

1990s

In 1990, an arsonist's fire killed more than 150 people aboard the *Scandinavian Star* passenger ship.[3] It is considered that many of the passengers died from smoke that entered the corridors and cabins. The incident raised a number of issues relating to fire protection and passenger/crew evacuation.

In December 1992, the International Maritime Organization adopted a comprehensive set of fire safety amendments applicable to new and existing passenger ships. Several regulations were affected, dealing with such matters as automatic sprinkler and smoke-detection systems; noncombustible fire safety bulkheads; improved methods to assist passenger/crew escape, such as low-location lighting; fire pump sizing; and prohibiting new halon systems.

Many new regulations were added, including making it mandatory for ships carrying more than 36 passengers to have plans providing information on fire safety measures (fire control plans). Regulations for means of escape were considerably altered; for example, corridors from which there is only one route of escape were prohibited on ships built after October 1, 1994. Additionally, all means of escape were required to be marked by lighting or photoluminescent strip indicators placed not more than one foot above the deck. The 1992 amendments also made it mandatory for new passenger ships carrying more than 36 passengers to be fitted with a fire detection system centralized in a continuously manned control station that must be able to control the fire detection system, fire doors, watertight doors, ventilation fans, alarms, communication system, and the public address system.

The *Scandinavian Star*, victim of an arsonist. Photo courtesy of the World Ship Society.

Also in 1992, the subcommittee on fire protection agreed to undertake a comprehensive revision of SOLAS II-2, as it was felt that various sets of amendments made the chapter difficult to use and implement. Further, technological advancements and lessons learned from incidents since the chapter's last revision in 1981 required adding new provisions and modifying existing requirements.

A new international code for the application of Fire Test Procedures (FTP code) was developed and made mandatory on July 1, 1998. Developed for use by administrations, when approving products for installation on ships flying their flag, the FTP code provided international requirements for laboratory testing, type approval and fire test procedures for non-combustibility, smoke and toxicity, class divisions, fire door control systems, surface flammability, primary deck

Unified Interpretations

In 2004, the IMO Maritime Safety Committee created a circular titled *Unified Interpretations of SOLAS Chapter II-2, the FSS Code, the FTP Code and Related Fire Test Procedures,* (MSC/Circ. 1120) to provide more specific guidance for expressions contained in IMO instruments that are open to different interpretations.

Flag administrations were invited to use the annexed unified interpretations when applying the relevant provisions to fire protection construction, installation, arrangements, and equipment.

Safe Return to Port

Factors such as larger vessel capacities, the presence of disabled or elderly passengers, and itineraries that now include cruising into remote regions of the world have all combined to emphasize the need to protect the ship and its occupants at sea.

Consequently, a lot of work has been carried out at IMO and elsewhere to improve vessel survivability and habitability. The work culminated into what is now known as the "safe return to port regulations," which went into force on July 1, 2010.

In terms of fire, the vessel must be able to return to port, provided that its casualty threshold is not exceeded. This threshold is defined as the loss of a single space between A-class fire bulkheads, provided that it is protected by a fixed fire extinguishing system, or including adjoining spaces up to their nearest A-class bulkheads if it is unprotected by fixed fire-extinguishing means.

Endnote:

Joughin, R. W. *The Era of the Large Passenger Ship—An Overview of Safety Problems and Solutions.* Southampton, UK: International Association for Safety and Survival Training, 2010. Available at IASST Website: www.iasst.com/gogn/the_era_of_the_large_passenger_ship_revrj.docx.

coverings, vertically supported textiles and films, upholstered furniture, and bedding components.

2000 to Present

There have been many recent improvements to the SOLAS fire protection requirements. In 2000, IMO Secretary General William O'Neill expressed concerns about whether SOLAS regulations fully addressed safety issues on large passenger ships, which initiated significant changes and guidance for the SOLAS fire protection requirements over the next decade. These included a new SOLAS Chapter II-2 structure, alternative design and arrangements, the Fire Safety Systems Code, safe return to port regulations, unified interpretations, and non-combustible construction on balconies and partitions.

Although this article is not all inclusive, it is evident that the evolution of SOLAS fire protection requirements has taken a long journey since the *Titanic* disaster of 1912. Through continued thorough marine investigations and international cooperative efforts under the IMO, the level of fire safety at sea throughout the world should be further improved in the years to come.

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About the author:

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Endnotes:

1. *History of SOLAS Fire Protection Requirements.*
2. *IMO Knowledge Centre.*
3. *IMO Knowledge Centre.*

We Are SAR

Search and rescue over the last 100 years.

by LCDR Leanne Lusk
Search and Rescue Program Analyst

One of the most important international guiding principles concerning maritime safety is the mariner's duty to render assistance to those in distress at sea, regardless of nationality. One hundred years ago, this principle was ably demonstrated by the RMS *Carpathia,* a transatlantic passenger steamship located 58 miles away from White Star Line's RMS *Titanic.* The *Carpathia* received the call for help and diverted to render assistance.

Since then, this principle has been incorporated into several international conventions, including the Convention for the Unification of Certain Rules of Law Respecting Assistance and Salvage at Sea, the International Convention on Salvage, the International Convention for the Safety of Life at Sea, and the United Nation's Convention on the Law of the Sea. Today, aiding fellow mariners continues to be an essential element of lifesaving at sea.

As for the U.S. Coast Guard, which is responsible for search and rescue operations in America's vast maritime regions, utilizing available mariners to search for and rescue people in distress will always be an indispensable component of our search and rescue system.

International Partnerships for a Common Cause: Lifesaving at Sea

Since the *Titanic* disaster, international collaboration among the nations of the world in saving lives at sea continues to improve, resulting in two international conventions, developed to serve as the basis for international cooperation and coordination of search and rescue operations:

- the International Maritime Organization's (IMO) International Convention on Maritime Search and Rescue,
- the International Civil Aviation Organization's International Convention on Civil Aviation, Annex 12—Search and Rescue.

Duty to Render Assistance

- **The Convention for the Unification of Certain Rules of Law Respecting Assistance and Salvage at Sea (1910). Article 11: *"Every master is bound, so far as he can without serious danger to his vessel, her crew and her passengers, to render assistance to everybody, even though an enemy, found at sea in danger of being lost."***
- **The International Convention on Salvage (1989). Article 10: *"Every master is bound, so far as he can do so without serious danger to his vessel and persons thereon, to render assistance to any person in danger of being lost at sea."***
- **The International Convention for the Safety of life at Sea (1974). Chapter V, Regulation 33: *"The master of a ship at sea which is in position to be able to provide assistance … is bound to proceed with all speed to their assistance … ."* The first version of the convention was developed in 1914 in response to the RMS *Titanic* disaster, prescribing the number of lifeboats and other emergency equipment along with safety procedures required on merchant ships. Newer versions were adopted in 1929, 1948, 1960, and 1974.**
- **The United Nations Convention on the Law of the Sea (1982). Article 98: *"Every State shall require the master of a ship flying its flag … to render assistance to any person found at sea in danger of being lost."***

The Amver density plot. Depicts Amver participant activity worldwide for the month of December 2011.

Red lines . . . . .50 vessels or more
Orange lines. . . .15-49 vessels
Green lines . . .5-14 vessels
Blue lines . . . . . .4 or fewer vessels

These conventions set the foundation for nations to work together to coordinate lifesaving operations at sea and serve as the basis for the global maritime and aeronautical search and rescue plan. As such, under these conventions, the world's oceans have been divided into a patchwork quilt of maritime and aeronautical search and rescue regions, where nations have assumed responsibility for coordinating lifesaving operations within their assigned geographic area.

As required in both conventions, each search and rescue region has a 24-hour rescue coordination center that can receive distress alerts and coordinate the responses for search and rescue missions. In addition, the International Maritime Organization and the International Civil Aviation Organization jointly developed the International Aeronautical and Maritime Search and Rescue (IAMSAR) manual, which sets international policies and procedures to standardize search and rescue operations worldwide. The United States and other nations utilize the IAMSAR manual as the basis to develop and implement national search and rescue policies and procedures.[1]

Once a mariner in distress activates the search and rescue system, IAMSAR command and control framework guides the mission. Unlike when the *Titanic* sank, a single search and rescue mission coordinator is designated upon receipt of the distress notification based on the geographic location of the distress. The search and rescue mission coordinator becomes the central planner for the response, ensuring effective coordination and communications among all responders to maximize lifesaving efforts. If a nation is notified of a person in distress outside its respective search and rescue region, the rescue coordination center maintains oversight of the case until it can be properly passed to the appropriate authority.

Amver

In many distress situations, an incident occurs hundreds or even thousands of miles from the nearest search and rescue entity. The challenge for a rescue coordination center then becomes locating another mariner in the area of the emergent situation able to

Amver in Action

On the evening of December 8, 1994, the Ukrainian-flagged cargo carrier *Salvador Allende* was transiting from the U.S. to Finland when it encountered a large storm with extremely heavy seas, approximately 850 miles northeast of Bermuda. The ship experienced a shift in its bulk cargo due to heavy swells, causing the vessel to become unstable.

With a significant list to port and the port deck remaining awash as the vessel was taking large rolls, the captain issued the order to abandon ship and repeatedly transmitted the SOS signal. By early morning on December 9, 1994, the port lifeboat was destroyed by a gigantic wave with crew members aboard, the starboard lifeboat was damaged and drifting, and life rafts were lost as the *Salvador Allende* ultimately capsized, and succumbed to the Atlantic Ocean.

Tragically, only two members of the crew survived. However, in the subsequent six-day search to locate the missing crew members, 32 Amver ships from 18 nations, along with six fishing vessels, assisted in the extensive search for survivors. Exemplifying the maritime tradition to render assistance, this massive search involved the largest number of Amver vessels in maritime history.

Sources:

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Mass Rescue Coordination

On November 8, 2010, the Panamanian-flagged cruise ship *Carnival Splendor* experienced an engine room fire that left the vessel stranded at sea, without power and propulsion, approximately 150 miles south of San Diego, Calif.

Maritime Rescue Coordination Center Mexico assumed mission coordinator responsibilities, as the incident occurred in their search and rescue region, and launched a Mexican Navy 140-foot patrol boat and an aircraft. The U.S. provided support in response to the incident by launching three Coast Guard cutters and a Coast Guard HC-130 Hercules aircraft, and arranging the response of Amver participant, German-flagged container ship *Dresden Express,* which remained with the *Carnival Splendor* until additional resources arrived.

While Carnival Cruise Lines coordinated two Mexico-based, ocean-going tugs to tow the ship into port, U.S. Navy vessel *Ronald Reagan* delivered nonperishable food and supplies. As a result of this multiagency coordination, the vessel was safely towed into San Diego harbor, without injuries or loss of life.

Endnote:

Update 4: Disabled Carnival Splendor *transiting to San Diego; escorted by Coast Guard.* California: U.S. Coast Guard Eleventh District, November 2010. Also available at www.d11.uscgnews.com/go/doc/823/947451/

The cruise ship *Carnival Splendor* H[SHULHQFHG DGHYDVWDWLQJ HQJLQH URRP ¿UH ZKLOH XQGHUZD\ P LOHV VRXWK RI 6 DQ 'LHJR & DOLI 8 6 & RDVW * XDUG SKRWR E\ 3 HWW\ 2 I¿FHU - HWWD + LVFR

render assistance. Following the *Titanic* tragedy, the need for quickly identifying other vessels in the vicinity of a ship in distress that could render assistance was recognized, though the concept did not come to fruition until the advent of computer-based technology.

In 1958, the United States Coast Guard launched the Atlantic Merchant Vessel Emergency Reporting (Amver) System. Within two years, Amver had grown to more than 5,000 volunteer ship participants.[2] Shortly thereafter, foreign rescue coordination centers began using Amver plots for search and rescue, and the system has become a valuable tool now utilized globally for search and rescue.

Under the Amver system, ships report their positions to a U.S. Coast Guard central database and any U.S. or internationally recognized rescue coordination center. Upon notification of a person or ship in distress, Amver queries to determine if any ships are in the vicinity to render assistance. When a possible vessel is identified, the appropriate rescue coordination center contacts the ship directly to divert for assistance. Since its beginning in the North Atlantic more than 50 years ago, participation has grown to more than 20,000 vessels, and Amver currently saves an average of one life every 33 hours.[3]

Mass Rescue

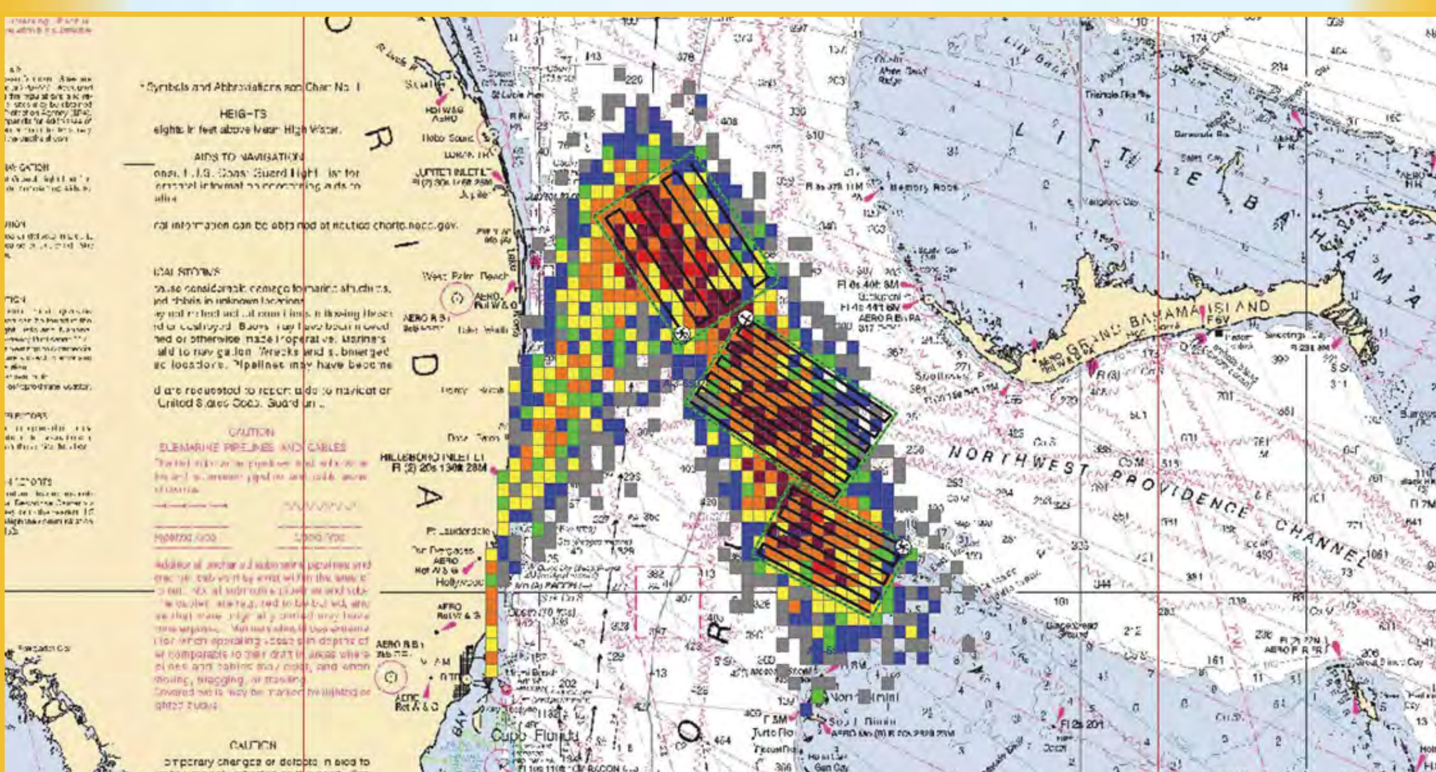
The Coast Guard must be ready to plan a response to a major search and rescue event and dispatch helicopters, ships, and small boats to the far reaches of a unit's geographic area of responsibility, or beyond. At times, this is logistically challenging, due to the finite number of Coast Guard resources. Additionally, cases outside the U.S. territorial seas result in significantly more complex and lengthier responses, due to the increased transit time to offshore positions and a decreased likelihood that a commercial vessel or pleasure craft is transiting the area, or another government agency can assist, especially when time is of the essence.

In response, the Coast Guard has developed baseline regional response strategies throughout U.S. search and rescue regions, planning for common and worst-case search and rescue scenarios in each particular region. Of these worst-case scenarios, perhaps the most challenging is a mass rescue operation. This type of operation involves such a large number of people in distress that the response capabilities normally available to search and rescue authorities are exceeded. In these cases, the Coast Guard relies on force-multipliers like Amver vessels, critical partnerships with maritime agencies, port partners, commercial mariners, and international partnerships, depending on the incident location.

Technological Advancements

At the time of the RMS *Titanic* incident, the ship was carrying the most modern radio system available, and the radio officer was able to transmit a distress call via Morse code. Since that ill-fated night, communications equipment, distress notification, and search planning technology has advanced tremendously. The initial notification in a search and rescue case is the trigger that activates the search and rescue system—bringing awareness of the incident to the search and rescue mission coordinator. Rapid notification with a position of the incident at the outset is critical to the success of response efforts, allowing search and rescue mission coordinators to launch the appropriate rescue craft directly to the location. As such, the Global Maritime Distress and Safety System enables mariners to utilize a combination of very high frequency, high frequency, and medium frequency radios, in addition to Inmarsat Satellite System capabilities, to communicate and receive distress information between vessels and shore stations.

The International Cospas-Sarsat Programme, which relays emergency beacon distress signals between ships and shore stations via satellite, continues to seek systematic improvements to ensure distress signals are received by search and rescue authorities, with as much information as possible to aid in coordinating a response. When activated anywhere in the world, a



The Search and Rescue Optimal Planning System (SAROPS) is a state-of-the-art computer-based search planning tool used to estimate where those in distress may be located by using near-real-time environmental data. The depicted search was planned for two survivors after a helicopter was reported overdue between Miami and Bimini. The hot colors represent more probable VXUYLYRUORFDWLRQVDQGWKHFRROFRORUVUHSUHVHQWOHVVSUREDEOHORFDWLRQVKRXUVDIWHUWKHÀLJKW86&*JUDSKLF

distress beacon signal is relayed to the satellite and is ultimately received by the mission control center. The mission control center sends the position to the appropriate rescue coordination center for action, which can then access the beacon registry database to obtain amplifying information for the particular vessel involved.

Further technology advancements include a variety of small or portable electronic devices that can provide the distress alert itself, serve as a means of locating those in distress, and communicating with responders (including transmitting the geographic coordinates). In addition, advanced computer-based search and rescue planning tools have significantly improved estimates of probable survivor locations in the marine environment. Innovations, such as the U.S. Coast Guard Search and Rescue Optimal Planning System (SAROPS), allow search and rescue planners to incorporate near-real-time environmental data from the latest supercomputer models to compute drift trajectories and generate a probability "map" of possible survivor locations. Utilizing this information, SAROPS produces optimal search patterns that maximize the chances of success for search aircraft and vessels.

The U.S. Coast Guard has been successfully using SAROPS as a primary search and rescue tool since 2007. Most recently, Lebanon, Malta, Mexico, and Vietnam utilize this search planning software, and SAROPS training centers were established in Malta for the Mediterranean region, and in Mexico for Central America.

The Future of Search and Rescue

The last century has been witness to major advancements in search and rescue, which have drastically improved the potential for survival of mariners in distress on the open ocean. However, expansion in the Arctic and Antarctic regions poses new challenges. The overarching search and rescue processes will remain applicable, but the nations who share responsibilities for future navigable areas within the remote polar regions will face major search and rescue planning and logistics issues in extremely harsh weather conditions. As commercial shipping, transportation, and tourism opportunities expand, further technological advancements will likely be required in radio and satellite communications technology.

Finally, in the aftermath of the January 2012 cruise ship *Costa Concordia* grounding off the Italian coast, search and rescue organizations throughout the world must continue to enhance policies and procedures to ensure we benefit from all opportunities available to maximize lifesaving efforts. As we reflect on the 100th anniversary of the sinking of the RMS *Titanic*, it is critical to the success of the global search and rescue system that the international maritime community continues to evaluate responses to cases worldwide. We must identify lessons learned and areas for improvement, while exercising foresight with the challenges on the horizon in the expanding maritime regions.

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LCDR Leanne Lusk serves as a program analyst in the U.S. Coast Guard Office of Search and Rescue. She was assigned to search and rescue planning billets within the Pacific Area for eight years, and she most recently served as the command center chief at Coast Guard Sector San Francisco.

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1. In the United States, the *National Search and Rescue Plan* was developed to meet U.S. domestic and international search and rescue responsibilities. The *National Search and Rescue Supplement to the IAMSAR Manual* further outlines U.S. domestic and international search and rescue system responsibilities.
2. The "AMVER" acronym was later changed to the Automated Mutual-assistance Vessel Rescue System, and is now commonly referred to as "Amver." Also available at http://www.amver.com/amverhistory.asp.
3. Amver summary statistics. Also available at www.amver.com/reports.asp?year=2010.

For more INFORMATION:

Search and Rescue Optimal Planning System Software Information is available at **www.uscg.mil/Acquisition/international/sarops.asp.**

Read more about U.S. Coast Guard search and rescue operations in the *Proceedings* Fall 2011 edition "Search and Rescue: Always Ready for the Call." Digital edition online at **http://uscgproceedings.epubxp.com/issue/43475/.**

Evolution of Standards

All Stations—Distress

Radio communications from the time of the Titanic.

by Mr. Joe Hersey
Chief, U.S. Coast Guard
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In 1912, the RMS *Titanic* carried the most modern radio system in existence. Its transmitter was a five-kilowatt rotary spark gap designed to provide the most transmit power possible in the days before electric oscillators. Designed with an operating range of 250 miles, communications could normally be maintained for a maximum of 400 miles during the day and 2,000 miles at night. However, only rudimentary transmitter tuning was possible, so when the *Titanic* was transmitting, other stations in its area often needed to wait until the ship finished before transmitting themselves.

The Marconi Company owned the ship's radio call sign "MGY." Radio operators John G. Phillips, chief operator, and Harold Bride, deputy, were both Marconi employees. The ship's radio handled 250 passenger telegrams from the time the ship left Southampton until her sinking, some 36 hours later. This is notable, as passenger telegrams financed the radio's operation.

It was well known that the *Titanic* received an ice report from the M/V *Mesaba* of the Atlantic Transport Line. At 7:50 p.m. on April 14, 1912, the *Mesaba* sent the following message to the *Titanic,* giving information regarding the ice pack the ship would soon encounter:

"In lat 42N to 41.25N long 49W to long 50.30W saw much heavy pack ice and great number of 0DUJH LFHEHUJV D0VR ¿H0G LFH : HDWKHU JRRG F0HDU´

Stanley Lord, the captain of the nearby vessel *Californian,* also instructed his radioman to inform the *Titanic* of the ice field.

The 1906 International Radiotelegraph Conference

Six years before the *Titanic* disaster, the first regulatory conference of its kind, the International Radiotelegraph Conference, met to sign the International Radiotelegraph Convention to regulate radio communications between coasts and ships at sea, and those exchanged between ships. The wavelengths 600m (frequency 500 kHz) and 300m (1 MHz) were allocated for maritime communications.

Coast stations were generally required to be operational 24 hours a day but ship stations were not. The radio distress signal "SOS" and general procedures for transmitting radio telegrams were established.

After 1906, the conference met in 1912 (three months after the *Titanic* casualty), 1927, 1932, 1938, and still meets roughly every four years, as the International Telecommunications Union World Radio Conference. It was renamed once radio use expanded beyond telegraphy. Conference decisions are still recognized as having treaty status.

So What Happened?

Navigational warnings telegrammed to ships included the prefix "MSG," which stood for Masters' Service Gram, requiring the operator to return with a personal acknowledgement receipt from the captain. While previous ice warnings sent to the *Titanic* used that prefix, the 7:50 p.m. warning from the *Mesaba* did not. Instead, the message prefix was simply "Ice Report."

As the *Titanic* came within range of the Cape Race coast station, the ship's radio operators needed to clear a huge backlog of passenger telegrams for the United States. The *Californian's* ice warning telegram also was not preceded by the MSG prefix, and since the content of the telegram was informal, *Titanic's* radio officer reportedly rejected the communications.

The Distress Calls

At 12:15 a.m. the *Titanic* transmitted its first distress call:

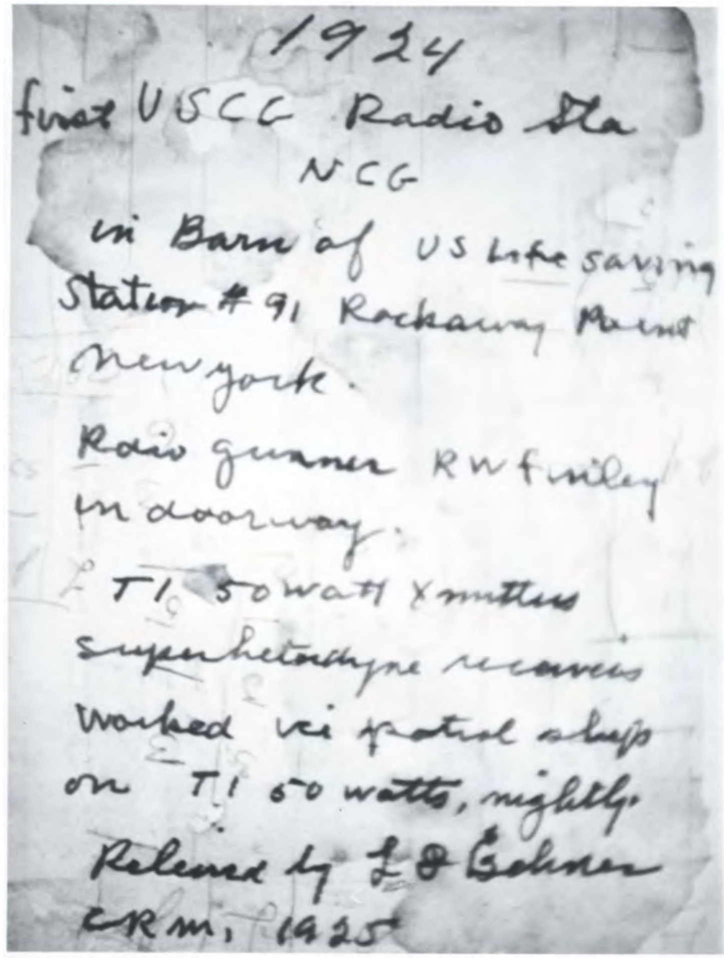
"CQD (all stations—distress) DE (this is) MGY SRVLWLRQ□□□□□□ □□1□□□□□□□□ :□´□

While Cape Race and various ships received the call, they were too far away to provide much assistance. It is reported that the *Californian* was quite near *Titanic,* but tragically, her radio operator had left his station for the night before the first distress call. The RMS *Carpathia,* a transatlantic passenger steamship, received the call at 12:25 a.m. The *Titanic* remained in communications with several ships that were rushing to its aid, until 2:17 a.m. when the steamship *Virginian* received the last message from the *Titanic:* "CQ." At that point, the *Titanic's* signal ended abruptly.

The ship foundered three minutes later. Both radio officers stayed at their stations until the end, despite being relieved by their captain. Harold Bride managed to survive, but Jack Phillips did not.

Changes as a Result

Radio communications procedural and technology changes addressing shortfalls from the *Titanic* casualty were gradually implemented. For example, a messaging priority was established that is still in use today, establishing warnings, including ice warnings, and precedence higher than general correspondence, including the stipulation that transmission be of no cost to ships. That regulation was also implemented in the U.S. as part of the Communications Act of 1934.



3LFWXUHG□LV□D□ORJ□HQWU\□UHFRUGHG□E\□WKH□¿UVW□8□6□□&RDVW□*XDUG□UDGLR□VWDWLRQ□□ call sign NCG, in Rockaway Point, NY. This station, established in 1924, in the barn of Lifesaving Station No. 91, was responsible for communicating with northeast coastal shipping and North Atlantic shipping vessels approaching the U.S. and documenting any distress alerts.

continued on page 57

Titanic's Distress Signals Ignored

The SS *Californian* was only a few miles away, but, unfortunately, the *Californian's* only wireless operator had already secured the watch position for the night before *Titanic* called for aid. While those aboard saw the pyrotechnic signals from *Titanic,* they failed to recognize they were signals of distress and did not go to her rescue.

The *Titanic* had received several ice warnings that night, including warnings coming from the *Californian.* However, the wireless operator aboard the *Titanic* dismissed those warnings.

The RMS *Carpathia* did answer the *Titanic's* wireless distress signals, but arrived after the vessel foundered. Captain Arthur Henry Rostron and his crew rescued more than 700 survivors in lifeboats.

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Call sign NMQ

USCG Radio Station Long Beach, Calif., early 1950s.

At that time, each Coast Guard district had one primary station and frequently one secondary station that served their district commander, providing services including:

- **voice communications on 2 MHz to and from district units (the way the majority of stations and smaller cutters received their radio messages),**
- **voice weather broadcasts and notices to mariners intended for all vessels within district boundaries,**
- **voice distress radio guard on 2182 KHz.**

Pictured (right) is a RM1 watch supervisor at USCG Radio Station Long Beach. It is not uncommon for those supervising to also serve as one of the operators.

“Position five in the photo depicting two variable receivers, two speakers, and a simple patch panel, which allows the receiver output be patched to various speakers. Photo suggests it is normally unmanned, indicating it was used to monitor specific frequencies.

The transmitter control panel, to the supervisor’s right, permits operator position assignment and control of a particular transmitter. The receiver antenna patch panel permits assigning a specific antenna to a specific radio receiver. Receiver antennas are located on the station grounds, separated from the transmitting antenna.

The automatic keying machine, shown behind the supervisor, was used in conjunction with another device to make Morse Code broadcasts. The machine keyed an associated transmitter a specified speed, freeing an operator from the need to key by hand.

Immediately behind the supervisor are two receivers, a limited transmitter control device, a patch panel, and a remote receiver amplifier, which indicates that the station had a receiver in another location.

The stations also provided three Morse code services:

- **continuous watch on the international Morse code distress and calling frequency 500 KHz (the same frequency used to make distress calls by the RMS *Titanic’s* radio operator);**
- **a 2 MHz intra-district Morse code circuit utilized by the larger cutters for all ship/shore/ship radio traffic;**
- **a Morse code broadcast service that provided weather and notices to mariners for suitably equipped vessels on a designated working frequency after an initial announcement on 500 KHz.**

Generally, each radio station had two teletype circuits, referred to as teletype wire private lines (TWPLs). One circuit connected the individual radio station to its district communications center, while the other connected each radio station to a communications center within its area for distress and other high-priority messages as well as informal coordination.

The operations room at USCG Radio Station Long Beach (left).

The radio operator monitors the international distress and calling frequency and operates the TWPL, which connected the station to the district headquarters. Through the glass is another radio operator monitoring another distress frequency and making all voice broadcasts.

Position four (the unmanned position) appears to be a combination voice/Morse position; two variable receivers, a patch panel, and speaker are visible.

The position in the background is most likely the guard position, where an operator monitors 500 KHz continuously for distress, while processing more WUDI¿F RQ D ZRUNLQJ IUHTXHQF\ 7KH SRVLWLRQ LQ WKH IRUHJURXQG VKRZV D WUDQV-mitter control device (the panel with the toggle switches and dial telephone pad) used to control the mode and frequency of the selected transmitter, and a device called a “whetstone machine,” used with the automatic keying machine.

Those same regulations also require that there be no charge for any distress-related communications.

The Safety of Life at Sea (SOLAS) Convention, first adopted in 1914 as a consequence of the *Titanic* casualty and now sponsored by the International Maritime Organization (IMO), complemented the International Radiotelegraph Convention and its International Telecommunications Union (ITU) radio regulation successors. SOLAS focused on mandating radio watchkeeping and defining carriage requirements for ships, while ITU radio regulations addressed distress radio frequency allocations radio procedures and personnel licensing, and radio equipment technical standards.

Lessons learned from this casualty affected regulations and procedures for shipboard distress and safety radiocommunications equipment still in existence today. Such technological innovations as radiotelephone, amplitude modulation, single sideband on 2182 kHz and later yet, very high frequency modulation on 156.8 MHz, were adopted in these conventions, as were automatic watchkeeping receivers and electronics based first on electron tubes, then transistors, and finally integrated circuit devices.

Nevertheless, Morse telegraphy distress watchkeeping on 500 kHz, first established by regulation on the 1906 International Radiotelegraph Convention and used by the *Titanic,* remained the primary international maritime distress system until the end of the 20th century.

COMSAT, INMARSAT

On August 27, 1962, President John F. Kennedy signed the Communications Satellite Act, establishing the Communications Satellite Corporation (COMSAT) to create a commercial satellite network. With the support of the U.S. Navy, COMSAT began operating MARISAT, the first maritime mobile satellite system in 1976 when three geostationary satellites were successfully launched over the Atlantic, Pacific, and Indian Oceans.

In 1966, the Inter-governmental Maritime Consultative Organization (predecessor to International Maritime Organization) appointed a panel of experts to investigate the possibilities of creating a maritime satellite system to improve maritime communications. In 1973, it hosted the first of a series of conferences to establish an international organization to operate such a system; and, from 1975 to 1976, a new intergovernmental organization named the International Maritime Satellite Organization (INMARSAT) worked to improve maritime, aeronautical, and land mobile communications. COMSAT became the U.S. representative to Inmarsat; and, in early 1982, Inmarsat commenced operations using leased MARISAT maritime satellites.

Upon Inmarsat’s successful start, the Intergovernmental Maritime Consultative Organization’s radiocommunications subcommittee began developing a maritime distress and safety system. ITU convened world administrative radio conferences in 1983 and 1987 in support of this effort. IMO adopted the Global Maritime Distress and Safety System (GMDSS) in 1988, as an amendment to the SOLAS Convention. This new system replaced the Morse radiotelegraphy system in place at the time of the *Titanic* casualty. GMDSS itself started to come into force on an incremental basis in 1993. It came into full effect on February 1, 1999.

The Global Maritime Distress and Safety System

GMDSS is a system of systems, comprised of Inmarsat satellite earth stations, satellite emergency position indicating radio beacons (EPIRBs) maintained by the COSPAS-SARSAT system, VHF, and MF/HF radio equipped with digital selective calling, search and rescue radar transponders, and maritime safety information receivers.

This technology eliminated the need for the radio officer position on ships and 500 kHz watchstanding positions ashore, and helped to fund GMDSS implementation. The International Hydrographic Organization, World Meteorological Organization, and IMO cooperatively established a worldwide system of navigational and meteorological areas by which GMDSS-equipped ships traveling anywhere on the globe could be assured of receiving relevant and timely navigational warnings, meteorological forecasts and warnings, search and rescue alerts, and ice warnings prepared by the International Ice patrol.

Under the SOLAS Convention, equipment carriage on ships was based upon the establishment of four areas of radio coverage:

- Sea Area A1 within VHF coverage of shore (~20 nm),
- Sea Area A2 based upon medium frequency coverage from shore (~70 nm),
- Sea Area A3 based upon Inmarsat's satellite footprint,
- Sea Area A4 for polar regions outside of Inmarsat's footprint.

With the later closing of most coast stations, Sea Area A3 became the default for most installations. In the U.S., Sea Area A2 was planned but never implemented and Sea Area A1 is being delayed until the end of 2012. While Sea Area A4's HF operations are still supported, the Coast Guard has no HF stations near the Arctic and GMDSS coverage there remains poor.

While GMDSS provided a clear and demonstrable improvement in maritime communications and in maritime safety, it wasn't an unqualified success. Digital selective calling, for example, assumed the existence of a public coast marine operator network, an assumption that proved wrong when such coast stations began disappearing as GMDSS came into force. Additionally, a high false-alert rate induced more than one ship to shut off the digital selective calling-equipped radios.

Continuing Improvement

Presently, new technology to replace elements of the Global Maritime Distress and Safety System is being developed. One example is the Automatic Identification System, a shipborne autonomous broadcast system that acts like a transponder and is already used on ships for navigation, vessel traffic management, and maritime domain awareness. IMO has already adopted the Automatic Identification System search and rescue transmitter as an element of the GMDSS, and IMO and ITU are investigating using AIS for distress communications as well. A scoping exercise on GMDSS modernization is nearing completion; and, if successful, full-scale planning may proceed.

Except possibly for such specialized equipment as the satellite EPIRB, the next generation GMDSS will likely not consist of specialized shipborne equipment at all, but instead may become embedded within the ship's communications and software systems, with capabilities provided to the mariner as part of an existing integrated navigation system display. Maritime safety broadcasts and distress messages will likely be graphically displayed, with communications largely by short message service or chat, backed by broadband communications systems.

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A Century of Technological Advancements on the Outer Continental Shelf

by CDR Robert L. Smith Jr.
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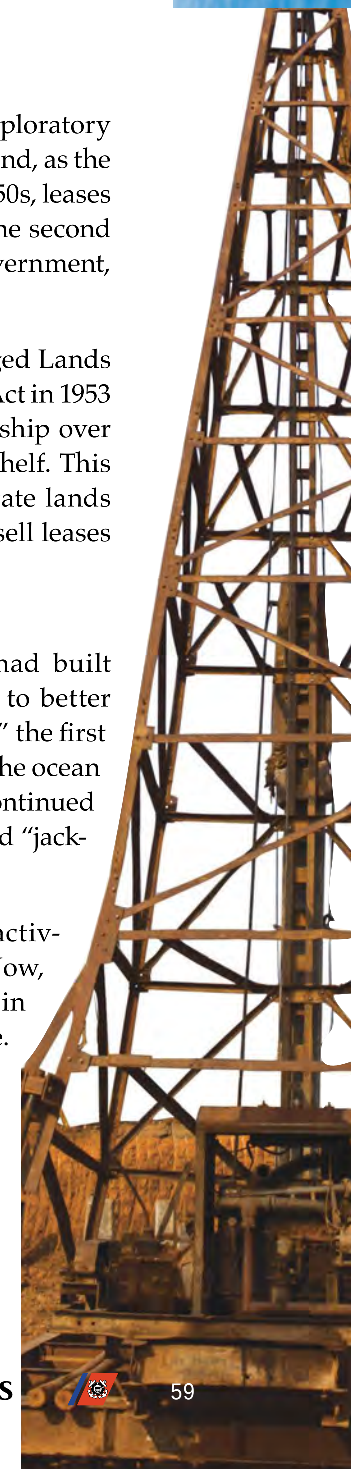

One hundred years ago, there was an offshore oil industry, but it was quite different than the one we know today. The maritime industry didn't operate in support of the outer continental shelf, and there were few maritime safety concerns regarding offshore oil exploration, discovery, and production. However, in the past 100 years, as U.S. and global thirst for oil has increased, technology has advanced, and maritime activity offshore has grown at an accelerated pace.

Offshore Origins

The origins of U.S. maritime offshore oil drilling and production can be traced to Summerland, Calif., in 1896, where oil wells extended out from the shore via wooden piers. However, this oil production method peaked by 1902 and only continued for approximately 25 more years. The piers were ultimately abandoned and the remaining structures razed by tidal storms. History also shows that oil wells were constructed over water without piers on the Great Lakes in the 1890s and on Louisiana's Caddo Lake in 1911. In the years following, oil companies continued to adapt land-based oil rig technologies to offshore maritime applications.

The American Petroleum Institute was founded in 1919 to facilitate communication among oil companies and government agencies. One of the first standards established was for drill pipe threading. Since then, it has developed more than 40 standards to improve offshore safety and oil production.

Oil Demand Boosts Post-War Economy

By early 20th century, oil had become an important resource to the public. The demand for oil and gas had skyrocketed and continued to escalate until after World War II. By 1949, 11 fields and 44 exploratory wells were operating in the Gulf of Mexico; and, as the U.S. economy continued to flourish in the 1950s, leases of federal land for oil production became the second largest revenue generator for the federal government, after income taxes.

The U.S. Congress passed the U.S. Submerged Lands Act and the Outer Continental Shelf Lands Act in 1953 to establish federal jurisdiction and ownership over submerged lands of the outer continental shelf. This defined the divide between federal and state lands and allowed the Department of Interior to sell leases for oil exploration and production.

Offshore Technology Evolves

By the early 1950s, various companies had built offshore oil drilling platforms, which led to better designs. One such project was "Mr. Charlie," the first mobile submersible drilling rig, secured to the ocean floor by anchors. Technological advances continued and gave rise to semi-submersible rigs called "jack-up" rigs, and drill ships.[1]

Additionally, limitations for maritime activity decreased as technology improved. Now, companies are not only able to drill for oil in greater depths but also farther from shore. For example, according to U.S. Mineral Management statistics, 79 percent of current oil production from federal leases in the Gulf of Mexico comes from wells drilled in water greater than 1,000 feet deep, dozens of discoveries have been made in depths

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Offshore Incidents, Resultant Safety Improvements

Major events have led to improvements in offshore safety in the past 50 years. Some of these notable events include:

1960s: Worker Safety Improvements, Environmental Protection Acts

In June 1964, a drilling barge experienced a blowout while drilling in the Gulf of Mexico. Of 43 crew members aboard, 21 were lost and another 22 suffered injuries. This incident led to the development of totally enclosed, motor-propelled offshore oil rig survival craft, which provide increased protection from fire and heat during blowouts and can facilitate a means of quick evacuation.

In January 1969, a blowout and ensuing oil spill from a platform in the Santa Barbara Channel received international attention and influenced future advancements in safety, responsible oversight, personnel training, and drilling technology. The Santa Barbara spill also influenced the passage of major state and federal legislation, such as the National Environmental Policy Act, the Clean Water Act, and the Coastal Zone Management Act.

1970s: Capping Strategies

In June 1979, an oil platform in the Gulf of Mexico experienced a blowout that led to a catastrophic explosion and oil spill that lasted for nine months until the well was finally capped. This blowout was at that time the world's largest oil spill in the history of the Gulf of Mexico. Although this accident served as a technological benchmark for well control and capping strategies, the lessons learned were not fully realized, as evidenced by further massive uncontrolled blowouts, such as *Deepwater Horizon.*

1980s: Regulatory Efforts

In March 1980, a semi-submersible rig was lost off the Norwegian continental shelf with 123 dead. The incident was attributed to a failed leg during gale-force winds, while the rig was serving as an accommodation vessel attached to another rig.

In July 1988, a fixed production platform in the North Sea was destroyed by a series of fires and explosions, resulting in 167 fatalities. The incident sparked major safety reform in the United Kingdom, namely designating only one regulatory authority for offshore safety. In that same year, the U.S. Department of Transportation (under which the Coast Guard operated at that time) created the National Offshore Safety Advisory Committee, which is a voluntary group assembled to assist the Coast Guard to gather information for the rulemaking process, particularly with regard to rules related to the safety and welfare of offshore workers, safeguarding the environment, and resource management.

Additionally, the U.S. Minerals Management Service formed a task force in 1989 to assess its outer continental shelf inspection program. Shortly afterward, it proposed safety and environmental management regulations for U.S. offshore operations, similar to safety changes made in the United Kingdom.

2010: Offshore Drilling Developments

In April 2010, the semi-submersible mobile offshore drilling unit *Deepwater Horizon* suffered a massive blowout in the Gulf of Mexico, leading to the loss of 11 offshore workers. The cause of the blowout and spill was attributed to an uncontrolled well flow, and fire. The spill lasted for almost three months and it was estimated that between 54,000 and 62,000 barrels of oil was released into the Gulf of Mexico daily.

The U.S. Coast Guard and the U.S. Department of Interior conducted an extensive joint investigation and published numerous safety recommendations. Additionally, the U.S. Coast Guard and the Bureau of Safety and Environmental Enforcement (a successor agency to Minerals Management Service) are considering amending existing safety regulations to further improve offshore safety and environmental protection.

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The *Thunder Horse* VHP LVXEP HUVLEOH SODWIRUP LV VHHQ OLVWLQJ DIWHU+ XUULFDQH'□ HQQLV□-XO□□□□□□8 6 &* □SKRWRE\ □3 HWW2 I¿FHU5 REHUW0 □5 HHG□

greater than 5,000 feet, and some oil production projects involve water depths of 10,000 feet or deeper.

MODU Standards

The International Maritime Organization (IMO) had established maritime safety standards for vessels through the International Convention for the Safety of Life at Sea early in the 20th century. However, safety standards for mobile offshore drilling units (MODUs) and semi-submersible oil drilling rigs did not exist until 1979, with publication of the Code for the Construction and Equipment of Mobile Offshore Drilling Units.

This MODU Code was further updated and amended in 1989; in 1994, amendments provided guidance for vessels with dynamic positioning systems, and introduced provisions for helicopter facilities.

The 2009 MODU Code is the most recent revision, providing an international standard for the new construction. The 2009 MODU Code facilitates international movement and operation to ensure a level of safety for such units and for personnel aboard. These updates, as well as lessons learned from drill rig accidents and the safety regulations created in their wake, all serve to help dramatically improve offshore safety.

Nonetheless, challenges continue. As oil drilling moves to deeper waters and technological advancement allows multiple vessels to operate in very close proximity, the stakes are higher and the margin for error is smaller.

Looking Ahead

Offshore projects have grown in size and complexity. As a result, drilling companies are now housing their workers on site in floating hotels (floatels). These accommodation vessels represent significant regulatory challenges, such as classification. Are they commercial structures or passenger vessels? Additionally, flag state and coastal state oversight of blowout preventer functionality and emergency disconnect systems remain significant challenges for the future.

The industry will continue to drill where oil can be discovered and produced at a competitive cost. The Arctic, and other areas with big potential, remain attractive targets for future maritime offshore drilling operations. As a result, the U.S. Coast Guard's

National Offshore Safety Advisory Committee continues to engage the public and offshore industry to identify best practices and deliver recommendations to improve safety.

These recommendations, coupled with lessons learned from past incidents, represent significant changes to come for safety standards on the outer continental shelf, as the next 100 years promise to bring even more change to the offshore industry.

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Endnotes:

1. A semi-submersible oil rig enjoys additional stability by flooding its pontoons and support columns with ballast water so that its structure is partially submerged. Jack-ups are floating rigs that can be jacked up out of the water on vertical support structures that are fixed to the ocean floor, adding increased stability.

   Early drill ships featured steerable propellers and used radar and sonar to determine position. Later developments included dynamic positioning systems with thrusters fore and aft that could rotate 360 degrees to maintain the vessel on station without being fixed or anchored to the sea floor.

Hazardous Materials Carriage

The history of vessel safety standards.

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Prior to the 20th century, requirements for safe hazardous materials carriage were considered unnecessary, since only a few of them were transported by vessel. Domestic legislation with reference to waterborne hazardous materials was scarce, and very basic rules applied. In general, hazardous materials were not permitted for vessel carriage if they were likely to endanger the health or safety of the passengers or the safety of the ship. In fact, vessel carriage of such goods was forbidden when the first convention for Safety of Life at Sea (SOLAS) was held in 1914. However, signatory nations moved forward and developed their own domestic carriage requirements, believing if certain approved conditions were followed, goods could be considered safe and thus allowed for carriage.

This loose structure of domestic hazardous material shipping regulations was maintained until the 1948 International SOLAS conference, where a new Chapter VI titled "Carriage of Grain and Dangerous Goods," was introduced. However, developing international standards such as the International Bulk Chemical Code, the International Gas Code, the International Maritime Solid Bulk Cargoes Code, and the International Maritime Dangerous Goods Code did not gain any real momentum until the International Maritime Organization (IMO) first met in 1959.

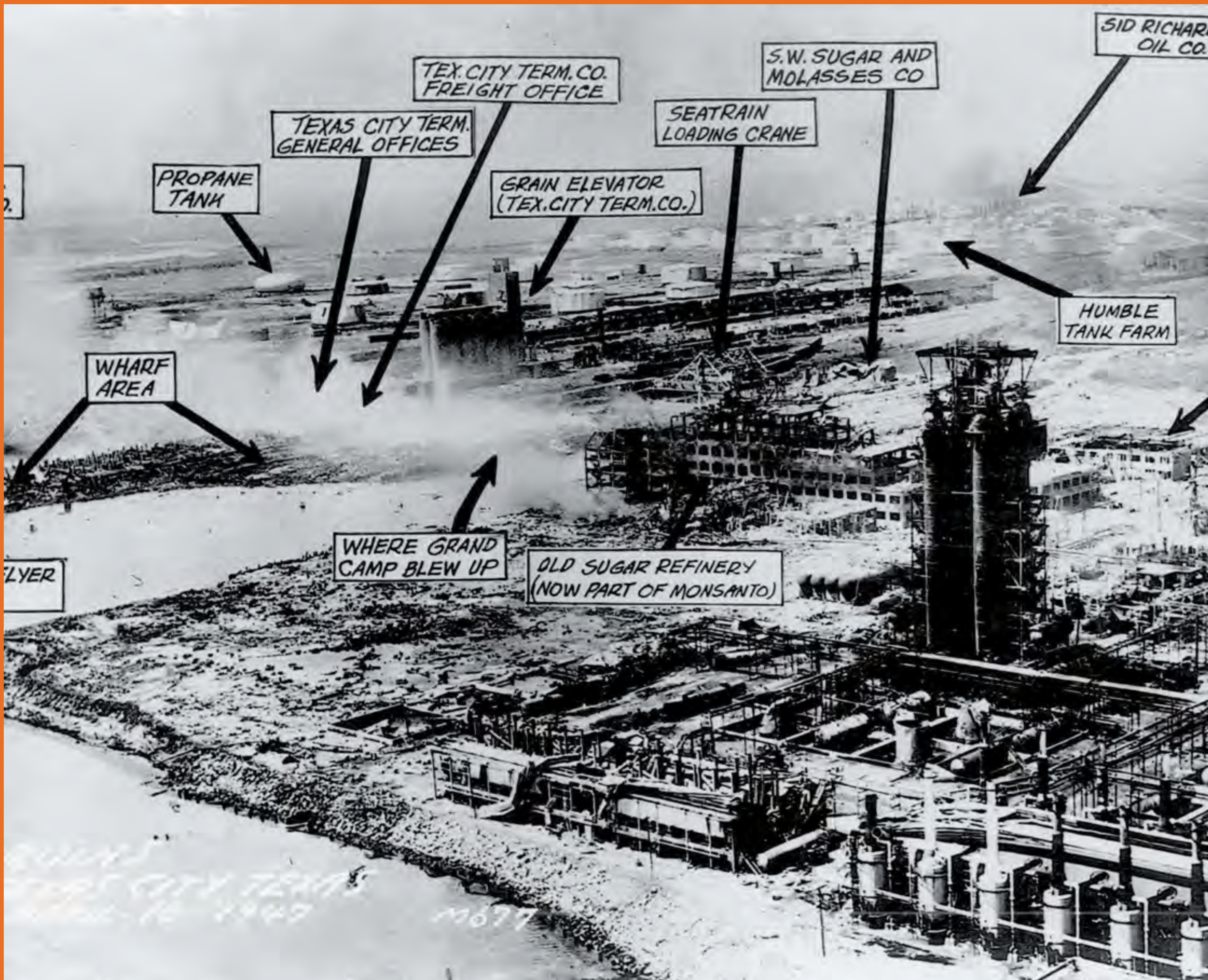
Incidents That Shaped Hazardous Materials Shipping

World War I and the Halifax Explosion

Congress passed the Espionage Act of 1917 shortly after the U.S. entered World War I, to prevent interference with military operations. In particular, the Coast Guard was given broad authority to control the movement of all vessels and establish anchorages and restricted areas.

This new authority was important in the context of increased munitions shipments in support of the war.

Tragically, such authority was validated on December 6, 1917, when the French freighter SS *Mont-Blanc,* fully loaded with explosive munitions, collided with the Norwegian steamship SS *Imo* in the harbor of Halifax, Nova Scotia, Canada. The collision resulted in a massive explosion that leveled nearly all buildings and structures within two square kilometers along the shoreline. Approximately 2,000 lives were lost and 9,000 were injured. This tragic event, coupled with increased war activities, led to the designation of Coast Guard officers as captains of the ports (COTP) in the United States, responsible to supervise safe loading, unloading, and handling of explosives in major ports.



Texas City disaster area, post-explosion photographs, 1947. Texas City disaster records, 1947–2003. Photo courtesy of Woodson Research Center, Fondren Library, Rice University.

World War II and the Port Chicago Disaster

On October 9, 1940, Congress passed the Dangerous Cargoes Act of 1940, anticipating a possible increase in United State's involvement in World War II. This act laid the groundwork for expanded hazardous materials regulations and new COTP authorities over vessel movements, dangerous cargoes loading and unloading, and anchorage protection. The U.S. officially entered the war the following year; and, as a result of this declaration of war, COTP activities expanded to handle wartime conditions.

Notwithstanding improvements in hazardous materials regulations and oversight, on July 17, 1944, the liberty ship SS *E. A. Bryan* exploded while docked at Port Chicago, Calif. The vessel was undergoing explosive munitions loading when a powerful explosion completely destroyed the vessel and caused extensive damage to an adjacent ship, *Quinault.* Approximately 320 individuals were lost and 390 were injured. This tragic event led to a mutiny within the U.S. Navy over unsafe working conditions during loading, unloading, and handling of explosives munitions. Aside from the social and political effects of the mutiny, the incident illustrated the need for more robust hazardous materials regulations.

Texas City Disaster

On April 16, 1947, the French vessel SS *Grandcamp,* loaded with industrial grade ammonium nitrate, exploded while docked in the Port of Texas City, Texas. The initial explosion leveled nearly 1,000 buildings and triggered fires and secondary explosions on the SS *High Flyer*, and on waterfront refineries and chemical facilities. A secondary explosion on the SS *High Flyer* tore the adjacent SS *Wilson B. Keene* to pieces. Nearly 600 lives were lost and approximately 3,500 were injured. This tragic event—still considered one of the largest industrial incidents in U.S. history—led to the creation of Chapter VI of SOLAS and international standards for vessel hazardous materials carriage.

Torrey Canyon Oil Disaster

On March 18, 1967, the supertanker *Torrey Canyon* ran aground off the coast of England, spilling 120,000 tons of crude oil into the sea—creating an oil slick of approximately 270 square miles. Oil washed ashore and contaminated coastlines in France and England. The oil spill led to changes in ship owner liability regulations and the adoption of the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1973.

Exxon Valdez

On March 24, 1989, shortly after midnight, the oil tanker *Exxon Valdez* struck Bligh Reef in Prince William Sound, Alaska, spilling more than 11 million gallons of crude oil. In the aftermath, the U.S. Congress passed the Oil Pollution Act of 1990, requiring the Coast Guard to strengthen its environmental regulations on oil tank vessels and oil tank owners and operators.

Hazardous Material Standards Evolution

U.S. Standards

Passenger Vessel Regulations

On February 28, 1871, Congress passed an act that placed restrictions and general requirements on certain articles carried by vessels. The law explicitly states:

> *"… gunpowder, nitro-glycerine, camphene, naphtha, benzene, benzole, coal-oil, crude or refined petroleum, oil of vitriol, nitric or other chemical acids, oil or spirits of turpentine, friction-matches and all other articles of like character, when packed or put up for shipment, shall be securely packed and put up separately from each other and from all other articles; and the package, box, cask, or other vessel containing the same shall be distinctly marked on the outside, with the name or description of the article contained therein."*

These and other common articles of the time, such as loose hay, loose cotton, and loose hemp, were prohibited by U.S. law on passenger steamers.

Tank Vessel Regulations

On August 26, 1935, the U.S. Congress passed Public Law No. 343 to:

> *"… provide for the inspection and regulation of vessels engaged in the transportation of inflammable, explosive, and like dangerous cargoes in navigable waters in the United States."*

Pursuant to this law, on August 5, 1936, the U.S. Department of Commerce's Bureau of Marine Inspection and Navigation published a comprehensive set of standards titled, "Rules and Regulations for Tank Vessels." With an effective date of November 10, 1936, these established comprehensive safety standards for tank vessels and formed the basis for subsequent bulk liquid carriage regulations found throughout CFR's Title 46. Of note, the August 5th regulations gave owners of existing vessels one year to comply with the new requirements.

Coast Guard Authority

Pursuant to the Dangerous Cargoes Act of 1940, regulations governing explosives or other dangerous articles or substances, and combustible liquids on board vessels were published in the *Federal Register* on January 11, 1941, and appeared in 46 CFR Part 146. These regulations were maintained primarily by the Coast Guard until shortly after the Hazardous Materials Transportation Act of 1974, which granted the Department of Transportation (DOT) expanded authority to provide protection against the risks to life and property inherent in the transportation of packaged hazardous materials in commerce.

Recognizing the intermodal nature of packaged hazardous materials, the Coast Guard relinquished primary control of those regulations to the DOT's Research and Special Programs Administration (RSPA), except for regulations governing vessel transport and storage of military explosives and regulations governing bulk transportation of solids, liquids, and gases in bulk carriers, tankers, and barges.

Many years later, in 1990, the Coast Guard further relinquished control of the regulations governing explosives to RSPA, and the explosives regulations were moved to Title 49 CFR Part 176. To this day, the Coast Guard maintains control of regulations governing ships' stores; shipboard fumigation; and bulk transportation of solids, liquids, and gases.

International Standards

International Bulk Chemical Code

IMO's Maritime Safety Committee (MSC) adopted the International Bulk Chemical (IBC) Code on June 17, 1983, to establish safe chemicals carriage. The code lists dangerous chemicals and noxious liquid substances transported in bulk by sea and their carriage and equipment requirements to minimize risk to the ship, crew, and environment. Under the provisions of Chapter VII of the SOLAS 74, as amended, chemical tankers constructed on or after July 1, 1986, must comply with IBC Code provisions.

MARPOL

The *Torrey Canyon* oil disaster raised questions about oil prevention measures and pollution control, triggering IMO to convene several conferences in 1973 to develop and adopt the International Convention for the Prevention of Pollution from Ships (MARPOL 73), which included regulations intended to prevent and minimize pollution from ships. Of particular note, MARPOL 73 contained two annexes related to the bulk transport of liquids by vessel: Annex I (pollution by oil) and Annex II (pollution by noxious liquid substances in bulk). These regulations included new double-hull requirements and discharge criteria that officially entered into force in 1983. IMO's Marine Environmental Protection Committee added carriage requirements to the IBC Code to implement Annex II, and, with that, the IBC Code was extended to cover marine pollution aspects.

International Gas Code

Under the provisions of Chapter VII in SOLAS 74, as amended, IMO's MSC also adopted the International Gas Code (IGC) at the same time as the IBC Code. The IGC applies to ships that carry bulk liquefied gases, having a vapor pressure exceeding 2.8 bar absolute at a temperature of 37.8 °C and other products. There are some chemicals the IGC describes, which takes precedence in those situations listed in both the International Bulk Chemical Code and International Gas Code.

International Maritime Solid Bulk Cargoes Code

Delegates to the 1960 International Conference on Safety of Life at Sea recognized the need to develop a code of safe practice for vessel carriage of solid bulk cargoes, as a result of the Texas City disaster and other related maritime incidents. IMO's Containers and Cargoes Subcommittee developed the code of safe practice; and, in 1965, published the first edition of the Code of Safe Practice for Solid Bulk Cargoes (BC Code), which focused on preventing accidents related to damage to the vessel due to improper cargo distribution, loss of stability during the voyage, and chemical reactions or hazards.

The BC Code was revised several times and remained non-mandatory until 1991, when IMO amended SOLAS Chapters VI and VII, which formerly applied only to grain cargoes and dangerous goods, respectively, to include all solid bulk cargoes. The amended Chapters VI and VII required the master be given written information about the cargo prior to loading and required oxygen and toxic and flammable gas detection equipment carriage when cargo was known to deplete oxygen or emit toxic or flammable gases in the cargo hold.

These amendments became binding for all nations signatory to the SOLAS Convention on January 1, 1994. In 2008, IMO further revised SOLAS Chapters VI and VII, officially making mandatory the International Maritime Solid Bulk Cargoes Code (previously known as the BC Code). These amendments became binding to all signatory nations on January 1, 2011.

International Maritime Dangerous Goods Code

During the 1948 International SOLAS conference, delegates adopted a recommendation that stressed the importance of international uniformity in hazardous materials regulations; and, in particular, established the need to develop definitions and classification criteria for hazardous materials and a standardized system of labeling and marking of packages. In addition, it called for developing a recognized standard; however, at the time there was no forum that could facilitate work in this regard with other modes of transportation.

This obstacle was removed in 1956, when the United Nations established the Committee of Experts on the Transport of Dangerous Goods (UN TDG). In 1957, the UN TDG developed the UN Recommendations on the Transport of Dangerous Goods, which is a set of transport requirements for hazardous materials that could be applied in all modes of transport. These regulations, commonly referred to as the "Orange Book," are updated every two years.

With the U.N. process in place, the delegates to the 1960 International SOLAS conference recommended developing a universal code for the transport of hazardous materials by sea. In response, IMO's Maritime Safety Committee held working group meetings to draft the first recommendatory version of the International Maritime Dangerous Goods (IMDG) Code, which IMO published in 1965. The code remained recommendatory for many years. It was reformatted in 2002; and, subsequently, made mandatory on January 1, 2004 (under SOLAS Chapters VI and VII). Additionally, it is updated and harmonized with the U.N. regulations every two years.

Going Forward

Although the history of hazardous materials shipping and regulations has been marred by tragedy and loss of life, many advances have been made over the years to improve shipping safety. The hazardous materials regulations are constantly evolving and the Coast Guard continues to work with the U.N., IMO, DOT, other governmental agencies, industry, and foreign governments to ensure an appropriate level of safety.

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The Coast Guard Marine Safety Center

Working to ensure cruise ship safety.

by LCDR Randy Jenkins
Chief, Major Vessel Branch
U.S. Coast Guard Marine Safety Center

Today, cruise ships are among the most technologically complex modes of transportation available to the consumer. These floating cities include entertainment venues, such as movie theaters, bowling alleys, interactive play areas, and water slides, and carry thousands of passengers. Therefore, it is imperative that these massive vessels are operated safely.

In the United States, the U.S. Coast Guard is responsible for ensuring that cruise ships operating out of U.S. ports comply with appropriate safety standards.

History

The Coast Guard's involvement in commercial vessel safety dates back to the 1800s with the Steamboat Inspection Service, one of the Coast Guard's ancestor agencies. The Steamboat Inspection Service was created to safeguard lives and property at sea. However, at the time when the RMS *Titanic* sailed on its fateful voyage, there were no requirements for the service to inspect foreign-flagged passenger vessels.

U.S. Coast Guard Marine Safety Center

The Marine Safety Center's primary mission is to review and approve plans for the design, construction, alteration and repair of U.S. and foreign flag commercial ships subject to U.S. laws, regulations and international standards.

We coordinate these actions with Coast Guard sector commands and marine safety units, who carry out vessel inspections and examinations, and work closely with the maritime community, including naval architects, marine engineers, classification societies, and the shipbuilding industry.

Our technical competency and relationships with the maritime community make us well suited to support the control verification examination program.

Mr. Tom Woodford and LCDR Brent Yezefski review plans for a new cruise ship. All photos USCG.

Galley water mist system test.

In the 1960s, the Navigation and Vessel Inspection Circular (NVIC) 3-08 program was developed to provide guidance for plan review and examinations on foreign cruise ships that embark passengers in U.S. ports or call at U.S. ports with U.S. citizens as passengers.

Coast Guard requirements for foreign-flagged cruise ships have come a long way since this program was first initiated. Today, prior to operation from a U.S. port, a foreign-flagged cruise ship must go through a rigorous "screening" process known as the control verification examination (CVE) program. In support of this program, the USCG Marine Safety Center (MSC) provides technical engineering oversight from the preliminary design proposal to the delivery of the ship to its first U.S. port of call.

Oversight Begins With Vessel Design

The first stage of a CVE begins in the planning process—well before a shipyard starts the construction of a new class of ships. The Marine Safety Center holds a concept review meeting to identify any unique engineering systems or proposed alternatives that may require compliance with U.S. interpretations of international standards.

In recent years, the Marine Safety Center has seen an increase in the number of designs offering alternatives to what is prescribed in international standards, as ship owners continuously develop new features and attractions to maintain their competitive edge and provide cruise ship customers with a unique sailing experience. Typical alternative designs include novel structural fire-protection boundaries or extension of main vertical fire zones.

Reviewing alternative designs can be especially challenging, as they are usually highly technical, full of engineering rigor and assumptions, and require the training and skills of our Marine Safety Center fire protection engineers.

Construction Plan Review

Once a design is accepted in concept, the next step is for the shipyard to develop detailed vessel construction plans. As established in the CVE program, the Marine Safety Center reviews these plans for compliance with appropriate international standards and Coast Guard interpretations of these standards.

The MSC's primary focus is on the vessel's fire protection and life safety arrangements. If a fire occurs, we want to ensure the ship is designed to keep the effects isolated. We do this during plan review by assessing the fire control, structural fire protection, and emergency escape arrangements.

Additionally, we review the subdivision arrangements and stability properties of the ship to ensure it will float—if it were to hit an object below the waterline. This review has ties back to the subdivision and

LCDR Randy Jenkins conducts a smoke-extraction system test. At the end of this 10-minute test, passengers should be able to see an exit sign.

7KLV SKRWR LOOXVWUDWHV LPSURSHU LQVWDOODWLRQ RI VWUXFWXUDO ¿UH SURWHFWLRQ² LQVXODWLRQ is excessively compressed in way of pins.

watertight integrity requirements that were implemented after the sinking of the *Titanic*.

Our review also includes a space-by-space assessment of how the different areas of the ship are going to be used, how they are going to be segregated and protected from impact damage and fire, and how the passengers are going to escape in the event of a fire or other incident.

Construction Inspection

The Marine Safety Center's involvement does not end there. We also travel to the shipyard to inspect the vessel during construction and verify that the ship is being constructed in accordance with the reviewed plans. Our first visit is usually near the halfway point of construction to inspect the workmanship and shipyard procedures related to the installation of fire protection measures.

We also attend the ship at the end of construction, right before the shipyard delivers the ship to the owner. At this stage, the ship is completely outfitted and ready for operation in the U.S., pending Coast Guard certification.

Certificate of Compliance Exam

This final inspection is the initial control verification examination (or initial certificate of compliance exam). During this exam, the MSC reviews the fire control arrangements, which include heat- and smoke-detection systems, alarms, sprinkler systems, and ventilation systems, among other things. The Marine Safety Center also witnesses tests of the emergency power system and smoke management systems.

USCG Examiner Training

In addition to carrying out plan review and initial control verification work, the Marine Safety Center also helps train Coast Guard inspectors for this type of work. We contribute regularly at each Advanced Foreign Passenger Vessel Examiner Course that is hosted by the Coast Guard's Cruise Ship National Center of Expertise in Fort Lauderdale, Fla. We send marine safety engineers as guest instructors during the structural fire protection portion of the course, share lessons learned from previous CVEs, and provide guidance to future Coast Guard cruise ship inspectors and representatives from the cruise ship industry.

The MSC is also called upon regularly to help interpret the requirements of relevant international standards and prepare inspection job aids for Coast Guard field units. If needed, we can also deploy to a port or vessel to help with ship design inspection or review modifications that are particularly challenging.

While most passengers may only be aware of the Coast Guard's involvement with periodic inspections of life preservers and lifeboats, we do much more to ensure cruise ship safety. The Marine Safety Center is involved from the earliest stages of ship concept approval to the last vessel exam before it is issued a certificate of compliance, allowing it to operate in the U.S.

About the author:

LCDR Randy Jenkins is the chief of the Major Vessel Branch at the USCG Marine Safety Center. His primary duties include managing plan review responsibilities and Marine Safety Center involvement in overseas inspections. His prior assignments include inspections field tours at MSO Hampton Roads and Sector San Diego. LCDR Jenkins graduated from the U.S. Merchant Marine Academy with a degree in marine transportation and received a master's degree in fire protection engineering from Worcester Polytechnic Institute.

What Hath Regulation Wrought?

Third-party ship management.

by Mr. Daniel F. Sheehan, P.E.
Maritime Advisor
Anglo Eastern Ship Management

The inexorable growth and expansion of international regulation of maritime shipping did not start with the RMS *Titanic;* however, the disaster did establish a need for international standards of safety beyond those that were the dominion of sovereign governments. International standards for some segments of maritime trade existed, but were often ignored through lack of enforcement or personal preference.

For example, in 1906, the International Wireless Congress adopted "SOS" as the standard Morse distress signal; in 1908, Britain adopted the standard. However, the radio operators aboard the *Titanic* initially sent the distress signal "CQD" because they preferred it over the new signal. The junior radio officer suggested to the laughter of the captain and the chief radio officer, "Why don't you send the new SOS signal; it may be the last time you get to do it." [1]

What Hath God Wrought

While there were missed opportunities for rescue, wireless radiotelegraphy was of recent vintage and implementation onboard ship was illustrative of technology outpacing standardization. The first telegraph message: "What Hath God Wrought?" had been sent just 68 years before.[2] This is a situation still evident in today's maritime endeavors. Technology and innovation are hallmarks of the maritime industry and the regulatory standards developed to safely transport new cargoes with new ships have required innovation.

While the *Titanic* was a maritime disaster that still resonates after 100 years, ironically, much of what is known about icebergs comes from observations related to the disaster. The statement that 80 to 90 percent of an iceberg's mass is invisible from the surface of the ocean is also an apt metaphor for shipping and the regulatory regimes and requirements that have developed in the 100 years since the *Titanic* disaster.

The Need for Requirements

In 1912, there wasn't an International Maritime Organization, no Safety of Life at Sea convention, nor were there many universally accepted international maritime treaties. The major maritime nations of the day, through tradition, practice, trade, and their own domestic law, established requirements for their ships and seafarers.

Port state control was limited primarily to customs and immigration officials; ships had few mandatory certificates or certifications other than a certificate of registry. Contrast that with today's ships that must have about two dozen internationally required certificates that attest to compliance with more than 30 international conventions, treaties, protocols, and guidelines. This is in addition to specific flag state requirements that may be in excess of international requirements.

The administrative, logistical support necessities and regulatory compliance requirements represent a considerable challenge to, and commitment from, the ship owner. Similar to the iceberg, considerable effort is not evident and is often under-appreciated in terms of expending resources and coordination to keep international shipping and trade performing with the enviable safety and environmental record now being achieved. Third-party ship managers are a common, important concept of this ship support network.

What are Third-Party Ship Managers and Why are They so Prevalent?

Let's examine the last part of the question first. The administrative, compliance, and documentation overhead involved in ship operation is not only complex but it is also always changing. Many owners with just one or two ships found that the personnel and capital investment required to accomplish all required documentation and administration to maintain continued compliance with flag and port state control requirements was disproportionate to the number of ships owned.

Similarly, with only one or two ships, there was minimal purchasing leverage for maintenance and stores, and recruiting and retaining trained seafarers was a challenge as well. For a fixed fee plus expenses, a third-party ship management organization can take advantage of economies of scale for purchases, substantially reduce the costs of administrative overhead, secure a trained crew, and provide uniform compliance with international requirements.

Some larger ship owners with established in-house staffs expanded their business model to manage ships for others, thereby taking advantage of the economies of scale that a larger fleet accorded their ships as well as the ships they managed by contract. In some instances, financial institutions that took over ships through foreclosure looked to third-party ship managers to maintain a revenue stream until the ships could be sold.

Options for ship ownership have also expanded. While there still are corporate and private family-owned ships, more and more ships are "investments," either owned by a publicly traded company or owned by a collection of owners with little or no ship owning or operating experience.

For example, the German KG system of off-balance ship financing established a mechanism for limited partners to invest in ship financing. Today, nearly a third of the world's container fleet is owned by KG financed limited partners.[3] While apocryphal, KGs are often characterized as owned by German dentists, not a cohort with traditional maritime background.

Ship Manager Responsibilities and Roles

Third-party ship managers typically perform or operate in one or more of the following roles:

Full, technical top-to-bottom ship management
The ship manager supplies:

- professional crews for ships, arranging for rotations and continued training;
- all maintenance, dry dockings, emergency repairs, and stores replenishment;
- all contact and interaction with the flag state and classification societies;
- all required documentation, certificates, and arrangements for all required surveys;
- quality assurance and independent compliance oversight;
- maintenance of emergency response capability and 24/7 technical support.

Crewing management and services

- Providing crews, managing crew rotation and training;
- The specific proviso and allocation of shipboard and ship support functions are negotiated on a vessel-by-vessel basis.

While some owners prefer to avail themselves of crew services only, this arrangement bifurcates the ship management function and requires clear delineation and definition of responsibilities.

Functions not normally performed by third-party ship managers
Typically, third-party ship management does not handle the commercial or chartering arrangements of the ship.

How Does a Third-Party Ship Management Organization Accomplish This?

The short answer is by focusing on people, processes, and quality control. To provide a perspective concerning the challenges for a third-party ship manager, it is instructive to look at the potential inherent complexities.

- **Multiple ship types:** tankers, bulk carriers, container ships, specialty ships, passenger vessels and mobile offshore drilling units.
- **Multiple flags:** often ship owners flag ships in their fleet under several flags. This is frequently driven by variables such as ship finance arrangements, personal preference, and charter party requirements.
- **Multiple markets:** port state control, port facilities, international conflicts, and changing market demands.
- **Multiple recognized organizations and class societies.**
- **Multiple owners and owning arrangements.**

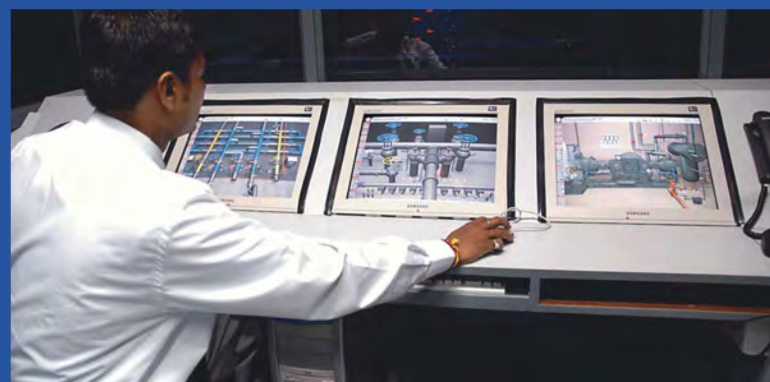
Trained Personnel

To deal with these issues, the third-party ship management firms provide trained personnel ashore and afloat. Large ship management companies often employ thousands of seafarers, including more than 1,000 shore-side personnel to support their sizable fleets.

Regional distribution centers often manage personnel located around the world, and some firms operate their own entry-level training centers, or cadet academies. A ship superintendent team consisting of staff shipmasters and engineers are tasked to handle around eight to 10 vessels, and an assigned fleet manager will oversee several of these groups.

Additionally, third-party managers provide refresher training for the professional, dedicated, and knowledgeable individuals who support shipping. As in professions like medicine, there are basic skill sets required by seafarers. A good ship management firm recognizes this and provides that support. As a result, licensed maritime officers, both deck and engineering, often become specialists in a type of ship, ship propulsion, and operation.

Anglo Eastern Ship Management's diesel engine maintenance module. Photos courtesy of Anglo Eastern Ship Management.



An instructor programs the control station to introduce tasks and problems for simulation exercises.

Information Technology

A centralized Web-based portal can provide superintendents and ship officers with day-to-day updates on every facet of a ship's operations as well as providing comprehensive maintenance scheduling, inspection, certificate renewal reminders, and complete information concerning the crew complement.

Quality, Health, Safety, and Environment (QHSE)

Many third-party ship management firms are ISO-certified, their quality management systems comply with classification society safety management rules, and many offer certificated auditors with Master Mariner Class 1 certificates who audit vessels on a regular basis.

Incident investigation and analysis are also integral parts of a QHSE program. Lessons learned from them are shared across the fleet as well as across the industry, as appropriate.

Final Thoughts

The maritime industry is used to change and unpredictability—just think about weather, piracy, and voyage charters. While uncertainty is a part of any ship operation, the prudent ship operator seeks to minimize any uncertainties through implementing processes, systems, and quality assurance accomplished by qualified personnel ashore and afloat.

Third-party ship management is a unique, important, and growing segment of the maritime industry. The function and role is analogous to a traditional Navy or Coast Guard, in that full technical management of all aspects of ship operation and support are planned for and provided. The fleet approach provides consistency, coupled with a cadre of continuously trained professional seafarers that ultimately provides substantial benefits to all stakeholders.

About the author:

Mr. Sheehan retired from the Coast Guard's Senior Executive Service in 2000. While with the Coast Guard, he held the following positions: director, Information and Technology; director, National Pollution Funds Center; associate program director, Office of Merchant Marine Safety, Security, and Environmental Protection. Mr. Sheehan served as a maritime advisor to the Republic of the Marshall Islands, and continues to participate in maritime matters involving safety, security, and environmental protection. Mr. Sheehan is the recipient of numerous awards and commendations, and holds the rank of Distinguished Presidential Executive.

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Industry Standards that Complement Safety Regulations

An international solution for a global industry.

by Captain Charles H. Piersall
*Chairman ISO Ships and Marine Technology Committee
and ISO Head of Delegations to IMO*

The public has witnessed an increase of standardization in the past 100 years. In fact, standardization is so common these days that one does not have to look far to find some form of it. It is often found in places like work environments, from manufacturing to service industries, and engineering departments to executive offices. Standardization helps companies and corporations run smoothly.

Standardization goes beyond product specifications and requirements. Today, standards are a routine way of life. For example, credit cards can be used globally, and the use of a "pdf" document is an international standard. It is difficult to imagine a time when almost nothing was "standardized."

Standards come in many manifestations: regulatory (mandatory requirements); rules (classification societies' technical requirements, documents, and associated unified interpretations of international statutory regulations); and industry standards (voluntary, consensus, and publicly available), which reduce barriers to trade and create harmonized global markets.

ISO and International Standards

The International Organization for Standardization (ISO) is the world's largest standards developing organization—comprised of 163 national standards bodies. From 1947 to present day, ISO has published more than 18,500 international standards.

By 1965, emphasis among multinational companies, standards institutions, and government regulatory authorities had begun to shift from national to international standards. One of the main causes for this acceleration in the pace of international standardization was an explosive growth in international trade linked to a revolution in transportation methods.

For industry, standardization is a strategic business decision. It is more than a set of technical documents: It is a market tool to open new markets, reduce trade barriers, and ensure competitiveness. The widespread

Standardization Over Time

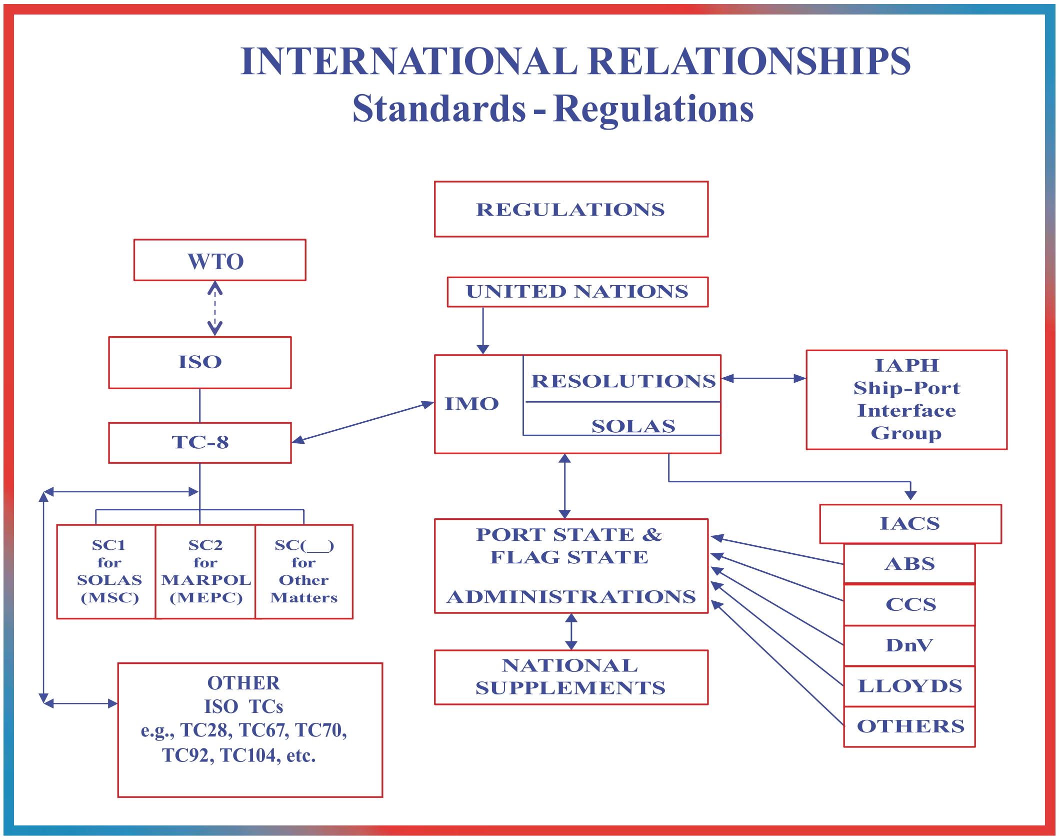
Standardization can be traced back to relics found from the ancient civilizations of Babylon and early Egypt, which show those societies' use of a system of weights and measures.

As trade and commerce developed, written documents evolved that set mutually agreed-upon standards for products and services. Initially, standards were part of a single contract between supplier and buyer.

These advanced across a wide range of transactions, ultimately forming the basis for a modern system of standardization.

adoption of international standards means suppliers can now develop and offer products and services meeting common specifications that have wide international acceptance in their sectors. Businesses using international standards can compete in markets around the world.

For governments, international standards provide solid technological and scientific basis for health, safety, and environmental legislation and regulations.



The organizational relationships among the ISO, international and national regulatory bodies, and recognized organizations commonly authorized to carry out certain vessel inspection functions on behalf of governments.

The Birth of Maritime Standards

It took several major disasters to focus the world's attention on the need for internationally recognized regulatory requirements for safety at sea and protection of the marine environment. The *Titanic* sinking in 1912, and the fire on the SS *Morro Castle* in 1934, are two main influences.

These events were major driving forces in the effort to create a permanent international body to promote maritime safety, but it was not until the United Nations was established that this idea became a reality. In 1948, an international convention established the Inter-Governmental Maritime Consultative Organization (IMCO), which was renamed the International Maritime Organization (IMO) in 1982.

While safety was IMO's most important responsibility, a new problem began to emerge—water pollution. In 1967, the *Torrey Canyon* spilled more than 500,000 barrels of oil when it ran aground off England's shore. This incident demonstrated that a large oil tanker carrying large volumes of oil has the potential to harm the marine environment.

Following that incident, IMO introduced a series of measures designed to prevent tanker accidents and to minimize consequences. The organization also tackled the environmental threat caused by routine operations, such as cleaning oil cargo tanks and disposing engine room wastes. In tonnage terms, this posed a bigger menace than accidental pollution. The most important of all these measures was the International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978 relating thereto, otherwise known as MARPOL 73/78.

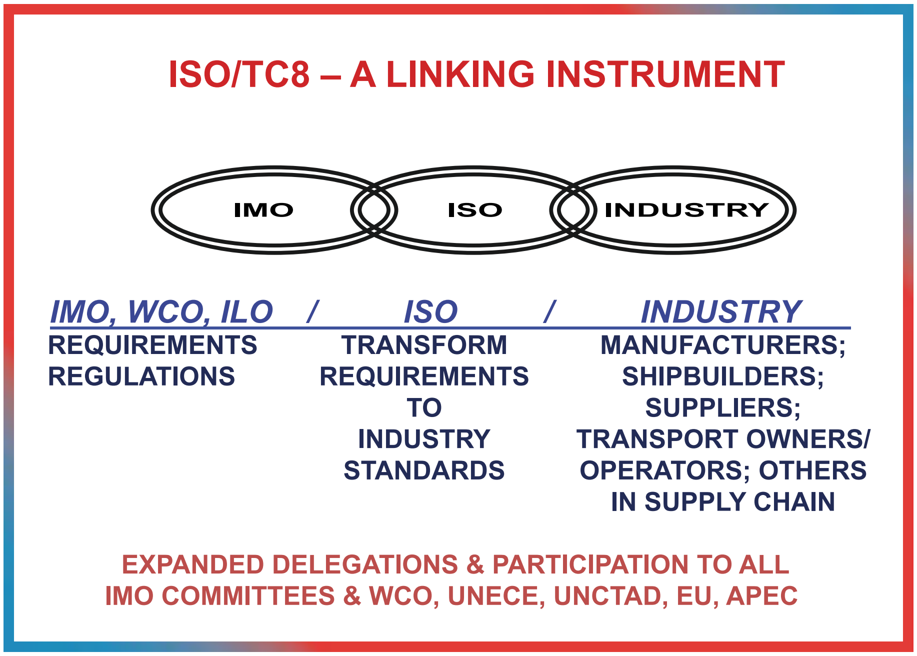
Organizing to Meet Paradigm Shifts and Market Needs

The ISO is organized into technical committees to address a wide range of standards. Its Ships and Marine Technology Committee (ISO/TC8) is the principal committee for maritime industry standards. ISO/TC8, founded in 1947, focused initially on individual product standards for shipbuilding and repair.

In 1995, ISO/TC8 adopted a new strategic vision that emphasized active collaboration with the International Maritime Organization and other regulatory governmental bodies, and a shift in focus toward process and system standards. The new objectives emphasized "sustainable" standards, bridging the needs of industry with those of regulatory bodies and creating specific subcommittees to address lifesaving, fire protection, and marine environmental protection standards.

Developing Strong Strategic Partnerships

International Maritime Organization. In 1961, ISO was the second non-governmental organization to which IMO granted collaborative observer status. This



ISO strategic partnerships.

partnership became more active and engaged in 1995 when the ISO Ships and Marine Technology Committee chair met with the deputy director of IMO's Maritime Safety Division, and they decided that ISO/TC8 would assist IMO on various items of interest. With the new ISO/TC8 committee structure, the start of a proactive relationship with IMO was underway, establishing the ISO/TC8 "linking instrument."

Ever since, the strategic partnership with IMO has grown exponentially. An ISO/TC8 delegation participates in all IMO committee and subcommittee meetings, with the exception of the legal committee. ISO has more than 100 work items, and published standards directly in support of IMO needs and the list is expanding.

Many ISO standards are referenced in the IMO Fire Safety Code, the High Speed Craft Code, Safety of Life at Sea, and MARPOL conventions as well as numerous other IMO regulations, resolutions, and circulars.

International Association of Classification Societies. ISO has established a close partnership with the International Association of Classification Societies, in recognition of the important rulemaking and surveying responsibilities of the classification societies in shipping and shipbuilding. Thus, in the overall standards developing process for the international maritime community, the complimentary roles of regulation, rules, and industry standards are well coordinated.

Other key liaisons. ISO/TC8 has liaisons with many international and regional governmental and non-governmental organizations including the International Chamber of Shipping, World Customs Organization, United Nations Conference on Trade and Development, International Mobile Satellite Organization, Asian Pacific Economic Cooperation, and European Union.

ISO/TC8 Current Major Work Areas

The focus of ISO's Ships and Marine Technology Committee has centered on the standards for marine safety, with a strong emphasis on lifesaving and fire protection, maritime and supply chain security, the marine environment, navigation, and ship operations.

Two major, certifiable, risk-based management systems standards are published and widely implemented:

- ISO 28000 series: Supply Chain Security Management Systems, which is the only published international, certifiable, risk-based standard covering all disruptions to supply chains. It addresses resilience and recovery, and is applicable to all transportation sectors.
- ISO 30000: Ship Recycling, developed with IMO and others, facilitates industry implementation of IMO requirements, and supports and supplements IMO conventions, guidelines, and regulations that address ship recycling.

ISO/TC8 continues to look for areas where additional standards are needed. Examples of future direction include:

- Arctic polar code support, focusing on ship design, ship operations, cruise ships, environment, security, piracy, navigation, and search and rescue;
- advances in marine technology, including offshore structures such as wind farms, wave energy farms, marine agriculture/aquaculture, buoys, and moored special purpose vessels;
- emerging vessel types, such as floating hotel ships, prison ships, and wing-in-ground vessels;
- significant advances in lifesaving, fire protection, and other marine environment issues, such as energy efficiency, marine fuels, and emissions.

The U.S. Coast Guard Example

President Clinton's 1993 Shipbuilding Initiative helped to develop internationally recognized standards, promoted use of international regulations consistent with domestic regulations, increased use of voluntary consensus industry standards in lieu of regulations, and fostered support for international standards, thus enhancing a U.S. leadership role in their development.

Reinforcing this initiative is Public Law 104-113, the National Technology Transfer and Advancement Act, enacted to strengthen the policies of OMB (Office of Management and Budget) Circular No. A-119 *Federal Register* (Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities). It enhances government commitment to voluntary consensus standards developed by the private sector, requires an agency to obtain a written waiver from OMB if they wish to forego the use of voluntary consensus standards, and requires OMB to transmit to Congress a written annual report summarizing all explanations for waivers granted during the preceding year.

Alternate Compliance Program

The Coast Guard has consistently followed these laws and directives, emphasizing adopting (when possible) IMO regulations instead of creating new national standards; maximizing the use of voluntary consensus standards; and removing obsolete, unnecessary, outdated regulations.

Additionally, the Coast Guard adopted a program known as the Alternate Compliance Program (ACP), intended to reduce the regulatory burden on the maritime industry, while maintaining existing levels of safety and providing increased flexibility in the construction and operation of U.S.-flag vessels.

In this voluntary program, classification society rules, international conventions, and an approved U.S. supplement provide alternatives equivalent to the requirements in the Code of Federal Regulations. Compliance with this equivalent alternative standard is administered through authorized classification society surveys and inspections. The Coast Guard issues a certificate of inspection based upon classification society reports.

Industry Standards

Additionally, the Coast Guard has adopted more than 500 industry standards, saving potentially thousands of pages of federal regulations and associated document maintenance. Industry-developed standards ensure best universal market acceptance, since the primary priority of industry is to produce standards in a timely manner for products capable of competing in worldwide markets.

The U.S. Coast Guard continues to be a government leader in the use of industry standards. USCG follows the full intent and spirit of the president's 1993 National Shipbuilding Initiative, Public Law 104-113, and OMB Circular A-119 as well as the World Trade Organization Technical Barriers to Trade Agreement.

Maximizing the use of its scarce human and capital resources, by following these management initiatives, allows the Coast Guard to focus on technical, inspection, and critical operational matters.

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About the author:

Captain Charles Piersall is a retired U.S. Navy captain with more than 55 years of maritime service, first as a senior naval officer and then as an industry executive. Captain Piersall is recognized worldwide as the leader in the field of international maritime standards and supply chain security. He has been chair of ISO's Committee on Ships and Marine Technology for 17 years. He is an engineer, economist, author, and teacher.

Classification's Imprint on International Regulation

by Mr. Steven McIntyre
Vice President of Regulatory Affairs
American Bureau of Shipping

After World War II, most of the world's maritime regulations were developed through the efforts of the International Maritime Organization (IMO), a specialized agency of the United Nations. Once the delegates of the IMO member nations, also known as the flag states, adopt international regulations for ship safety and pollution prevention, many routinely authorize classification societies, or other organizations, to act as agents and conduct design reviews and statutory surveys to ensure all vessels comply with the standards required for their class.

Classification societies began performing statutory surveys on behalf of flag states as a significant service in 1952, the year the 1948 International Convention on Safety of Life at Sea (SOLAS) entered into force. As successive international regulations entered into force over the years, statutory surveys grew to become vital elements in the maritime world's safety and pollution prevention regime. Some of the most important regulations created at that time came from the revised SOLAS Convention in 1980, the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1983, and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers in 1984.

An equally vital component of the maritime safety regime is the imprint that classification societies have made on international regulation via their advisory roles at the IMO. Through their professional organization, the International Association of Classification Societies (IACS), classification societies have served IMO since 1969 as technical experts in the legislative debates through which international regulations are created and amended.

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The first IACS-like pooling of classification society experience occurred in 1938, when seven societies began gathering informally with the intent of developing a degree of harmony among their rules. These meetings came about following a request written into the 1930 Load Line Convention (an international treaty establishing limits on the draught to which ships may be loaded, expressed as freeboard), which asked classification societies to uniformly apply the standards of strength on which freeboard is based.

Regulation 1 of the 1966 Load Line Convention instructs that when applying load line requirements, if a vessel complies with the rules of a classification society, the flag state can conclude that it has sufficient strength to be compatible with the requirements of the load line convention.[1] The reasoning behind this is that ship strength and stability are intrinsically linked; therefore, complying with a class society's strength rules and statutory stability requirements provide the fundamental basis for ship safety on which the IMO conventions build. Recognizing classification societies still promulgated their own standards at the time, which in some matters differed significantly, regulators again called on them to harmonize their strength requirements, which led to the formal establishment of IACS in 1968.


The Marine Environment Protection Committee is a key IMO forum for regulatory formation, where classification societies play a key role. Photo courtesy of the IMO Information Office.

The International Association of Classification Societies was made a non-governmental organization with observer status at the IMO in 1969. Over the ensuing four decades, classification societies have provided the independent voice of technical reality in IMO's regulatory debates.

How Classification Contributes to the International Regulatory Process

Classification societies participate at the International Maritime Organization collectively through IACS, or individually as advisors to national delegations. For example, several flag states, including the United States through the U.S. Coast Guard, regularly invite the American Bureau of Shipping (ABS) to provide advisors to their IMO delegations. Most often, classification societies provide input to regulatory development through their collaborative work in the International Association of Classification Societies, through their people chairing, or otherwise participating in the IACS groups that develop submissions to the IMO, or by contributing to the various groups and committees that develop IACS unified interpretations of the international conventions for IMO member states' consideration.

Because regulations form in a crucible of politics, debate, and compromise, regulatory text can end up containing vague expressions that are sometimes open to widely varying interpretations when individual recognized organizations attempt to apply them to ships. When different interpretations lead to implementation conflicts, the matter is frequently brought before IACS, primarily its statutory panel, and is frequently resolved by developing unified interpretations (UIs).

Since interpretation of the convention regulations is the prerogative of the flag states (and not their recognized organizations), IACS UIs are submitted to the IMO with the advice to all flag states that IACS societies will apply the UIs when acting on behalf of the flag states, which authorize them as recognized organizations, unless a flag state instructs its recognized organizations otherwise.

Subsequently, IMO committees or subcommittees formally review the IACS UIs and may agree with them, modify them, or ask IACS to undertake further work to modify them. In many cases, these unified interpretations are subsequently used to further update/amend the related regulations, so that the regulations themselves become progressively clearer and better developed through this feedback.

Even texts that are not so vague can be problematic. The many agendas in play at IMO, and their need to compromise to reach agreement on regulatory text, often produce a working atmosphere, where essentially, the practical details and difficulties of implementation may not be fully anticipated at the time of adoption. As proposals progress along the path of development, the International Association of Classification Societies informs the IMO membership of their technical implications, advises on implementation, and, through its technical committees, goes through the often painstaking process of turning regulatory concepts into technical instructions. This part of the process, which is critical to a convention's ability to achieve the goals of its framers, can become a very complex, long-term endeavor, requiring the collective labors of hundreds of classification society engineers and surveyors.

Collaborating in these ways, the IACS member societies have contributed significantly to bringing many of the regulatory goals of the International Maritime

ABS statutory survey of a Portuguese-flag tugboat in the Naval Rocha shipyard, Lisbon. Acting as recognized organizations, class societies provide verification that vessels adhere to the rules of their flag state. Photo courtesy of the American Bureau of Shipping.

Organization to practical fruition. One notable example is the enhanced survey program. In 1992, IMO followed the U.S. Oil Pollution Act of 1990 by amending MARPOL with a mandate that oil tankers would henceforth be built with double hulls. The convention also mandated that existing single-hull tankers be subjected to a more rigorous scope of periodic surveys in the lead up to their mandatory phase-out. The IACS Working Party on Surveys, Reporting and Certification, under the chairmanship of Gus Bourneuf, at the time assistant chief surveyor of the American Bureau of Shipping, responded to this instruction by developing the enhanced survey program. By the following year, enhanced surveys were being performed on single-hull oil tankers and bulk carriers in shipyards around the world.

One major set of issues confronting the International Maritime Organization membership today concerns emissions of greenhouse gases. The relevant regulations have been adopted and are scheduled to enter into force, but because their adoption was somewhat contentious and done under significant time pressures, the new regulations have left some complex technical issues yet to be developed before the regulations enter into force. Two IACS groups, the Expert Group on the Environment, chaired by Ah Kuan Seah, vice president of American Bureau of Shipping, Environmental Solutions Group, and an IACS/industry joint working group have undertaken to find solutions and standards to some of these technical issues for submission to IMO, aimed at achieving uniform and consistent application of these major new regulations.

Another major IACS project is harmonizing and updating the common structural rules for oil tankers and bulk carriers. IMO standards for structural design, construction, and maintenance of these ship types, which set function requirements that classification society rules will be required to meet, can be seen as the fruition of the original IMO request for harmonized structural rule requirements that brought IACS together in the first place. Led by Chairperson Gary Horn, director of the ABS IACS Hull Panel team, the collective effort seeks to fulfill that vision, harmonize the various common structural rules requirements, and update them to comply with IMO's goal-based standards.

Direct Impact on Regulation

Classification societies also make a direct, individual impact on regulatory development. For example, in 1983 the U.S. Coast Guard commissioned ABS to prepare a report that integrated into a single document: all U.S. load line regulations and policies, all ABS and IACS interpretations of load line regulation, and all IMO circulars and the International Convention on Load Lines. Senior Engineer Jim Graf, vice president of Business Planning and Analysis at ABS, prepared the report over the course of two years. The Coast Guard submitted the resultant "Load Line Technical Manual" to IMO as an information document reflecting accepted U.S. practice and interpretations of the load line convention. Updated in 2011, the manual continues to be a unique and valuable international reference work.

Another example of a direct class impact on regulation is the work led some years ago by Greg Shark, current director of Regulatory Affairs for ABS, and Dr. Hsien-Yun Jan, former director of the SafeHull project, on mobile offshore drilling unit (MODU) stability. After the 1980 *Alexander Kielland* drilling rig disaster,[2] the Norwegian government proposed more onerous stability standards that required a major increase in minimum metacentric height and in upper hull buoyancy for semisubmersible rigs, such that they would not capsize in the event of major damage. It was estimated, in some instances, the proposal would reduce deck load capacity by about 5,000 tons.

Industry was interested in confirming the belief that an intact semisubmersible MODU already possessed significant amounts of stability margin, and in finding an alternative practical approach to improved stability criteria that would achieve the same objectives without the large loss of deck load capacity. Because of the American Bureau of Shipping's long leadership in classing MODUs, industry approached the classification society to assess semisubmersible MODU stability from a first principles perspective to determine if the proposed increase in stability was warranted and, if so, develop a rational, technically based solution. In a three-year joint industry project led by ABS, advanced non-linear motion techniques were used to develop new dynamic stability criteria for semisubmersible MODUs. The results showed that the proposed increase in metacentric height was not necessary, were used to develop dynamic stability criteria that were submitted to IMO, and ultimately became part of IMO's MODU stability criteria. They were also incorporated into the ABS MODU rules as alternative stability criteria.

In 1993, the IMO adopted Assembly Resolution A.739(18), an extensive set of minimum requirements that organizations must fulfill to be authorized as flag state recognized organizations as well as recommendatory guidance to flag states on the appointment, coordination, and oversight of their recognized organizations. Ed Reilly, an ABS corporate director, drafted much of what became the "Guidelines for the Authorization of Organizations Acting on the Behalf of the Administration." In 1992, he was appointed as IACS' permanent representative to the International Maritime Organization.

These minimum requirements became necessary as the greater portion of the world's merchant fleet began dropping the flags of traditional maritime nations in favor of the lower-cost operations possible under the flag authorities of open ship registers, while the number of organizations seeking to act as recognized organizations for those flags grew rapidly. Until that time, the relationships among the major classification societies and their home governments, and those governments' recognition and use of classification rules in conjunction with international regulations and national requirements had been, essentially, a matter

The IMO assembly is the main arena where regulatory agendas play out. Photo cour-WHV\ RI WKH ,02 ,QIRUPDWLRQ 2I¿FH

Ballast water sampling. The Ballast Water Convention is one of IMO's latest environmental protection measures. U.S. Coast Guard photo.

of maritime tradition, based on an historical understanding that classification rules provide the basic technical foundation for ship structures and essential engineering systems upon which national and international regulations build.

As a result, compliance with classification rules, although understood or required as a prerequisite for compliance with IMO conventions by many flag states, was not explicitly stated as such in the IMO conventions themselves (other than in the limited manner in the Load Line Convention, as previously mentioned).

Starting with SOLAS, the major international conventions have been amended so that vessels are also required to comply with the class society rules (recognized by the flag state) for structural strength and essential engineering services. This has helped to re-establish the essential, complementary relationship of classification rule requirements and the international convention regulations in providing a comprehensive framework for ship safety and pollution prevention.

Altogether, the International Association of Classification Societies' member classification societies, through the dedicated, collective efforts of their numerous technical experts have, for more than four decades, been good partners of the world's maritime administrations in developing and implementing rational, practical, and critical international regulations in the service of the protection of life, property, and the natural environment at sea.

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About the author:

Mr. Steve McIntyre is the vice president of Regulatory Affairs for the American Bureau of Shipping, and coordinates activities and relationships with flag administrations, the International Maritime Organization, and the International Association of Classification Societies. He has served on the IACS General Policy Group since 1993, and served as chairman for 1995-1996 and 2005-2006. He is a graduate of the University of Michigan with a B.S. in engineering and naval architecture and marine engineering. He has completed some graduate work in engineering at Columbia University, and has completed the Program for Management Development at Harvard Business School.

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Protection and Indemnity Clubs

Insuring and ensuring marine safety since the time of the Titanic.

by Mr. Karl Lumbers
Loss Prevention Director
UK P&I Club

When Judge Julius M. Mayer of the U.S. District Court of New York issued the decree to close all suits related to the RMS *Titanic* in July 1916, a total of $663,000 had been distributed to the claimants. This sum, paid to those who lost property as well as to the survivors and the relatives of the 1,500 souls who perished, is equivalent to about $50 million today.[1]

In 1912, the ship owner would look to the protection and indemnity (P&I) club to secure this liability exposure. This situation continues, but the sums involved are considerably higher.

Today, a typical ship owner would have in place two types of insurance coverages—hull and machinery (H&M), and protection and indemnity. The ship itself would be insured under H&M, which pays out if the ship sinks or is damaged, say in a collision, or if there is a major engine failure.

Typically, several underwriters, who each take a share of the risk, provide the required area of cover. The *Titanic's* hull was insured among a number of British and American underwriters for $5 million—equivalent to around $375 million today. Traditionally, Lloyd's of London housed most of these underwriters. Now, it is very much a global market.

P&I covers a ship owner's liability for death or injuries to crew, passengers, stevedores, and any other personnel aboard, or participating in loading and unloading the vessel. Environmental damage is another significant area, including oil spill response and other clean-ups, such as the cost of wreck removal. This insurance also covers loss or damage to cargo where the ship owner is held to be at fault, and damage to structures like shore cranes, quay walls, and lock gates.

P&I Clubs

For most ocean-going ships, protection and indemnity coverage is provided by P&I clubs, which predate the *Titanic* by several decades. Most have their origins in the 18th century, when ship owners in a local area, perhaps around a large port, would form a mutual insurance company. Members of these clubs pay an annual premium that would be invested, while the clubs waited for the claims to come in. If the claims exceeded the premiums in any one year, then an extra "call" would be made. Any surplus in the year would typically be transferred to reserves to provide a solid financial structure to weather the bad years.

While the original P&I clubs were based in various towns and cities within the United Kingdom, clubs were subsequently established and today flourish in Scandinavia; the United States and Japan each have one club. Most of the major clubs now belong to the International Group for reinsurance and other purposes.

Moreover, many clubs originally based in the U.K. have comparatively recently been reformed in places such as Bermuda, and Luxembourg to secure freedom from exchange controls.

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Promoting Marine Safety

One of the initiatives inspired by the *Titanic* was the first International Convention for the Safety of Life at Sea. This convention has continued to establish effective and far-reaching shipping industry safety regulation.

In most walks of life, you don't expect insurance providers to play a high-profile role in encouraging safe practice; this tends to be left to other bodies such as governments and trade associations. In the shipping industry, though, things are different. P&I clubs have traditionally taken on the challenge to inform ship owners, ship managers, and seafarers about the risks they run as they go about their business. You could say that P&I clubs were providing risk management services long before the term risk management had been invented.

Because International Group clubs share their claims through the pooling system, they have a common interest in loss prevention and control and in maintaining quality standards throughout the membership.

Each club runs its own loss prevention program; and my own club, the UK P&I Club, has a reputation for the depth and scale of its marine safety activities. We receive strong support from our individual members, as all of them are naturally interested in reducing the level of claims. No company wants injured employees and neither do they want to fight claims in the courts; they just want to run safe ships in a profitable fashion.

The main target audience tends to be the crew and the employees of ship owners and managers who have ultimate responsibility for safety. We also include surveyors, port state control inspectors, port authorities, terminal operators, and stevedores, since they all have a role to play in the safe handling of ships and their cargoes.

Navigational safety is a claims sector that occupies the UK club a great deal, since groundings, collisions, and subsequent oil pollution can generate the largest claims. Bodily injury claims, including those where there are fatalities, may not capture the media's interest in quite the same way they did in 1912, but cumulatively, they still form a significant part of the total claims settled in any one year.

Human Error

Just as in shore-based industries, many accidents result from not following prescribed procedures. For example, entering enclosed spaces such as holds, tanks, and store lockers without establishing that it is safe to do so, often results in fatalities, not only to the crew members who make the initial mistake, but also to those who rush to help their colleagues without first donning the appropriate equipment. Also, failure to maintain equipment properly may lead to injuries or death.

Today, ships are permitted to operate with small crews, and it is difficult to do all of the maintenance work that should be done. Crewing a ship has always had its associated risks—even in the days of sail when seafarers had to go aloft often in appalling weather. The risks are different now, but they are still present. It is particularly frustrating to see so many serious injury claims resulting from crew members who simply don't think about the risks associated with not wearing the correct protective clothing or standing in a dangerous location during mooring operations.

Carriage Guidelines

The UK club even endeavours to influence shippers—the companies that send their cargoes by sea—regarding the risks to ships and their crews that can be attributed to the cargoes they export. For example, calcium hypochlorite, often used to disinfect drinking water or swimming pool water, is viewed with great mistrust by many container shipping lines. It is considered to be relatively stable, but it is best kept in a cool dry place away from any organic material. It is known to undergo self-heating and rapid decomposition accompanied by the release of toxic chlorine gas. Several major fires on container ships have been attributed to this product.

The UK Club has drawn up guidelines for its carriage, including the need to avoid external heat sources such as bulkheads and tank tops that may conduct heat from bunker oil on the other side of the steel plate or from simply being warmed by the sun. Additionally, shippers are requested to ensure that their cargo is not off-spec, which can make it less stable.

A major campaign has been running lately to highlight the risks associated with carrying iron ore fines. If the moisture content is too high, this cargo can liquefy in the ship's hold and impair stability to such an extent that the ship capsizes. Several modern large bulk carriers have had narrow escapes, while a handful have been less lucky, sinking with major loss of life.[1]

Endnote:

1. The UK P&I Club is tackling this issue in conjunction with the other P&I clubs of the International Group of P&I Clubs, *Loss Prevention Bulletin* No. 739 on the *Safe Carriage of Nickel Ore Cargoes*, is based on an International Group circular. More information can be found on the UK Club's website at www.ukpandi.com.

In the event of a maritime incident, the financial strength and technical expertise of P&I clubs can help ensure security for legitimate claimants and minimizes interruption to international trade. Image courtesy of Maritime New Zealand.

The International Group

The International Group of P&I clubs exists to arrange collective insurance and reinsurance for P&I clubs, to represent the views of ship owners and charterers who belong to those clubs on matters of concern to the shipping industry, and to provide a forum to exchange information.

Each of the 13 constituent P&I clubs is an independent, nonprofit-making mutual insurance association, providing coverage for its ship owner and charterer members against liabilities of their respective businesses. Each club is controlled through a board of directors or committee elected from the membership. This board retains responsibility for strategic and policy issues but delegates the day-to-day running of the club to full-time managers.

Insurance Pool

Clubs have found it beneficial to pool their larger risks under the auspices of the International

Innovation

Approximately nine out of 10 ocean-going ships are currently entered in a P&I club. Notwithstanding their long history, they remain highly topical. For example, P&I clubs are engaged in issues related to piracy, such as the medical treatment and repatriation of crew.

The UK club makes extensive use of the Internet to get its messages across to seafarers and ship owners worldwide, and recently it has initiated a series of podcasts. One of these, devoted to the safe carriage of ore cargoes, was produced as a Chinese-language podcast, because most of these cargoes are destined for China in either Chinese-owned or Chinese-chartered bulk carriers.

Group, even though they compete with each other for business. This is regulated by a contractual agreement that defines the risks that are to be pooled and exactly how these are to be shared among the participating clubs. The pool provides a mechanism for sharing all claims in excess of $8 million to a limit of about $4.5 billion.

For a layer of claims between $60 million and $3.06 billion, the group clubs purchase reinsurance from the commercial market. The pooling system provides participating clubs with reinsurance protection to much higher levels than would normally be available in the commercial reinsurance market.

The International Group arranges a market reinsurance contract to help the pool deal with claims that exceed $60 million. This is the largest single contract in the world's marine insurance market. It currently extends for claims against ship owners to a little more than $3.06 billion per claim, except for oil pollution, where the maximum is $1 billion. There are lower limits for claims against charterers.

Taking Risk Management to the Next Stage

Drawing on the experience of claims executives and in-depth claims analysis from the past 23 years, United Kingdom's P&I Club has defined 76 major threat areas that cause liability claims, and some 450 controls that may be able to help reduce the likelihood of an incident.

The club also works closely with its individual members to develop a system to rate and record these risks. As the club extends this system, members can use the trends and benchmarks within their own safety systems to help manage their risks and enable a scientific approach to claims prevention/control.

About the author:
Mr. Karl Lumbers is a master mariner with more than 35 years of experience in the marine industry. He joined Thomas Miller, managers of the UK P&I Club, in 1986, from a leading firm of marine consultants in London. He is presently a director of Thomas Miller P&I Ltd., and is responsible for the club's ship inspection and loss prevention programs.

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Lessons Learned

Special Report: ***Titanic***

A regular feature in Proceedings: "Lessons Learned from USCG Casualty Investigations."

In this special edition, we take a closer look at the sinking of the Titanic*. We explore how the incident most likely occurred, including environmental, vessel design, and human error factors that may have contributed to this tragic event.*

Additionally, we highlight the U.S. Senate investigation of the sinking and the marine safety legislation that followed.

An Indelible Mark

The titanic impact on marine investigations.

by CAPT David Fish
Chief, U.S. Coast Guard
Coast Guard Office of Investigations and Casualty Analysis

CDR Brian Penoyer
Deputy Chief, U.S. Coast Guard
Coast Guard Congressional and Governmental Affairs

Mr. Timothy Farley
U.S. Merchant Marine
Chief, U.S. Coast Guard
Office of Investigations and Casualty Analysis
Marine Investigations Division

Arriving at lunch aboard *Titanic* on April 14, 1912, J. Bruce Ismay of White Star Lines found passengers discussing ice. Asked if they would slow down, he replied "Oh, no. On the contrary, we are going to let her run faster and get out of it."[1]

For the three authors, professional marine investigators, perhaps no greater illustration of our profession's evolution exists than the explanation of the *Titanic's* sinking. One hundred years later, virtually every facet of the ship and its relationship to its sinking has been examined and dissected—from rivets to subdivision, lifeboats to radio signals. The safety reforms launched as a result of the disaster are the cornerstones of virtually every international safety of life at sea regime, and serve to help protect mariners and the public. Our own service was indelibly changed by this disaster, forging the core Coast Guard "prevent-respond" strategy.

Today, marine investigators have collectively come to see disasters of this magnitude as system failures. Once we spoke of the single or primary cause, a "proximate" cause. No longer; we now talk of the error chain that originates years and miles in advance with companies, regulators, and international regimes—a series of unsafe conditions that set the stage for disaster and lay waiting to manifest. Yet the *Titanic,* with its voluminous public record, remains frozen in time. For marine investigators, the remaining mystery of the disaster is to understand how the recipe for this maritime disaster was mixed: How the many diverse factors—human and systems alike—aligned that one fateful night.

Key Facts

Here are some facts, documented and analyzed beyond debate, which cut to the heart of the incident.

Fact: In 1907 the Cunard *Mauretania* and *Lusitania* were launched with steam turbine propulsion systems, both faster than previous ships and innovative for this period of shipbuilding. This amounted to a revolution in maritime affairs during the 1890s—ships had typically been both smaller and slower.[2] White Star responded that same year with the Olympic-class ships, designed to carry more than 3,400 passengers and crew, but with design speed of "just" 21.5 knots, 3 knots less than the *Lusitania.*[3]

Fact: Mariners and operating companies were still adapting to this revolution in maritime affairs in 1912. By one informed estimate, drawing on *Lloyds Register* data in 1914, two years after the *Titanic* was launched, only 35 percent of the British merchant fleet was capable of making speeds of more than 12 knots.[4]

Fact: Every mariner (today as in 1912) will tell you that passengers and crew should abandon ship only as a last resort or "when she sinks from under feet." A large ship is better suited to survive the rugged conditions of wave and wind than is a lifeboat (or a person in a lifejacket), and a large ship is more easily found by rescuers than a small lifeboat or even smaller semi-submerged person. In 1912, mariners, shipbuilders, and line operators were well informed about low-speed collisions aboard smaller ships. For example, when the *Republic* collided with the *Florida* in fog off Nantucket in 1909, both remained afloat. The *Florida,* with her bow demolished, survived the wreck. The *Republic,* struck amidships, remained stable for more than 40 hours, long enough to enable the crew and passengers to be gradually ferried (using a few lifeboats) to the less-damaged *Florida.*[5] The *Florida* had proven her ability to sustain a head-on collision, and the *Republic* had served as her own lifeboat, damaged as she was.[6] But the *Titanic*, twice *Florida's* tonnage, moved through the seas at 21 knots. Her momentum and the ensuing havoc wreaked upon the ship created a unique and hazardous situation.

Fact: On September 20, 1911, the HMS *Olympic,* sister ship to *Titanic,* collided with the HMS *Hawke. Olympic* was under the command of Captain Edward J. Smith at the time; a court of inquiry supported Smith and blamed the incident on suction caused by the *Olympic's* hull. *Olympic* showed a combination of buckling and brittle-like fractures in the sideshell hull plating, along with the failure of hundreds of wrought-iron rivets.[7]

Fact: On April 10, 1912, the entire crew of the *Titanic* mustered, followed by a brief lifeboat drill that utilized only two starboard boats—11 and 15.[8] About 30 to 40 able seaman participated in the lifeboat drill, but only nine crewmembers were sent out in each boat.[9] When asked why so few participated, and why no stewards were involved (who normally help man the boats), the stewards replied that if they had participated the meals would not have been ready for the arriving passengers.[10]

Fact: Metallurgy was still an emerging technology when the *Titanic* was built; recent evidence suggests that use of cast iron rivets, with slag inclusions, could have made these rivets brittle and prone to shattering.[11] In our work with naval architect Bill Garzke and metallurgists Jennifer Hooper McCarty and Timothy Foecke, they eloquently and legitimately postulated that a simple supply-chain-driven decision set in motion an unsafe condition—brittle rivets—that defeated *Titanic's* key defense against a collision: the ability of the hull to deform without breaching to the sea.[12]

Fact: J. Bruce Ismay's remarks about crossing the ice field quoted at the beginning of this article closely follow the common practice, at the time, for navigating through fog, long since discredited. The 1912 edition of *Modern Seamanship* states: "A common reason given for advocating high speed in a fog is that, the fog bank being of definite width, the danger of collision will be reduced by getting across as quickly as possible. This is like saying that if one is called on a dark night to cross a public square in which people are moving about in all directions, it will be safer to run across at full speed than to walk across slowly."[13]

Fact: At 10:30 p.m. on the evening of April 14, the night of the collision, *Titanic's* bridge crew received a message by signal lamp from the passing freighter *Tappahannock,* outward bound from Halifax: "Have just passed through heavy field ice and several icebergs." *Titanic* acknowledged the message, but First Officer William McMaster Murdoch took no action.[14] Murdoch failed to reduce speed or post additional lookouts; by contrast, the *Carpathia's* captain posted seven lookouts at varying heights (deck to crow's nest), while transiting the same ice field hours later.[15]

Fact: Captain Smith posted to the bridge of *Titanic,* and discussed with Second Officer Charles Herbert Lightoller the complexities of maintaining a lookout given the unusual weather conditions present: little wind and flat calm seas (meaning that no breaking waves would increase iceberg visibility). Captain Smith reportedly also noted the moon had not yet risen and would not do so for more than two hours, making it difficult to see icebergs. The reflection of the stars in the calm water was further disorienting, making it difficult to determine the horizon. The captain and Lightoller discussed the difficulty in seeing icebergs, with the senior-most mariner suggesting starlight would be reflected by the bergs, and Lightoller cautioning that the "blue side" of the berg might

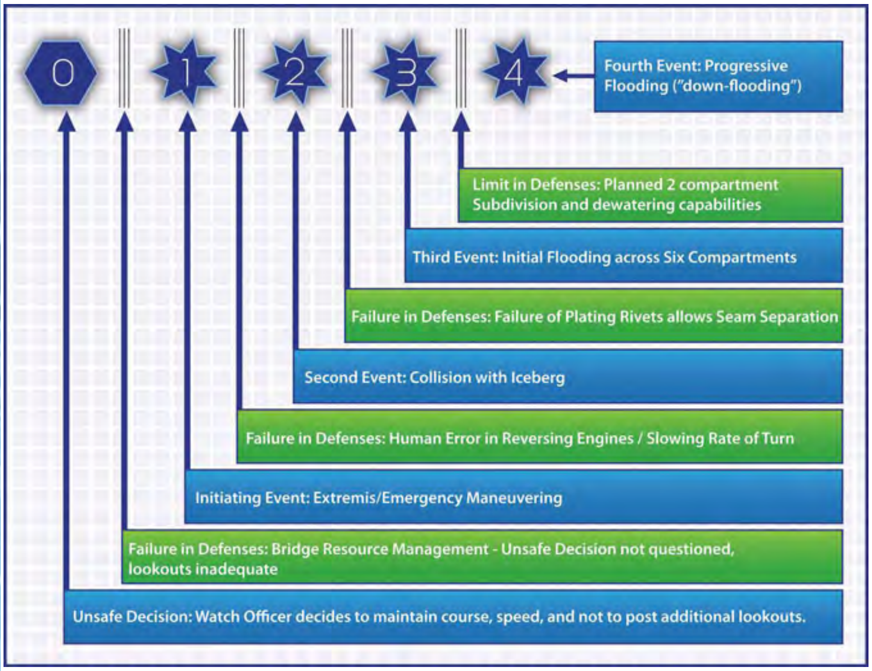

Figure 1. The *Titanic's* final "error chain" begins. USCG graphics by Mr. Robert Stratton.

be facing the ship. The concern over visibility existed, but Lightoller demurred to his superior, hoping the white outline of the berg would give sufficient warning to see the berg at a distance.[16] When Captain Smith retired for the evening, he too was concerned, stating he should be roused: "if it becomes at all doubtful let me know at once…If there is even the slightest haze to any degree noticeable, immediately notify me."[17] Haze is common around ice floes, but some large bergs do not generate much.[18]

Fact: In preparation for a television program addressing the *Titanic* lookout conditions, a U.S. Coast Guard smallboat was operated at approximately 18 knots in similar temperatures. As any mariner would expect, without shielding, the apparent wind struck the lookout directly in the face and caused tearing of the eyes that impeded vision. So, we find it very likely the *Titanic* lookouts faced similar conditions and it would have been human nature to be tempted to hunker down out of the wind, popping up to scan the horizon at regular intervals.

Breaking the Error Chain

These are just a taste of the cornucopia of facts in perhaps the most documented and least commonly understood marine casualty in maritime history. How do we make sense of them all? How do we stitch together a narrative that provides insight into understanding how the casualty occurred and how we can prevent a similar casualty in the future, which is the primary goal of any investigation?

Modern accident investigation doctrine holds that none of these unsafe conditions should have gone unnoticed in the system. Where these conditions do crop up, the system should incorporate human, procedural, and mechanical defenses against them. The "error chain" is broken when these defenses work, and the accident remains a mere mistake, failing to progress into a disaster.

Figure 1 diagrams this disaster, which started the moment the vessel entered the unsafe ice field and was initiated when emergency maneuvering began. As the maneuvering defenses failed, the collision became inevitable. Having collided and delivered its enormous momentum into the iceberg through the hull plating, could the *Titanic* have survived? Only if the vessel's watertight envelope remained intact across the entire "crumple zone." It clearly did not—a defensive failure we lay squarely on the riveted construction of the sideshell hull plating.

Having compromised the hull, the *Titanic* was doomed to flood. Flooding is, however, a predictable outcome of collisions and other hull failures brought about by operating in the harsh marine environment, and *Titanic* was conceived with built-in defenses—subdivision into watertight compartments, any two of which could be flooded. Nevertheless, this defense was inadequate. The glancing blow compromised an unimagined six watertight compartments, and dewatering pumps were insufficient to keep four of these from flooding. The progressive flooding was at this time inevitable, so vividly re-enacted in any number of films and television programs.

Rightfully, the master and crew understood their fate as rapid progressive flooding loomed, and they initiated distress calls (as noted in figure 2). But radio distress calls were not an infallible or true defense, as wireless radio communication was a novelty at the time, something primarily directed toward passenger amenities. A distress call was considered a "defense of opportunity." With limited operating hours, no requirements to monitor the radio, and poorly developed or lack of unified international distress systems, the *Titanic's* famous Morse code radio signal "CQD" went unheard by the closest ships.

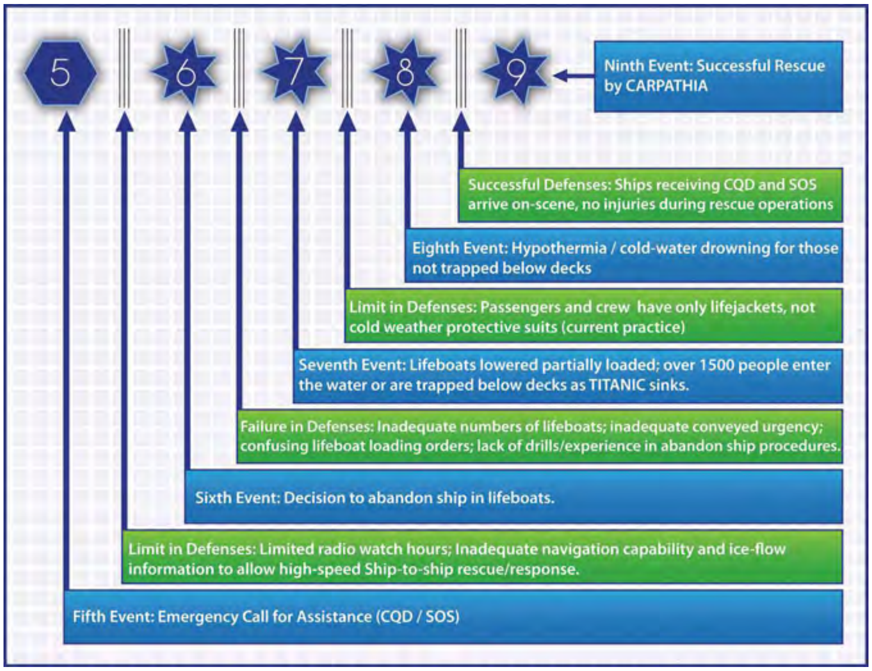

Figure 2. *Titanic's* defenses are inadequate to prevent disaster.

Nonetheless, hoping that help was on its way, and as the vessel quickly foundered, the crew faced a horrific decision on whether to abandon ship (recall, the conventional wisdom of the day that it was prudent to remain aboard the vessel and primarily use the lifeboats to shuttle passengers to a rescuing ship). Sadly, the *Titanic* wasn't outfitted to evacuate all of the souls aboard in the lifeboats and the abandon-ship process was anything but efficient and smooth.

With this inadequate abandon-ship defense, it was inevitable that a large number of passengers and crew would be forced to enter the frigid North Atlantic waters. More than 1,500 people perished as a result.

Only then, at this late point in the error chain, did the survivors get a break. Showing great skill and acumen, the *Carpathia's* master rushed to the scene of the disaster, and retrieved passengers and crew from lifeboats before cold-weather exposure could take their lives.

But … Why?

We've outlined what happened; it's a simple sequence in time, even with defensive failures that originated years or even decades earlier. But why did it happen? How should we understand the circumstances that forced *Titanic* into the first fateful pre-collision emergency maneuvering? Only when the "why" is fully understood can effective countermeasures or defenses be developed to prevent recurrence.

Without question, for us, the initiating event is the navigational watch officer's decision to charge ahead into the ice field without posting additional lookouts, or reducing speed. Had the bridge team questioned this decision, it is conceivable that the collective concern might have increased lookout detection and time to maneuver.

But of course, the unsafe decision about navigating into the ice field was made, and the bridge crew didn't challenge that decision nor act as a safety net for the deck officer. How could it have come to this? Simply put, the environmental factors (poor visibility) and navigation doctrine (go fast, get out of the ice, reduce the exposure to the risk) lined up for a few fateful hours like dice thrown thousands of times. Eventually, you get snake eyes.

Moreover, the captain, ship builder, and the line operator didn't foresee this possibility. They managed the vessel with no eye toward providing ice warnings to the navigators, counterweighing the hierarchical influence of their time with aggressive bridge resource management, or using the radio as anything

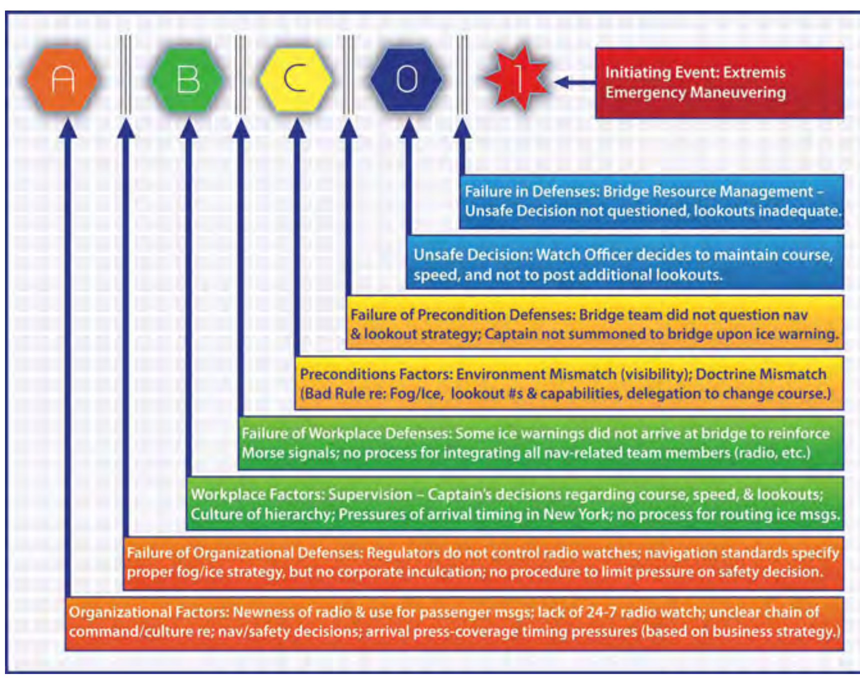

Figure 3. The human, procedural, and mechanical elements that contributed to the incident.

but a novelty for the passengers. To operate and forge ahead as they did through the ice field was a judgment call. In hindsight, it was clearly a poor decision, but not necessarily one mariners of that time would have recognized.

Finally, it is important to recognize that the regulators, the insurers, and the economics involved played a part in this tragedy. Did the pressure to arrive when the news media was expected at the dock to photograph the rich and famous as they disembarked cause the *Titanic* disaster? Not directly. But it did cascade unchecked into the unseen but very real pressures weighing upon the captain and line operator to make speed and to transit an ice field at night.

As Felix Riesenberg, famous mariner, prolific maritime writer, historian, once wrote: “The sea is selective, slow at recognition of effort and aptitude, fast at sinking the unfit.” But, in this sense, the “unfit” not only include those proximate to the incident and easy to blame, such as the captain and crew, but must include all of the decision makers involved in the vessel design, construction, and ship management to even encompass the lawmakers and regulators of the time for failing to recognize the limitations, or even benefits of the emerging technologies and what impact they might have on the system.

Investigation Today

Today’s investigations treat ships, crews, ports, waterways, equipment, operating companies, government regulators, and insurance companies as a system. In the day of the *Titanic,* it was fashionable to ask whether the captain or the deck watch officer was responsible for the disaster. And, surely professional responsibility is important at sea—where lives literally depend on a mariner’s judgment.

Yet, as we’ve seen, it hardly makes sense to fixate on this one element and ignore the rest. Today, U.S. Coast Guard marine investigators and our worldwide peers in other transportation modes think of each accident as a system failure. The pressures and dynamics of all large systems, including luxury passenger transportation, begin long before incidents occur. Investigators examine these incidents at all levels, and then recommend safety improvements to address them. In the end, the system is only as strong as its weakest link, or, in this case its weakest defense.

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The Senate Investigation into the Loss of the *Titanic*

A search for facts and the beginning of the myths.

by CDR Joe Raymond
U.S. Coast Guard Senate Liaison

The *Titanic* Memorial in Washington, D.C. Photo by USCG *Proceedings*.

Many people come to Washington, D.C., to go sightseeing and to look at the many memorials and monuments that are dedicated to notable individuals and events significant to our nation. Some memorials are more popular than others, such as the ones on the National Mall. However, all monuments and memorials—no matter their placement—represent the spirit, honor, and bravery of someone or some event that helped to empower this nation.

In the southwest area of Washington, D.C., not far from U.S. Coast Guard headquarters, on the waterfront, stands a little-known statue of a 13-foot high male figure with his arms outstretched, parallel to the water. The inscription on the memorial states:

> *"To the brave men who perished in the wreck of the Titanic April 15, 1912. They gave their lives that women and children might be saved."*

All Eyes on Washington, D.C.

The RMS *Titanic* sank off the coast of Newfoundland, Canada, on its maiden voyage. Yet, this memorial is located in a relatively obscure spot along the D.C. waterfront. Why is that? What does the sinking of the *Titanic* mean to this nation? To answer these questions, one must go back nearly 100 years to the days immediately following the sinking of the *Titanic,* when the rest of world focused its attention on our nation's capitol and the investigation the U.S. Senate conducted into this tragic incident.

Much of what we know today about the *Titanic's* sinking is based on the Senate's investigation that began the very day the first survivors stepped ashore in New York City. This investigation was conducted before packed hearing rooms in New York City and Washington, D.C., and resulted in some of the most sensational newspaper coverage of the day. This investigation was timely, focused on one of the most prominent tragedies in modern times, and involved some of the most famous people of the day, including J. P. Morgan, the ultimate owner of the *Titanic.*

The investigation provided the key facts about this tragedy, laid the foundation for other subsequent investigations, and led to U.S. legislation mandating improvements to maritime safety. It also contributed significantly to the London International Conference on Safety of Life at Sea, which in turn led to the International Convention for the Safety of Life at Sea (SOLAS). Additionally, this investigation inspired much of what is known about this disaster within popular culture and influenced many of the narratives, stories, and even myths of this event, including James Cameron's epic film, *Titanic.*

The Background

The *Titanic* was an 882-foot long luxury cruise liner, designed to be the most luxurious ocean liner of its time. While it was British flagged, the ownership of the *Titanic* was a complicated web that ultimately led to American rail tycoon, J. P. Morgan. The ship was part of the White Star Line and was owned by Oceanic Steam Navigation Company of England, which in turn was owned by the International Navigation Company Ltd., of England. Its stock was in turn owned by the International Mercantile Marine Company, an American holding company organized by J. P. Morgan under the laws of the state of New Jersey.[1]

On April 10, 1912, the *Titanic* departed from Southampton, Great Britain, and then proceeded to Cherbourg, France, later that day to embark more passengers. It made a final stop at Queenstown, Ireland, to embark its last passengers before departing for New York on April 11. On the night of April 14, 1912, at 11:40 p.m., the *Titanic* struck an iceberg. Two hours and 40 minutes later, it sank in the Atlantic, taking the lives of more than two-thirds of its passengers and crew members, including such prominent persons as millionaire John Jacob Astor IV, industrialist Benjamin Guggenheim, and Macy's department store owner Isidor Straus.

The Public Demands Answers

As the news of this calamity made it ashore, the American people wanted to know why this had happened. How could the world's newest, largest, and most luxurious ocean liner sink so quickly on its maiden voyage? Why weren't there enough lifeboats for everyone? Why couldn't nearby vessels rescue more survivors? These questions demanded immediate answers, and the U.S. Senate quickly moved to initiate an investigation, with Sen. William Smith, a Republican from Michigan, taking a strong leadership role. On April 17, 1912, as the world was learning the true scope of this tragedy, Sen. Smith took to the senate floor and asked for passage of a resolution authorizing the Senate Commerce Committee to investigate the sinking of the *Titanic,* determine what had taken place, and recommend what could be done to prevent similar recurrences.

Senate Action

Smith's motives in taking a leadership role in this high-profile and historic investigation so quickly have long been debated. He was a populist Republican attorney from Michigan who had previously crusaded against the Morgan banking interests, and many thought the investigation was personally motivated to find possible malpractice by railroad tycoon J. P. Morgan, *Titanic's* ultimate owner.

Ironically, J. P. Morgan was initially scheduled to travel on the *Titanic,* but had cancelled at the last minute. Others saw Sen. Smith as an early advocate for transportation safety who was focusing on an obvious safety catastrophe. Prior to the sinking of the *Titanic,* he was probably best known for chairing a Senate subcommittee focused on rail safety. Others condemned Smith as an opportunist, seeking acclaim, while insensitively questioning the *Titanic's* survivors as they came ashore. Looking back 100 years later, it is probably safe to say all three of these motives have some merit.[2] Regardless of his motives, Smith moved quickly to convince the Senate to approve the investigation under his leadership.

The U.S. Senate quickly approved Senate Resolution 283, authorizing the Commerce Committee to hold hearings and summon witnesses to determine responsibility, and investigate whether it would be feasible for Congress to initiate an international agreement for the protection of sea traffic.

After the Senate passed this resolution, Sen. Knute Nelson, chairman of the Senate Commerce Committee, quickly named Smith as the chairman of the subcommittee that would investigate the loss. Nelson and Smith then put together the subcommittee that would conduct the investigation. They selected an even number of Republicans and Democrats, including Jonathan Bourne (R-Oregon), Theodore Burton (R-Ohio), Duncan Fletcher (D-Florida), Francis Newlands (D-Nevada), George Perkins (R-California), and Furnifold Simmons (D-North Carolina).

The Senator's Personal Crusade

Sen. Smith then made plans to travel—with subpoenas in hand—to meet the *Carpathia* as it arrived in New York City, to prevent any possible witnesses from departing the country to avoid providing testimony. Sen. Smith wanted to question the surviving passengers and crew members, while the events were still fresh in their minds, and he wanted to be on site, in case any surviving crew members tried to evade questioning.[3]

In fact, it is believed the U.S. Navy had intercepted a wireless signal sent from the *Carpathia* that suggested that Mr. J. Bruce Ismay intended to depart the *Carpathia* with the other surviving *Titanic* crew members upon its arrival in New York City, and board another White Star vessel back to Great Britain in an attempt to escape U.S. jurisdiction. Mr. Ismay was the managing director of the White Star Line, a first class passenger on the *Titanic,* and one of its few adult male survivors. It is believed that Sen. Smith spoke with President Taft about these concerns; and, the president authorized a Treasury Revenue cutter to intercept the *Carpathia* before it docked to ensure no one was able to evade Sen. Smith's subpoenas.[4]

Senators Smith and Newlands arrived in New York on April 18, just as the *Carpathia* moored, armed with subpoenas for Mr. Ismay and other members of the *Titanic* crew. They brought with them three people to assist with the investigation. Pres. Taft had offered U.S. Steamship Inspector General George Uhler to provide key expertise with the investigation; Sheriff Bayliss of Chippewa County, Mich., had been specifically deputized to serve subpoenas in support of this investigation; and Bill McKinsty Sen. Smith's private secretary, served as the recorder for the investigation. He was largely responsible for drafting the resulting 1,100-page transcript.

Thus began the Senate's hearing into the loss of the *Titanic.* These hearings took 18 days and involved 86 witnesses—53 British citizens and 29 U.S. citizens. Witnesses included Mr. J. Bruce Ismay, the president of the company that owned the *Titanic,* 34 members of the *Titanic* crew and 21 passengers.[5]

The Investigation

Testimony began on April 19, 1912, in the ornate East Room of the Waldorf-Astoria Hotel in New York City, the day after the first survivors arrived ashore. Sen. Smith convened the investigation and called Mr. Ismay as the hearing's first witness. In a standing-room-only crowd, reporters, curious bystanders, and relatives of the *Titanic* passengers showed up to hear his testimony.

Senators Smith and Newlands returned to Washington, D.C., after questioning all of the witnesses, and the full seven-member subcommittee convened in the new Caucus Room (in what is now called the Russell Senate Office Building) to continue the investigation. This investigation was the first major hearing conducted in the Caucus Room of this new Senate office building, and would be the first of many notable hearings to be held there. (Other notable hearings


"TITANIC" DISASTER

HEARINGS

SUBCOMMITTEE OF THE COMMITTEE ON COMMERCE UNITED STATES SENATE

SIXTY-SECOND CONGRESS SECOND SESSION

S. RES. 283

Senate Commerce Committee report.

Hearing Transcripts

In addition to the Senate Commerce Committee Report, the Senate also released its more than 1,100-page hearing transcript. For almost 100 years, this transcript has served as the most comprehensive source for this tragedy and was used exhaustively in later investigations, in Dr. Robert Ballard's successful search for the wreckage of the *Titanic*, and for the many books and movies focusing on this tragedy.

In the wake of James Cameron's blockbuster movie, the *New York Times* released transcript as a hard-bound and paperback book.

included the McCarthy hearings in the 1950s and the Watergate hearings in the 1970s.)

The *Titanic* hearings continued for 18 days and included additional trips to New York City to question witnesses and to visit the *Titanic's* sister ship, the *Olympic*, during its port call to New York on May 28.

The Report

Upon the conclusion of the hearings, the Senate Commerce Committee released its report on the *Titanic* disaster on May 28, 1912. This relatively concise document summarized the investigation, reconstructed the timeline of the *Titanic's* final voyage and ultimate demise, and laid out the major issues the subcommittee believed had contributed to its sinking and the astounding loss of life. The report also included the design of the vessel, its lifeboats, safety equipment, the *Titanic's* speed, the location of the icebergs, the available ice warnings, how the *Titanic* struck the iceberg, the manner in which it sank, the conduct of the passengers and crew, and how it was decided who would enter the lifeboats.

The report also summarized how the distress calls went out and how the nearby vessels did or did not respond in a timely manner to render assistance. At the conclusion of the report, the subcommittee found the "accident clearly indicated the necessity of additional legislation to secure safety of life at sea."[6]

This investigation did not result in any quick U.S. legislation as originally intended, but it did provide critical momentum that led to the enactment of a series of U.S. legislation and international conventions that changed the face of maritime safety. For example, in 1915, the U.S. Congress passed the Seamen's Act, which was designed, in part, to improve the safety and security of U.S. mariners. This legislation was followed by the Merchant Marine Act of 1920, which today is more commonly known as the Jones Act.

The Senate's Recommendations

The Senate report listed the following recommendations that have had an impact on maritime safety that continues to this day.

That the U.S. not accept the inspection certificates from other countries for foreign-flagged vessels embarking passengers from U.S. ports unless they complied with the applicable laws and regulations of the U.S.

That sections 4481 and 4488 of the revised statutes be amended to require sufficient lifeboats to accommodate all passengers and crewmembers.[1] The report went on to recommend that crewmembers be skilled in handling the boats, drills be conducted, and log entries be made documenting those drills.

That passengers and crew be assigned to lifeboats prior to sailing and those assignments be located near their staterooms with the route to the lifeboats posted in every stateroom.

That every ocean steamship carrying 100 or more passengers be required to carry two electric search lights.

That it was evident there was a need to regulate radiotelegraphy. The subcommittee recommended an operator be on duty at all times to ensure the immediate receipts of distress calls. Additionally, the subcommittee recommended there be direct communication between the wireless room and the bridge.

That Congress passes Senate Bill 6412, which had been previously passed by the Senate and favorably reported by the House of Representatives.[2]

That the firing of rockets or candles on the high seas for any purposes other than as a sign of distress be made a misdemeanor.

That all steel ocean and coastwise seagoing ships carrying 100 or more passengers be required to have a water-tight skin inboard of the outside plating, ending not less than 10 percent of the load draft above the full-load waterline, either in the form of an inner bottom or of longitudinal water-tight bulkheads, and this construction should extend from the forward collision bulkhead over not less than two-thirds of the length of the ship.

That "all steel ocean and coastwise seagoing ships carrying 100 or more passengers have bulkheads meeting specific requirements to ensure that any two adjacent compartments of the ship may be flooded without destroying the floatability and stability of the ship."[3]

Endnotes:

1. These sections were from the portions of U.S. law that at the time were focused on life-saving equipment aboard vessels. They were later amended by the Seamen's Act in 1915.
2. Senate Bill 6412 was entitled the Radio Act, and it was approved on August 13, 1912 to regulate radio communications. This was the first U.S. act that required radio stations on land and on ships to be licensed and provided the requirements and limitations for operating radios.
3. Senate Report No. 806, 62nd Congress, 2nd Session, 19.

Coast Guard Petty Officer Scott Baumgartner of the International Ice Patrol kneels on the ramp of a Coast Guard Air Station Elizabeth City-based HC-130J, as he prepares to toss out wreaths over the site where the *Titanic* sank. (U.S. Coast Guard photo by Chief Petty Officer Bob Laura)

The Legacy

In response to the loss of the *Titanic,* the International Conference on Safety of Life at Sea convened in London from December 1913 to January 1914. From these efforts sprang the International Convention for the Safety of Life at Sea, ratified in 1914, which proscribed standards for life rafts, emergency equipment, safety procedures, and radio watch standing. It also included chapters on safety of navigation, construction, radiotelegraphy, life-saving appliances, and fire protection. Additionally, this conference also led to the establishment of the International Ice Patrol in 1914, which continues to operate to this day.

The role the U.S. Senate and federal agencies in Washington, D.C., played in this investigation was still fresh in people's minds when the *Titanic* memorial was unveiled in 1931 by Helen Herron Taft, the widow of President Taft, who had served as the U.S. president during the loss of the *Titanic* and its subsequent investigation. This memorial was originally located in Rock Creek Park along the Potomac River, but was moved in 1966 to its current location to accommodate the construction of the Kennedy Center. Today, it is located on P Street Southwest, next to the Washington Channel, just outside the gate of Fort McNair.

About the author:

CDR Joe Raymond is assigned to Coast Guard Congressional and Governmental Affairs and serves as the Coast Guard's Senate liaison. He most recently served as the commanding officer of Maritime Force Protection Unit Kings Bay. He previously served on four Coast Guard cutters, commanding USCGC Sapelo *and* Shamal.

Endnotes:

1. Senate Report No. 806, 62nd Congress, 2nd Session. *Titanic Disaster: Report of the Committee on Commerce United States Senate Pursuant to Senate Resolution 283 Directing the Committee On Commerce to Investigate the Causes Leading to the Wreck of the White Star Line Titanic.* Washington, DC: Government Printing Office, 1912.
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Understanding Ammonium Nitrate

by LT Jodi Min
U.S. Coast Guard
Hazardous Materials Division

Chemical of the Quarter

What is it?

Ammonium nitrate is used primarily as a fertilizer, but it also used as a blasting agent. Fertilizer-grade ammonium nitrate is a compound of nitrogen, hydrogen, and oxygen produced when nitric acid is chemically combined with ammonia. It can be in solid, molten form, or in solution. Accidental explosions of ammonium nitrate resulting in deaths and destruction have given this chemical a particularly bad reputation. Many safe handling procedures were developed after these accidents.

How is it shipped?

Fertilizer-grade ammonium nitrate is shipped in granular or crystalline form coated with an anti-caking chemical. It can be shipped in bulk containers, packaged into bags, or in loose bulk form on break bulk carriers. There are strict regulations regarding stowage and transport requirements due to its strong oxidizing characteristics (it can support and intensify a fire without oxygen present).

Why should I care?

Shipping concerns

The main concern is combustion. Therefore, ammonium nitrate-based fertilizer should be stored away from all sources of heat and should be separated from combustible materials—particularly liquids such as bromates, chlorates, chlorites, nitrites, and powdered metals. This chemical is also identified as a "stowage category C" cargo, which means it must be stowed on deck only on board a vessel.[1]

Health Concerns

Ammonium nitrate can cause minor irritation, nausea, headaches, dizziness, and hypertension if exposed to it during a short period of time. In all cases, it is important to seek medical attention after any exposure. Extremely toxic nitrogen oxide gases are produced if ammonium nitrate decomposes or combusts.

Fire or explosion concerns

Ammonium nitrate is generally a stable compound; however, explosions can occur when it is exposed to strong shock or high temperatures under confinement. As a result, venting is required for any ship carrying the chemical.

Actions that may help to prevent explosions and fire include:

- Avoid heating the cargo, especially in a confined space.
- Do not expose ammonium nitrate to strong shock waves.
- Do not combine ammonium nitrate with carbonaceous or combustible materials.
- Avoid low pH (acidic conditions).

What is the Coast Guard doing about it?

Transport of fertilizer-grade ammonium nitrate is regulated under 49 Code of Federal Regulations Subchapter C, Hazardous Material Regulations, and the IMDG Code when it is shipped internationally.

About the author:
LT Jodi Min is currently working in the Hazardous Materials Division at the U.S. Coast Guard Headquarters. She was previously stationed at MSU Pittsburgh and on the CGC Legare *out of Portsmouth, Va. She graduated from Coast Guard Academy with a B.S. in marine environmental science and graduated from Johns Hopkins University with an M.S. in chemical and biomolecular engineering.*

Endnote:

1. All transportation requirements for a hazardous material can be found in the Hazardous Materials Table located in Part 172.101 of Title 49 CFR. Information can be found at the Pipeline and Hazardous Material Safety Administration Office of Hazardous Materials Safety website at www.phmsa.dot.gov/hazmat/library.

Nautical Engineering Queries

Prepared by NMC Engineering Examination Team

Questions

1. **Which of the test pressures listed is considered to be satisfactory when conducting a hydrostatic test on a desuperheater, which has undergone a welding repair, and has been reinstalled in a boiler having a MAWP of 900 psi?**

   A. 250 psi
   B. 900 psi
   C. 1125 psi
   D. 1350 psi

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2. **A decision has been made to change out 1,000 gallons of lube oil in a vessel's main propulsion unit. Which of the following statements is true regarding this decision?**

   A. The neutralization number has decreased below minimum levels.
   B. The sole use of the increase in the neutralization number need only be the basis for the decision.
   C. In addition to the increase in the neutralization number, the viscosity of oil has also increased.
   D. A small rise in the neutralization number over several years of use has prompted this decision.

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3. **One function of a replenishing pump installed in many pressure-closed hydraulic systems is to supply fluid flow to __________.**

   A. the reservoir
   B. a servo control circuit
   C. position a manually controlled valve
   D. the main system accumulators under all operating conditions

1. *Note: Boiler hydrostatic tests are performed for a number of reasons. Most hydrostatic tests are performed at one of three test pressures: boiler design pressure (maximum allowable working pressure, MAWP), 125 percent of design pressure, and 150 percent of design pressure, depending upon the purpose of the test. Other test pressures may be authorized for specific purposes.*

A.	250 psi	Correct Answer. A hydrostatic test at this pressure could hypothetically qualify as a test pressure authorized for specific purposes, if applicable. A boiler desuperheater is subjected to a very modest differential pressure when the boiler is in operation. For this reason, a relatively low hydrostatic test pressure is authorized, even though the work performed in this case is a welding repair. Typical hydrostatic test pressures to test a desuperheater for leakage typically range from 150 to 300 psi. The actual hydrostatic test pressure to be used, of course, must be obtained from the tested boiler technical manual.
B.	900 psi	Incorrect Answer. A hydrostatic test at this pressure (which in this case is the boiler design pressure) is performed to prove the tightness of all valves, gaskets, flanged joints, rolled joints, welded joints and boiler fittings, and is accomplished upon the completion of overhaul, cleaning, and routine repairs that affect the boiler or its parts or is performed at any other time when it is considered necessary to test the boiler for leakage.
C.	1125 psi	Incorrect Answer. A hydrostatic test at this pressure (which in this case is 125 percent of the boiler design pressure) is performed after renewal of pressure parts, chemical cleaning of the boiler, minor welding repairs to manhole and handhole seats, minor repairs to tube sheets, and tube renewals except downcomers and superheater support tubes.
D.	1350 psi	Incorrect Answer. A hydrostatic test at this pressure (which in this case is 150 percent of the boiler design pressure) is performed after welding repairs to headers and drums, tube sheets, nozzles, drain and vent nipples, and after renewal or re-welding of downcomers and superheater support tubes.

2. *Note: Regardless of the application and severity of service, all lubricating oils need to be changed at specified intervals or when the condition of the oil warrants an oil change. The conditions to be checked for include viscosity, neutralization number, and the presence of water and sediment. The neutralization number of lubricating oil is a measure of the acidity or alkalinity of the oil and is an important measure of the suitability of the oil as it undergoes chemical changes over its useful life.*

A.	The neutralization number has decreased below minimum levels.	Incorrect Answer. Generally, as lubricating oil undergoes the chemical changes associated with the oxidation process, the oil will experience a rise in the neutralization number. Thus, for a given application, there would be a maximum allowable level specified, not a minimum allowable level.
B.	The sole use of the increase in the neutralization number need only be the basis for the decision.	Incorrect Answer. As lubricating oil undergoes oxidation over time, the amount of suspended oil-insolubles increase. The result is in an increase in the viscosity of the oil that diminishes the effectiveness of lubrication. Thus, an increase in the neutralization number should not be the sole criterion for oil change decision-making.
C.	In addition to the increase in the neutralization number, the viscosity of oil has also increased.	Correct Answer. See explanation for Choice "B". Along with an increase in neutralization number, an increase in viscosity is also an important criterion for oil change decision-making.
D.	A small rise in the neutralization number over several years of use has prompted this decision.	Incorrect Answer. Even more important than the neutralization number itself, is the rate of rise of the neutralization number. However, a small rise over several years would not likely be used as a criterion for deciding to change the oil.

3. *Note: Open-loop hydraulic systems generally utilize a single uni-directional pump which has a designated suction port that is connected to the reservoir. If a leak occurs anywhere in the system, the pump will function to keep the system filled, as long as enough fluid remains in the reservoir. Closed-loop hydraulic systems utilize two pumps: a power pump and a replenishing pump. The power pump is bi-directional and is typically a servo-controlled variable displacement pump. The replenishing pump (usually driven by the same motor driving the power pump) primarily functions to keep the system filled should a leak develop in the system.*

A.	the reservoir	Incorrect Answer. Should a leak occur, the replenishing pump draws suction from the reservoir and discharges into the closed-loop through a check valve to replenish the system. If the reservoir requires make-up fluid, a make-up transfer pump is used for this purpose.
B.	a servo control circuit	Correct Answer. As the name implies, the replenishing pump replenishes the system as needed. However, the replenishing pump is the only source of hydraulic pressure with the power pump off stroke, and upon demand will place the power pump on stroke via the servo control circuit.
C.	position a manually controlled valve	Incorrect Answer. In a system with a manually controlled valve, the positioning of such a valve is done manually, not with a replenishing pump.
D.	the main system accumulators under all operating conditions	Incorrect Answer. An accumulator is a pressurized reservoir used in some open-loop hydraulic systems to store hydraulic fluid and absorb excessive pressure increases in the system. When the accumulator requires replenishing, it is supplied fluid by the system's power pump via a branch connection off the pump's discharge line.

1. What is the effect of the combination of sinkage and trim?

A. Squat
B. Bank Suction
C. Bank Cushion
D. Heel

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2. Your vessel is discharging containers from the main deck with the ship's cranes. How would you estimate the vertical center of gravity of a container as it is being discharged from the deck?

A. The vertical center of gravity for the main deck plus half the height of the container.
B. The vertical center of gravity for the main deck plus the vertical distance to the head of the jib.
C. The vertical center of gravity for the main deck plus the height of the container.
D. The vertical measurement from the main deck to the heel of the jib plus half the height of the container.

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3. Which item is of the most use in getting a lifeboat away from a moving vessel?

A. The falls
B. Sea painter
C. Fleming gear
D. Boat hook

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4. What is the proper treatment for frostbite?

A. Rubbing the affected area with ice or snow
B. Rubbing the affected area briskly to restore circulation
C. Wrapping the area tightly in warm cloths
D. Warming exposed parts rapidly

1. A. Squat — Correct Answer. As a vessel moves through the water, it experiences a change in mean draft known as sinkage. This change could be equally distributed fore and aft or could be more pronounced on either the bow or stern. The simultaneous change in mean draft or sinkage and change in trim is known as squat.
   B. Bank Suction — Incorrect Answer. This is the effect experienced when a vessel is navigating on the outer limits of channel and the stern swings into the bank.
   C. Bank Cushion — Incorrect Answer. This is the effect experienced when a vessel is navigating on the outer limits of channel and the bow is pushed away from the bank.
   D. Heel — Incorrect Answer. Heel is defined as the transverse angle of inclination of a vessel.

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2. A. The vertical center of gravity for the main deck plus half the height of the container. — Incorrect Answer. This would be the estimate of the container if it were still secured on deck.
   B. The vertical center of gravity for the main deck plus the vertical distance to the head of the jib. — Correct Answer. As the crane lifts the load, the vertical center of gravity is transposed to the head of the boom.
   C. The vertical center of gravity for the main deck plus the height of the container. — Incorrect Answer. This formula cannot be used to calculate the vertical center of gravity of a container.
   D. The vertical measurement from the main deck to the heel of the jib plus half the height of the container. — Incorrect Answer. This formula has no validity.

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3. A. The falls — Incorrect Answer. The falls are used to lower the lifeboat to the water.
   B. Sea painter — Correct Answer. If the vessel has way on, the lifeboat will clear the side by riding on the sea painter, which can then be cast off when the boat is clear.
   C. Fleming gear — Incorrect Answer. The fleming gear is a hand-operated propulsion system for the lifeboat, but does not have the ability to steer the craft.
   D. Boat hook — Incorrect Answer. The boat hook would be utilized to fend off the vessel if it were not making way through the water.

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4. A. Rubbing the affected area with ice or snow — Incorrect Answer. This treatment would only worsen the condition
   B. Rubbing the affected area briskly to restore circulation — Incorrect Answer. This could burst the blisters if present, and reduce core temperature
   C. Wrapping the area tightly in warm cloths — Incorrect Answer. This could slow down circulation and burst any blisters
   D. Warming exposed parts rapidly — Correct Answer. This treatment ensures warming of the exposed area without lowering the core temperature of the patient.

Exercise Black Swan

Why black swan? In his book, *The Black Swan,* Nassim N. Taleb describes major scientific discoveries, historical events, and artistic accomplishments as “black swans,” or rare events, which can change the course of history.

Exercise “Black Swan” is part of a series of mass rescue operation exercises designed to educate and prepare participants for a potential mass rescue operation at sea.

These exercises also examine our ability to implement mass rescue operation response and recovery plans in support of federal, state, local, and private-sector response and recovery activities.

Exercise Black Swan
CG District 7
Miami, Fla.

April 1–5, 2013

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WASHINGTON DC 20593-7681

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