The Sinking of the R.M.S. Titanic
One of the Most Disastrous Marine Failures in History

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Abstract

On April 14, 1912 the R.M.S Titanic collided with and iceberg taking 1,517 of the passengers down with it. The said to be unsinkable ship sank in under three hours as a result of naïve behavior, engineering flaws, and a lack of safety procedures. After this disaster happened, Harland & Wolff’s, the ship’s owner, made a series of changes to the design of their liners and materials used. Also there were many updates to the safety regulations and procedures vessels needed to follow in order to prevent something like this from happening again.
The *Titanic* was a British passenger ship that sank during its maiden voyage from Southampton, England to New York City on April 10, 1912. The sinking of the *Titanic* is one of the most disastrous marine failures in history. Naïve behavior, engineering flaws, and a lack of safety procedures created an American disaster known as the *Titanic*. To many at the time, the sinking of the *Titanic* was synonymous with impossibility. The ship was viewed as a technological masterpiece and was believed to be so great in design and function that it could never sink. With a destination of New York City and a passenger manifest that included both Americans and many immigrants, the sinking of the Titanic had all the elements of an American disaster (destruction, loss, distress, difficulty, suffering and death)\(^1\). Over 50 percent of the *Titanic*’s passengers did not survive and the ship was never recovered. The sinking of the *Titanic* was the result of misplaced confidence in a defective ship that had the unfortunate fate of running into poor environmental conditions with insufficient rescue equipment. A review of the facts surrounding the voyage of the *Titanic* reveals that it is sinking on the evening of April 14, 1912 was one of the most disastrous marine failures in history.

In the spring of 1909, three thousand men at the Harland & Wolff’s shipyard started the construction on the *Titanic* in Belfast, Ireland. Two years after construction started on the largest ship ever built to that point, it was finally finished, standing 175 feet high and 882 feet long and weighing an incredible 46,000 tons. Harland and Wolff had to make alterations to their shipyard increasing the size of the piers and gantries just to accommodate the giant liner.

On April 10, 1912, the *Titanic* left port on its voyage from Southampton, England to New York. When *Titanic* left port she as carrying 1,317 first, second, and third class passengers and 905 crewmembers. Captain Edward John Smith who had served 32 years for the White Star line

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and had 26 years of experience in the North Atlantic navigated the ship. “In all my experience, I have never been in any accident of any sort worth speaking about. I never saw a wreck and never have been wrecked, nor was I ever in any predicament that threatened to end in disaster of any sort”, Captain Smith said this a few years prior to the voyage of the Titanic. 2

On April 14, 1912, the experienced shipmaster ordered the liner to sail at full speed, aiming to better the crossing time of Titanic’s sister ship Olympia. The crossing time of the Olympia was fifteen days, sixteen hours and forty-two minutes to reach New York from Southampton, England. Despite the wireless operators receiving multiple warnings of ice from other ships in the area. At 11:40 p.m., a 25-year-old crew member named Frederick Fleet screamed, “Iceberg right ahead!”3 informing the bridge of the iceberg ahead. Immediately the engines were put in reverse and the helm was put hard at starboard4. However, due to the incredible size of the ship, slowing down and turning took longer than there was. Just thirty-seven seconds after Heet’s warning the Titanic struck the iceberg. The collision with the Iceberg, ripped open two hundred feet of the Titanic’s side plating. Side plating that was below the waterline. The rip in the side plating was between adjacent boiler rooms number five and six. The rip allowed water to flood six of the sixteen major watertight compartments at a rate of four hundred tons per minute. As the water flooded into these compartments, it got so high that it spilled over the inadequate bulkheads and into adjacent compartments. The engineering design for the Titanic described these compartments as watertight compartments. Following an inspection of the damage by Captain Smith and Thomas Andrews, the chief designer, it was clear the Titanic was sinking. The Titanic then sent out one of the most famous distress messages in

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4 Starboard is the right side of the ship
“CQD MGY I REQUIRE ASSISTANCE IMMEDIATELY STRUCK BY ICEBERG IN POSITION 41 46 N 50 14 W.” At 12:05 a.m., twenty-five minutes after the collision occurred at Captain Smith ordered the crew to get the passengers on deck and prepare the lifeboats. It took another twenty-five minutes for the first lifeboat to be lowered into the 28-degree freezing water at 12:45 a.m. The crew successfully launched lifeboats up until 1:55 a.m. and the final wireless transmission was made at 2:10 a.m. By 2:18 a.m. the lights blinked one final time and then went out forever. The *Titanic* then broke into two pieces and sank to the ocean floor. It took two hours and forty minutes to sink a ship that was once said to be unsinkable.

The two pieces of the *Titanic* now sit 12,500 feet below the oceans surface and on the ocean floor. For seventy-three years the *Titanic* sat undetected until on September 1 1985, Bob Ballard and his crew uncovered the lost ship 350 miles southeast of Newfoundland. However, it took another six years for the first scientific team to visit the site. This scientific team was able to dive down to the wreck. The dive to the wreck was named the IMAX dive because the film collected was going to be used to create an IMAX film. With advancements in technology, the divers were able to stay submerged and take pictures of the wreck for almost for twenty hours. A team of experts examined the pictures and evidence collected and the results of those examinations provided many of the answered needed to understand how such a disasters occurred. These pictures provided the evidence needed to show that is was flaws in the engineering designs that resulted in the sinking of the *Titanic*.

During another expedition in 1991, a scientist discovered a chunk of metal lying on the ocean floor. This chunk of metal was once part of the *Titanic*’s hull. The Frisbee sized piece of steel was an inch thick and contained three rivets holes; each rivet hole was 1.25 inches in

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5 Ritche, Davie. “Shipwrecks: an Encyclopedia of the Worlds, Worst Disasters at Sea
diameter. Discovering this piece of evidence proved to scientist of a major engineering flaw in the Titanic’s design contributing to its sinking.

Roughly three million low-grade iron rivets were used in the building of the Titanic to hold all the sections together. “From the very day that she was designed she was almost doomed…this [the use of iron rivets] was almost the Achilles heel of the Titanic.”

During the time the Titanic was built the better high grade rivets, made out of steel, were short in supply, which was a reason the low-grade iron rivets were used.

One of the reasons why the Titanic sank so quickly was that these low-grade rivets ripped apart very easily when the ship hit the iceberg. Had the higher graded rivets been used the Titanic probably would have stayed afloat long enough for rescuers. Such a situation would have saved many more lives. Another factor that did not help with this rivet situation was that the Titanic was traveling through freezing cold waters. The low temperatures of the water caused the rivets to become extremely brittle. The huge force created when hitting the iceberg caused these low-grade rivet heads to pop off and the seams of the hull to open up. Also as the iceberg scrapped down the side of the ship, the rivets were sheared off. This caused even more hull seams to open up. These huge holes that opened in the hull of the ship, enabled large quantities of water to pour into the hull of the ship.

The rivets were not the only thing that failed the Titanic that night. “Her fragility and vulnerability lie in the fact that the framework is overlaid with a relatively thin skin of plating, an inch or so in thickness, which, while amply strong to resist the inward pressure of the water the impact of the seas, and the tensile and compressive stresses due to the motion of the ship in a

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8 Broad, William J. “In Weak Rivets, a Possible Key to Titanic’s Doom.” New York Times, April 14, 2008.
seaway, etc., is readily fractured by the blow of a collision.\(^9\) (Walker) The Titanic was traveling at a speed of 21 knots (24 miles per hour). Traveling this fast put the outer skin of the hull at risk. Constructing a ship with an inner skin in the hull above the waterline protects would have protected the Titanic’s buoyancy. The inner floor plating should have been carried up the side frames creating an inner skin. (See figure 1) Had an inner skin been created, it would have prevented the inward flow of water to the compartments, thus possibly saving the ship from sinking.

Another element designed to protect against flooding was subdivision. Subdivision is dividing the hull into separate watertight compartments. The Titanic was divided into sixteen separate compartments, each divided by fifteen bulkheads. Each compartment was connected using a special door that could be controlled from the bridge and closed automatically in the event of an emergency. To have a true watertight compartment you need to have all six sides enclosed within the hull. However, this design limited the crew and passengers access to all parts of the ship without having to go up a staircase and over the bulkhead. For convenience purposes they put doors, stairways, hatchways, and other openings into the bulkheads, taking away the watertight aspect. For example on upper deck E, (See figure 2) also known as “working-crew alleyway”, contained six non-watertight doors which had iron ladders leading down to the boiler room for the crew. The doors were open framed with grating for easy ventilation. As the water flooded the compartments after the collision water poured down the alleyway and through all these openings. Subdivisions effectiveness relies on the degree to which the deck is watertight. The watertight effectiveness was lowered greatly and only two-thirds of the hull received the benefit of subdivision.

Had the watertight compartments been implemented/designed properly, subdivision still would not have saved the *Titanic*. Where the *Titanic* collided with the iceberg caused extensive flooding to the bow compartments pulling the ship below waterline. The watertight compartments then attempted to keep all the water in those compartments as designed. However, if subdivision was not part of the design there wouldn’t have been any compartments holding the water in the bow of the ship causing it to pitch forward. The water could have spread out keeping the ship horizontal. This would not have saved the ship from sinking, but it would have kept it afloat a little longer allowing more time for passengers to get off safely.

“It was largely the most serious defect, the existence of many unprotected openings in the bulkhead deck of the *Titanic*—that caused her to go down so soon after the collision” ¹⁰ Unlike many ships, the bulkheads on the *Titanic* did not extend through the whole height of the ship to the shelter deck. The only one out of fifteen bulkheads that carried all the way up to the shelter deck was the first one where the collision occurred. The second and third bulkhead carried up to the saloon deck, third-ninth bulkhead carried up to the upper deck, tenth-fourteen were carried back up to the saloon deck and finally the fifteenth was carried up to the upper deck. (See figure 2)

When deciding what height to make the bulkheads the Board of Trade stipulations established an imaginary “safety line”. A safety line is a calculated depth to which a ship will sink when two adjacent compartments are flooded. This explains the change in bulkhead height at the engine and turbine room because those two adjacent compartments are the biggest and when flooded would sink the ship more than the others. (See figure 3) When comparing the bulkheads heights of the *Titanic* to other ships of its time, they were much lower. If the

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bulkheads extended even a few feet higher the water might have been better contained in the compartments ripped open during the collision. Had the water been better contained sinking would have been at a slower rate giving more time for rescuers to arrive and get passengers safely off the ship into lifeboats. When combining the lower bulkheads and the non-watertight compartments in the hull of the ship, its no wonder the Titanic sank so fast.

Another huge fault in the design of the hull was the size of the compartments. They were much greater in size especially the engine and turbine room. The plan for larger compartments was to allow the coalbunkers to be in the most convenient position to the boilers. As shown in figure 2 the twenty-nine boilers transversely and double ended with the furnaces in front and behind them. Once again, for convenience purposes they placed the coalbunkers on each side of the bulkheads so getting the coal to the bunkers was more easily done. Even though this might have lessened the work of the workers and increased productivity, it put the safety of the Titanic and its passengers second because any damage done to the hull would now admit water across the whole ship. “The use of transverse coal-bunkers must be regarded as one among many instances, in which the safety of passenger ships is sacrificed to considerations of economy and convenience of operations.”11 Also shown in figure 2 the Mauretania, another passenger steamer at the time, had its coalbunkers on the sides of the ship longitudinally. Placing the coalbunkers on the side of the ship prevented flooding of the main boiler room compartments by providing another layer of defense in the hull of the ship. Although this placement of the coalbunkers would increase operation expenses, due to increased need of coal passers, it increases the safety of its passengers. Harland & Wolff approved designs that were more efficient but took away safety elements.

Another major factor in the sinking of the Titanic was naïve behavior through ignoring wireless warnings and many communication failures. As Titanic steamed across the Atlantic Ocean heading towards New York Titanic had clear weather and calm seas. On the third day out, April 14, Titanic received multiple wireless messages from other ships warning of ice on the track to which she was steaming. These messages read: From Baltic at noon: “Greek steamship Athinai reports passing icebergs and large quantity of field ice to-day in latitude 41.51 north, longitude 49.52 west”, from Californian at 7p.m: “Latitude 42.3 north, longitude 49.9 west. Three large bergs five miles to southward of us”, from Californian: “Amerika passed two large icebergs in 41.27 north, 50.8 west on the 14th of April”, rom Californian at 10:40p.m: “We are stopped and surrounded by ice”\(^{12}\) Receiving these warnings shows the Titanic knew of the possibility of ice up ahead. Officers on duty instructed the looks outs to keep an eye out for ice. The Titanic’s passenger’s lives were resting in the rate of spotting the iceberg in time.

Captain Smith was planning on retiring once making it to New York. There was talk that his retirement relied greatly on him beating the crossing time of Titanic’s sister ship Olympic. After leaving Queenstown it was full steam ahead for the Titanic. On Friday, the first day they traveled 440 miles, on Saturday the second day 519 miles and on Sunday, the third day 546 miles. To increase the speed, on Sunday night Captain Smith ordered for 3 more boilers to be started up, having 24 of 29 boilers going. Captain Smith and his crew were determined to keep moving at this pace and why after receiving multiple warning of ice up ahead, they didn’t slow down.

Probably one of the most well known failures in safety procedures was the number of lifeboats on the Titanic. “One of the factors that makes the sinking of the Titanic so memorable

is the fact that lives were needlessly lost. There were not enough lifeboats on board to hold all the passengers and crew and when the lifeboats were launched they were not filled to capacity.”¹³ The Titanic was carrying a total of 2,222 passengers with a total of 20 lifeboats; 2 wooden cutters, 14 standard wooden lifeboats, and 4 collapsible canvas lifeboats.¹⁴ With that many lifeboats on board only 33% (1178 persons) of the Titanic’s total passengers and crew would have fit on the boats. Titanic also carried 3,500 lifebelts and 48 life rings; they were basically useless because the majority of passengers that fled to the water didn’t drown to death, they froze to death. The Titanic could have fit 64 lifeboats on the ship with a capability of carrying 3547 passengers. However, the chief designer Alexander Carlisle originally planned for only 48 and later reduced the number to 20 to make the top deck less crowded and fear in his passengers. "Control your Irish passions, Thomas. Your uncle here tells me you proposed 64 lifeboats and he had to pull your arm to get you down to 32. Now, I will remind you just as I reminded him these are my ships. And, according to our contract, I have final say on the design. I’ll not have so many little boats, as you call them, cluttering up my decks and putting fear into my passengers."¹⁵ Bruce Ismay, the owner of the White Star Line, told Andrew Thomas, designer of the Titanic. Once again it is evident that the Titanic's safety was sacrificed.

Even though only 33% of passengers had a spot in the lifeboats, it was still legal because the Board of Trade only required enough boats to only fit 1,060 passengers. After the disaster, Sir Alfred Chalmers of the Board of Trade was asked why the law had not been updated since 1896. He believed that during a disaster crewmembers would only be able to deploy sixteen

¹⁴ See figure 4.
lifeboats and ironically that the latest boat designs had stronger than ever water tight compartments making sinking near impossible.

On the Titanic there were other flaws in the safety precautions taken. There was no public warning system, which was uncommon, that allowed the crew to let the passengers know what was happening, so many were confused. Some passengers even thought it was a drill and stayed inside rather than going out onto the freezing deck. Not only were the passengers confused but many crewmembers were confused on where to go to launch the lifeboats. The only lifeboat drill planned was on April 14 however; Captain Smith cancelled it to allow passengers to attend church. Crewmembers and stewards woke up the first and second-class passengers and told them to come to the deck and put life jackets on. The third class passengers were not made aware of the situation happening and when they did they started clogging up the corridors trying to get to the boat deck.

Even as the first lifeboat (lifeboat #7) was lowered, people still did not believe they were in danger and only twenty-eight people occupied the sixty-five-person lifeboat. “The matter was treated calmly and with no urgency, for in the minds of the captain and officers was the knowledge that out of all their charges only little more than half, as best could hope to be saved”.\(^\text{16}\) The crew was able to successfully launch only eighteen lifeboats out of twenty. Another sixty-five-person lifeboat, lifeboat #1, was the fifth lifeboat lowered at 1:05a.m containing only twelve people. One of the passangers on the lifeboat paid off the other crewmembers to ignore the cries for help from people in the water. “The partly filled lifeboat standing by about 100 yards away never came back. Why on Earth they never came back is a

\(^{16}\) Hocking, Charles. “Dictionary of Disasters at Sea During The Age of Steam: Including Sailing Ships and Ships of War Lost in Action 1824-1962” Vo. 11
mystery. How could any human being fail to heed those cries."17 Jack Thayer a survivor stated. After all the lifeboats were launched a total of 472 spots went unused. Had the crew been better trained and there was a better system of communication possibly 472 more lives could have been saved.

After the disaster occurred, the White Star Line made several changes to their ships. Along with design changes, new safety regulations were established and agreed upon by the American and British governments. Developing new safety regulations was also an attempt at preventing something like this in the future.

Many modifications were made to the safety regulations 36 years later by the 1948 Convention on Safety of Life at Sea. The outdated British Trade of Commission regulation of the number of lifeboats needed has since been updated since 1912 and now requires enough lifeboat spots for every passenger and crewmember on board. Also to increase quickness on deploying the lifeboats, davits, the device used to lower boats into the water, are mounted along the side of the lower deck. The regulations also state that lifeboats must contain food, water, signaling devices, compass, oars, and sails to help with survival if the lifeboats ever need to be deployed. Also on large vessels at least two of the lifeboats must be motorized. Also to keep an eye on the icebergs, an International Ice Patrol was formed. The Ice Patrols job was to alert ships traveling between the United States and England of approaching ice fields. The United States also stated that no ship carrying passengers is allowed to leave unless it is conformed to U.S policies. U.S. policie state that the radio needs to be manned 24 hours a day. Had all these regulations been implemented before the sinking occurred, there might not have been a sinking at all.

There were also modifications made to ship design. As discussed earlier in the paper, the White Star Line extended the double bottoms up the sides of the ship creating an inner skin. The

transverse bulkheads were raised hoping to not have the same problem. The increase in height of the bulkheads would stop the water from flooding over top the bulkheads as it did in the Titanic. In the event another disaster like this occurred and a ships hull is damaged, it would limit the water only to the damaged sections. The 1948 Convention on Safety of Life at Sea also established criteria for watertight compartments. They created specific orientations, length and number of compartments requirements on the ship. The number of compartments and length of them are determined by the size of the ship, and the only requirement is that a ship must be able to float if two of the compartments are flooded and that the walls for the compartments are to be oriented horizontally. The new regulations were developed to preventing something like the Titanic from ever happening again.

The sinking of the Titanic was the result of naïve behavior, engineering flaws and a lack of safety procedures. Due to its size, everyone believed that it would be impossible to sink the Titanic. It had been built by a workforce of nearly 15,000 and contained “turn-of-the-century design and technology”\textsuperscript{18}. Press reports and advertising for the Titanic by its owner, the White Star Line, focused on its unsinkability. In today’s dollars, first-class suites were priced at more than $55,000.00. It was viewed as a rare and privileged opportunity to cross the Atlantic Ocean as a passenger on the Titanic. An overall analysis of the events leading up to and including those which occurred on the evening of April 14, 1912, support determinations that naïve behavior was a contributing factor that made the sinking of the Titanic one of the most disastrous marine failures in history. It was the inexperience of the time and an unsuspecting over-inflated level confidence that created a belief that the Titanic was so great in design and function that it would never sink.\textsuperscript{19} The Titanic was thought to be a “technological masterpiece”\textsuperscript{20}. Most passengers

\textsuperscript{18} Gannon, Robert, "What Really Sank the Titanic," Popular Science, vol. 246, no. 2 (February 1995), 50
\textsuperscript{19} Ibid
who embarked on the sailing of the Titanic on April 10, 1912, did so with the belief and understanding that the Titanic could not sink. Engineering design flaws were a major contributing factor to the sinking of the Titanic. Analysis of the remains of the Titanic has revealed that there were a number of engineering flaws within the construction of the Titanic. The ship was routinely described as luxurious and unsinkable because of its technological advances. These technological advances and engineering designs were later found to be a major factor in the sinking of the Titanic and thus disastrous marine failures in history. From a technological standpoint, the engineering design for the watertight compartments was such that if, “for some unimaginable reason, the hull were punctured, only the compartment actually ruptured would flood. In a worst-case situation – two ships ramming each other, for example – builders figured that the Titanic would take from one to three days to sink, time for nearby ships to help”\(^{21}\). After hitting the iceberg, this engineering design proved to be faulty and the ultimate reason for the speed in which the Titanic sank.

A third factor in this assessment of why the sinking of the Titanic is one of the most disastrous marine failures in history is that in 1912, safety procedures and safety regulations did not exist for the governance of passenger ships at sea. “Along with the changes in ship design that resulted from the Titanic disaster, safety regulations were established to govern passenger ships while at sea.”\(^{22}\) It was at the 1948 Convention on Safety of Life at Sea that an assortment of governance based safety regulations were established. It was the United States that began the ice patrol of waters between the United States and England.

\(^{20}\) Ibid
\(^{21}\) Ibid
Without a doubt, the sinking of the *Titanic* has become one of the most well known disasters in history. It was the terrible loss of life and the abrupt ending to a naïve belief in the unsinkability of such a large ocean liner that continues to have society intrigued and curious about what caused the rapid sinking of the *Titanic*. As more and more investigative studies are completed on the reasons behind the sinking of the *Titanic*, the common thread within all of it is that this disaster was the result of a misplaced confidence in a defective ship that had the unfortunate fate of running into poor environmental conditions with insufficient rescue equipment, naïve behavior, engineering flaws, and a lack of safety procedures created an American disaster known as the *Titanic*. 
Figure 1: shows how the plating of the bottom of the Titanic could have been carried up the side from to form an inner skin, it also shows how the web frame would have created about a 6 inches gap between the inner and outer skin for more protection.

Figure 2: Shows the 16 compartments and 15 bulkheads. The compartments numbered 1-6 in black ink are the 6 compartments ripped open from the collision. The compartments are labeled 1-15 in blue ink. Also on the 2nd diagram is a bird’s eye view of the layout of the transverse coal beds and boilers and compared to the longitudinal layout of the Mauretania.

Figure 3: Compares the bulkhead height of the Titanic to other vessels at the time. It shows how much lower the heights were especially when looking at the water level. The Titanic was the lowest at only 10 feet above the water level.

Figure 4: Shows in white the way the Titanic stored the lifeboats on deck. In black is a design created after the fact that would have stored enough boats to get everyone off safely.

Figure 5: Shows most of the design flaws of the hull of the *Titanic* compared to other liners at the time. It shows how the bulkhead deck only went 10 feet above the waterline, there was no double skin, and the coal was kept transverse.

Bibliography


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