



NASA SAFETY CENTER
SYSTEM FAILURE CASE STUDY

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Kiloton Killer

The Collision of the SS *Mont-Blanc* and the Halifax Explosion

December 6, 1917, Halifax, Nova Scotia, Canada: the Great War reached across the Atlantic to transform one of North America's natural deepwater ports into a teeming logistics hub. In a new tactic, the Allies formed shipping convoys against lurking German U-boats to deliver tons of supplies. To join one such convoy, the French freighter SS *Mont-Blanc* entered Halifax Harbour that bright sunny afternoon. Known only to the crew and a few port officials, the ship was packed with munitions. Steaming outbound, the SS *Imo* collided with the *Mont-Blanc*. Sparks set the French ship on fire beyond the crew's ability to extinguish the flames; they escaped and the ship erupted into the largest explosion yet created by man. Blast pressure leveled every structure within a mile and blew wreckage for tens of miles. Approximately 2,000 people were killed and over 9,000 injured. The unprecedented recovery effort that followed was the genesis of modern disaster relief programs.

PROXIMATE CAUSE

- The *Imo* collided with the *Mont-Blanc*, rupturing containers of benzol on the *Mont-Blanc*'s deck. Sparks from the grinding metal hulls ignited barrels of benzene which, in turn, set off the *Mont-Blanc*'s explosive cargo.

UNDERLYING ISSUES

- Procedures Fail
- Poor Communication

AFTERMATH

- The large numbers of disciplined men stationed at Halifax greatly expedited immediate disaster response and later recovery.
- Disaster relief supplies and money were sent from nations around the world.
- Samuel Henry Prince used the Halifax Explosion as the subject for the first systematic study of a disaster.

BACKGROUND

Halifax Harbour

Founded in 1749 by British settlers, Halifax's geography and harbor—one of the deepest, ice-free natural harbors in the world—established the city as a strategic rally point for wartime shipping during the American Revolution, the Napoleonic Wars, the War of 1812, and the American Civil War. The Bedford Basin, Halifax Harbour's innermost feature, once again became invaluable as Allied forces during World War I (WWI) required a secure convoy staging ground

in advent of German U-boat strikes on shipping crossing the Atlantic. The maritime population of Halifax multiplied during wartime; WWI saw the city's population swell to over 50,000.

The connecting channel between the outer harbor and Bedford Basin is known as the Narrows. Ships enter via the Northern (Dartmouth) side and exit from Bedford Basin using the Southern (Halifax) side, keeping to one's right, similar to land-based vehicle traffic. Although Halifax Harbour has a reputation as a safe port, the tight quarters of the Narrows have contributed to many ship collisions,



Figure 1. Submarine nets consisted of chain gates weighted by concrete at the bottom and supported by buoys.

a feature that also makes the harbor easily defensible, especially important considering U-boat threats. Newly invented chain link anti-submarine nets could be rigged across the Narrows to further bolster harbor defenses.

The SS *Mont-Blanc* and the SS *Imo*

The SS *Imo*, chartered by the Belgian Relief Commission and flagged as a neutral vessel, had anchored in Bedford Basin bound for New York from Rotterdam to pick up relief supplies. The 430-foot converted steamship's single propeller limited maneuverability in restricted waters; it induced strong torque, twisting the ship sideways while accelerating or backing down at low speeds.

The slower, shorter SS *Mont-Blanc*, en route to Bordeaux, was loaded to the decks with munitions destined for Allied forces, including 2,366.5 tons of both wet and dry picric acid (2,4,6 trinitrophenol—more powerful and volatile by weight than TNT), 250 tons of TNT, 246 tons of benzol (benzene) in barrels topside, and 62.1 tons of guncotton (nitrocellulose). The *Mont-Blanc* also carried 300 rounds of ammunition for the vessel's 90- and 95-mm defensive guns. Peacetime vessels flew red flags to designate explosive cargo, but no red flags were flown on the *Mont-Blanc* due to the threat of U-boat attacks. *Mont-Blanc's* Captain Aime Le Medec had no history of maritime accidents.

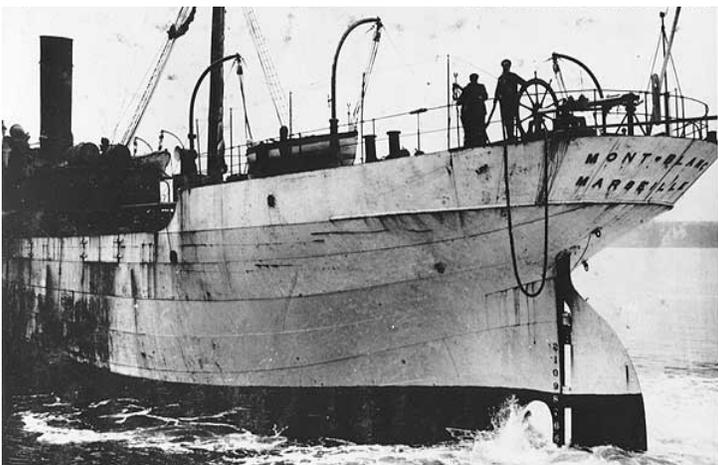


Figure 2. The only known photograph of the SS *Mont-Blanc*.



Figure 3. A map of Halifax Harbour.

WHAT HAPPENED

Navigation

On December 3, the *Imo* arrived at Halifax and cleared the submarine nets, mooring in the Bedford Basin to refuel. The *Mont-Blanc* arrived on December 5 and was boarded by harbor pilot Francis Mackey (with a 24-year accident free career) and a cargo examination officer who was startled by the *Mont-Blanc's* hazardous cargo manifest. Prior to the war, ships carrying explosive cargo unloaded on George's Island before mooring in the basin, but the exponential increase in wartime traffic induced the current port authorities to relax explosive cargo regulations. No arrangements for the *Mont-Blanc* to unload cargo were made; however, the submarine nets were already deployed for the night, delaying the *Mont-Blanc* from entering the harbor. Mackey inquired if there were to be any special protections, such as an escort, for *Mont-Blanc* while navigating the Narrows with such a cargo, but no protections were established; the ship was to be piloted through the Narrows and crowded wartime traffic.

On the morning of December 6, the *Imo*—having been delayed a full day by a tardy coal train—raised anchor and churned towards the Narrows above the harbor speed limit, making up for lost time. The *Mont-Blanc* left anchorage and was heading to the harbor. The *Imo* encountered oncoming harbor traffic and steered toward the left side of the channel rather than maintaining the right of way.

At less than a mile apart, the *Mont-Blanc*—travelling well below harbor limits on the correct side of the Narrows—spotted the *Imo* converging and sounded a single blast to the *Imo* declaring right of way in the channel. The *Imo* responded with two blasts, stating intention of holding

course to the wrong side. The *Mont-Blanc*, now steering close along the Dartmouth shore at a crawl, sounded again for the *Imo* to divert, receiving again two blasts from the *Imo*.

Collision

With two blasts, the *Mont-Blanc* turned hard to port, crossing the bow of the *Imo*, attempting to give the *Imo* room, but the *Imo* gave three blasts and ordered full reverse, torquing right and crashing into the *Mont-Blanc*. Stacks of benzol barrels on the *Mont-Blanc*'s deck toppled and broke open, flooding the topside with flammable liquid. The grinding metal hulls showered the benzol with sparks, igniting the *Mont-Blanc*'s forward deck. Crowds flooded out of Halifax's buildings and gathered on the shores to watch the spectacle as more barrels exploded. No spectators knew what the *Mont-Blanc* carried—and there were scant minutes to spread the word for those who were aware of the cargo. The captain of the *Mont-Blanc* ordered the crew to abandon ship. The *Imo*, unable to maneuver back to the basin, made for sea.

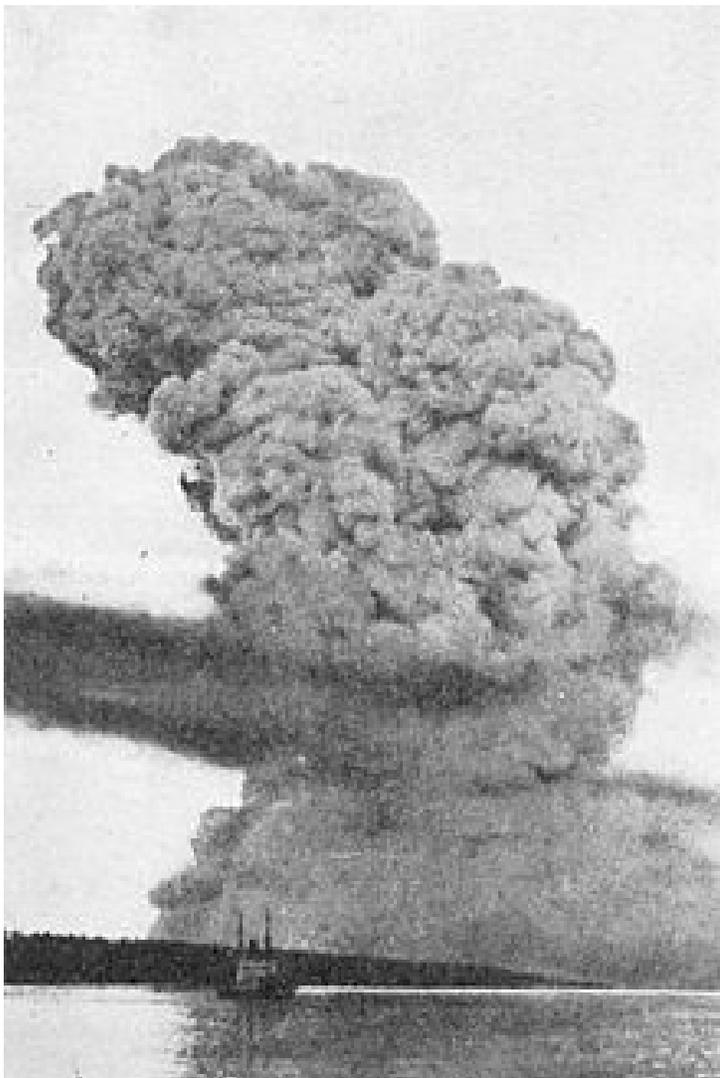


Figure 4. The cloud of smoke and debris from the explosion.



Figure 5. The SS *Imo*, post explosion, thrown against the Dartmouth-side of the Narrows.

Explosion

The *Mont-Blanc* drifted toward the Halifax shore and then blew apart, with a shockwave equivalent to 2,989 tons of TNT expanding across Halifax at more than 4,900 feet per second and reached across 325 acres. The pressure and temperature (in excess of 9,000 degrees Fahrenheit at the origin) pushed a fireball of hot gas and debris into the sky that rained shrapnel on people in the streets below. The water around the *Mont-Blanc* was immediately vaporized and a 52-foot tidal wave swept three city blocks deep into Halifax's Richmond neighborhood. Windows were reportedly shattered over 50 miles away from the epicenter.

Approximately 1,600 people died in an instant. Over 9,000 were wounded. Over 300 injured died later from wounds. Twenty-two percent of the population were casualties (two man-made explosions are comparable: Hiroshima 60 percent, Nagasaki, 35 percent). The *Mont-Blanc*, as a vessel, ceased to exist. Much of Halifax was flattened; over 12,000 buildings were either obliterated or made uninhabitable, displacing Halifax's population and forcing them into the cold. One of the ship's gun barrels was found 3.5 miles away at Albro Lake in Dartmouth. A 1,140-pound anchor fragment was found partially buried, 2.35 miles away in Armdale. Small fragments of the ship shot through other vessels, buildings, and the crowds gathered on the shore. The *Imo* was lifted and slammed against the Dartmouth shore.

PROXIMATE CAUSE

The *Imo* collided with the *Mont-Blanc*, rupturing containers of benzol on the *Mont-Blanc*'s deck. Sparks from the grinding metal hulls lit the benzol, which consumed the vessel and eventually the *Mont-Blanc*'s explosive cargo.

UNDERLYING ISSUES

Procedures Fail

According to maritime convention, the *Mont-Blanc* would have been flying a red flag to indicate it carried explosive cargo, but because Canada entered the war with Britain in 1914, British Admiralty had taken charge of Halifax harbor regulation. Flying a red flag was deemed optional by ship captains and thought dangerous to mark a ship as a high priority target for German U-boats. Furthermore, the *Mont-Blanc* and its dangerous cargo would not previously have been allowed past the outer harbor, but in 1917 the *Mont-Blanc* was directed to dock within Bedford basin.

Moreover, multiple ships crowding the channel created a momentary culture of rule-breaking that the *Imo* joined in unyielding haste. The *Imo* could have slowed until the proper Halifax-side of the channel was clear to navigate. Instead, the *Imo* took the Dartmouth-side and encountered the *Mont-Blanc*. Harbor pilot Francis Mackey's testimony of events recalled the pre-war port procedure did not allow departing vessels to use the Narrows while vessels were coming in. While this may have been tacitly relaxed by port authorities because of increased traffic, the reason of Captain From's (of the *Imo*) decision not to yield to the *Mont-Blanc* remains unknown as he was killed in the blast.

Numerous collisions had occurred in the Narrows before, but none had involved such volatile cargo. The threat was unprecedented.

Poor Communication

Mont-Blanc's choice not to fly a red flag should have been corrected while entering the harbor. The *Imo* was unaware of the *Mont-Blanc's* cargo and confusion between signals while the ships steamed toward each other could have been met with caution if both Captain From and harbor pilot Hayes realized the nature of the *Mont-Blanc's* cargo. Rules required outbound harbor pilots for ships leaving Bedford Basin to alert port authorities, but no such notification from the *Imo* was known to have been made.



Figure 6. Ruins remained after the fires were put out.



Figure 7. An example of one of Halifax's more resilient structures farther away from the blast.

Those with authority to delay the vessel further lacked the information to do so.

The few individuals who were aware of the potent cargo failed to notify others who may have encountered the *Mont-Blanc*. This resulted in a lack of protections for the *Mont-Blanc*, protections that may have allowed safe passage through the Narrows.

AFTERMATH

Response and Recovery

Immediately after the explosion, those not badly injured from the blast helped others and rescued fellow Halifaxians from burning buildings. Soldiers formed barracks to shelter the newly homeless, and commandeered every available vehicle to remove the injured. The large numbers of disciplined men stationed at Halifax greatly expedited immediate disaster response and later recovery.

Disaster relief arrived as news of the disaster spread. On the afternoon of December 6, a trainload of injured and homeless victims left for Truro. Doctors and nurses flocked from cities both near and far to care for the injured.

Money was sent from as far away as China and New Zealand. The Canadian government gave \$18 million to defer the costs of clearing wreckage, rebuilding and caring for the people of Halifax. The British government gave almost \$5 million, also to ease the cost of the disaster. Massachusetts, which donated \$750,000 in money and goods, provided an invaluable number of volunteers.

The Dominion Government appointed the Halifax Relief Commission on January 22, 1918 to head pensions, claims for loss and damage, and coordinate re-housing and the rehabilitation of victims.

The influx of skilled laborers, money, and attention promoted new developments in Halifax, a city widely regarded as steadfastly conservative. Progress

manifested in various forms, many in the form of medical advancements: notably pediatrics optics. While the explosion left only a few completely blind, there were numerous eye injuries due to the flying glass. Many advances were also made in triage, emergency medicine, rehabilitation, psychology, psychiatry, ophthalmology, anesthesia, orthopedics, reconstructive surgery, and prosthetics.

Samuel Henry Prince

In 1919, Samuel Henry Prince, an ordained priest and Halifax survivor who had assisted with the city's recovery efforts (and who had participated twice in search and rescue efforts for SS *Titanic* survivors on the SS *Montmangy*), was completing his Ph.D. in Sociology at Columbia University. Using the Halifax explosion as the basis for his thesis, *Catastrophe and Social Change* (Prince, 1920), he penned the first systematic study of disaster.

Although *Catastrophe and Social Change* includes theories now outdated in modern sociological contexts and information from unreliable sources, it was the first documentation of convergence (when relief pours in from surrounding areas), scapegoating (identifying the explosion as a subversive German attack, blame on Haligonians of German descent), and emergent behavior, and includes the first evidence against the theory of role abandonment during crisis. The study was also the first thorough documentation of community recovery and conflict during relief.

All of these topics tied under Prince's overarching theory on social change: that catastrophe leads to social change in conservative societies, and that fundamental progress requires adversity. Prince referred to the Triangle Shirtwaist Factory fire of 1911, the Chicago fire of 1871, and the sinking of the RMS *Titanic* in 1912 as catalysts for social change in labor laws, fire regulations, and shipping safety.

Current Disaster Management

Whether resultant solely from the Halifax explosion or not, governments now maintain disaster response and emergency management systems to protect the public during crisis.

Critical assests are both protected and redundant to ensure resilience and recovery from catastrophe. The very act of emergency planning and simulation keeps those involved vigilant against man-made hazards posing serious risk to the public.

RELEVANCE TO NASA

Contractor secrecy and proprietary technology often result in poor communication between private companies and other contactors on a team, or between private companies and

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government points of contact. Risk increases when essential safety information is hidden against a greater perceived risk. Such information, known to few but not all with need to know, has been called the "unknown known" by Slovenian philosopher Slavoj Zizek.

Adherence to regulation is vital, even when wrapping up a project or transitioning from stage to stage within the project lifecycle. A strict adherence to regulation was not observed on multiple occasions in the Halifax disaster and led to the explosion.

Public trust in government itself was so shaken in Halifax after the explosion that when a shipboard fire was observed several nights after the *Mont-Blanc* disaster, terrified Haligonians stumbled from their homes into the snowy night fearing another blast.

Wherever NASA activities occur, the first priority must remain to protect the public. Range safety planning and auto-destruct mechanisms for launch vehicles have evolved into a state of amazing reliability. Return-to-Earth planning for balloons and for de-orbiting large payloads are but two examples that demand worst-case planning. What are others?

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