National Aeronautics and Space Administration

SYSTEM FAILURE CASE STUDIES

October 2010 Volume 4 Issue 10

Brace for Impact

On December 14, 1996, hundreds of shoppers and sightseers near the New Orleans Riverwalk fled at sighting the Motor Vessel (MV) Bright Field, a massive cargo ship, bearing down upon them. As the crowd escaped, the fully loaded vessel rammed into the waterfront wharf. A popular shopping mall, a Hilton hotel, and a condominium parking garage sustained severe damage when the Bright Field destroyed their outer walls and came to rest between a gaming boat and cruise ship. Remarkably, there were no fatalities, but the combined damages to the vessel, wharf, and shoreside buildings reached $20 million.

Background

Flag-of-Convenience

In the interests of reducing costs and avoiding government regulations, owners of commercial vessels often register their ships with emerging nations because those nations charge lower taxes and lower registry fees. These nations also have lower maintenance standards because they lack the capability to enforce stricter criteria. Ships so registered are known as Flag-of-Convenience vessels, and the MV *Bright Field* was one such freighter (Figure 1). Sasebo Heavy Industries of Japan built the *Bright Field* in 1988. Its 68,200 deadweight tons, 735 foot length, and 106 foot width placed the *Bright Field* under the Panamax classification for bulk carriers; this designation is reserved for largest ships still able to fit within the locks of the Panama and Suez canals. The China Ocean Shipping Company operated the *Bright Field* and registered it under the Liberian flag. A Chinese crew and captain manned the freighter in 1996, and Chinese was the primary language spoken on board at that time.

Main Engine

The *Bright Field* drew propulsion power from one five-cylinder, two-stroke, turbocharged diesel engine. The engine could be started, stopped, reversed, accelerated, and decelerated from either the bridge or the engine room. Increasing the vessel's speed (and thereby increasing engine rpm) too quickly could damage the engine, so a scavenging air pressure limiter restricted the engine's acceleration rate. During emergencies requiring a rapid increase in rpm, bridge officers could override the limiter by ordering personnel in the engine room to activate a "crash maneuver" button.

Figure 1: 'Allision' is the nautical term used when a moving vessel strikes a stationary object. Here, tugboats guide the MV Bright Field away from the allision site in New Orleans.

Use of a single engine onboard large vessels instead of a traditional redundant, multi-engine approach became popular with supertankers in the 1970's due to increased operating economy and reduced maintenance costs.

Engine Oil System

One of two engine oil pumps – a primary pump (#1) and a backup pump (#2) – drew oil from a sump and pushed it through filters before injecting the oil into the engine. Standard oil pressure was 4 bar (1 bar ≈ 1 atmosphere), and if the system sensed pressure below 3 bar, an alarm would sound on the bridge and in the engine room. If pressure fell below 2.4 bar, an automated switch would activate the backup pump as long as it was set to standby. The two pumps would work simultaneously until pressure was restored. If pressure dropped below 2.3 bar, the main engine would shut down. The engine

Liberian Bulk Carrier Allides With Riverfront Mall: 67 Injured.

Proximate Causes:

- Low oil pressure causes trip in main engine
- Main engine trip results in loss of propulsion and steering power

Underlying Issues:

- Poor risk assessment and management
- Insufficient maintenance practices

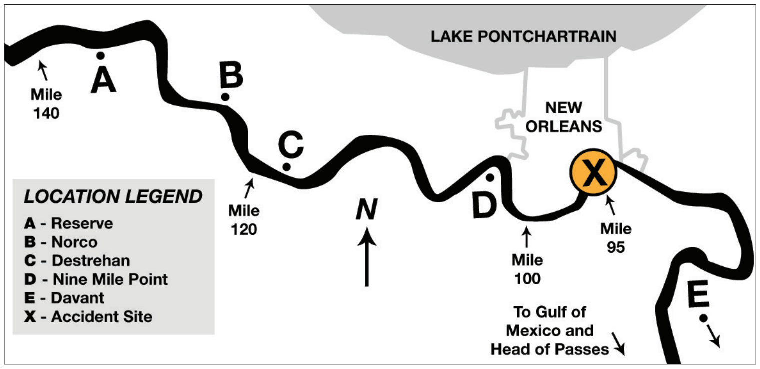

Figure 2: Distances along the Mississippi are measured in miles "above head of Passes." Head of Passes is where the river branches as it spills into the Gulf of Mexico.

could not be restarted until operators fixed the low-pressure situation. The *Bright Field*'s standard procedures for navigating in restricted waters such as the Mississippi River required the No. 1 lubricating oil pump to be running and the No. 2 pump to be set to standby.

Waterway

The Port of New Orleans stretches from mile 88 to mile 120 above Head of Passes (AHP, Figure 2). A major attraction in the Port of New Orleans is the Riverwalk, a mile-long stretch of property containing shops, restaurants, and other amusements. The area affords sightseers an up-close view of passing ships: fourteen thousand deep draft vessels such as the *Bright Field* pass the Riverwalk each year. Maneuvering large freighters through the Lower Mississippi's twists is uniquely challenging; therefore Louisiana State law mandates foreign trade vessels to have a certified State pilot on board when sailing in State waters. River pilots are dispatched by the New Orleans Baton Rouge Steamship Pilots Association (NOBRA) or similar pilot associations.

What Happened?

Cargo Delivery

On September 2, 1996, the *Bright Field* departed Banjarmasin, Indonesia with a cargo of coal bound for the United States. Its arrival in Davant, LA was scheduled for October 26, 1996, but multiple problems with the engine forced several stops for repairs, and these delayed the *Bright Field*'s timetable by almost a month. On November 21, 1996, the freighter unloaded its cargo in Davant, LA, then traveled upriver to Reserve, LA where it loaded 56,397 metric tons of grain for delivery to Japan (Figure 2). Next, it traveled further upriver to Anchorage, LA to make additional repairs.

Departure

On December 14, 1996, the *Bright Field*'s crew prepared to depart for Japan, and NOBRA dispatched a river pilot. Before leaving, the pilot asked the vessel's captain about the condition of the ship's navigational equipment and engine. Both were reported "in good working order." But as the *Bright Field* began its journey toward the Gulf of Mexico, it experienced recurring engine difficulties of which the pilot was not informed. Unacquainted with the *Bright Field*'s long history of engine failures and unaware of the current problems, the pilot guided the vessel downriver and allowed it to accelerate to full speed (60 rpm). Once the vessel had been underway for some time, the pilot gave the order for sea speed (72 rpm) because he was dissatisfied with the ship's handling at the lower rpm. He believed sea speed would give better maneuverability. By the time the *Bright Field* attained sea speed, it was approaching Algier's Point, a landmark containing one of the river's sharpest turns.

Allision

As the *Bright Field* passed beneath the Crescent City Connection Bridges (Figure 3), the pilot noticed that the ever present vibrations induced by the engine had ceased. He asked the captain and second mate if there was a problem, but instead of answering him, they conferred together in Chinese. At this point, the pilot noticed the rpm indicator had dropped from 72 to 30, reflecting a significant loss of propulsion power. Without propulsion, the *Bright Field* would be unable to battle the river currents to navigate successfully around Algier's point. Faced with this realization, the pilot sent urgent radio transmissions warning people on the harbor and on entertainment vessels moored along the wharf that he had lost control of his ship. Then he sounded the warning whistle while the second mate called the engine room and, in Chinese, demanded an immediate increase in engine rpm.

Meanwhile, in the engine room, the chief engineer observed the engine oil pressure gauge dropping below normal levels just before the engine stopped. Although he testified that he saw the backup oil pump start automatically, evidence later showed that the #2 pump was not set to standby and the pump changeover switch was inoperable. Therefore, the #2 pump had to be started manually. Once it activated, the oil pressure began to rise. This allowed the chief engineer to restart the engine. At this point, the second mate called from the bridge and demanded an immediate increase in rpm, but gave no indication of the *Bright Field*'s urgent situation. He did not order the chief engineer to activate the "crash maneuver" button. Instead, they initiated the 20-30 second process of transferring engine control to the engine room. The chief

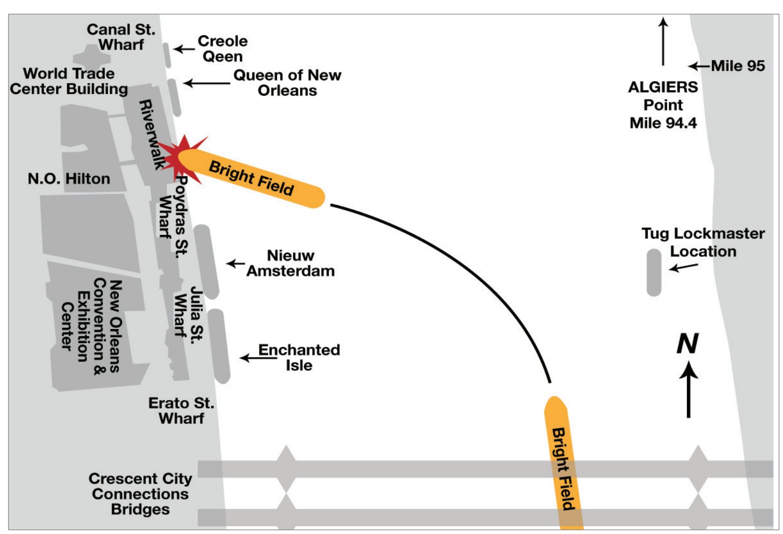

Figure 3: Path of the Bright Field (not to scale)

engineer did not inform the second mate that this transition time could be saved because rpm could now be increased from the bridge since engine power had been restored. According to the ship's logs, the *Bright Field* regained power and the engine reached 52 rpm approximately 2 minutes after the engine trip. Unfortunately, too much time had already elapsed. Roughly three minutes after the engine trip, the *Bright Field*'s bow rammed into the Poydras Street Wharf at a 45-degree angle. It crushed approximately 50 to 60 feet of the harbor before skidding sideways until it was parallel to the Riverwalk. It stopped in a position between a cruise ship and a gaming boat anchored along the wharf. Remarkably, the *Bright Field* did not impact either of the vessels, but instead struck a shopping complex, a Hilton hotel, and a condominium parking garage (Figure 4). Sixty-seven people were injured while attempting to evacuate the buildings or the nearby gaming and cruise ships. No one on board the *Bright Field* was injured, and no fatalities resulted from the accident. Repairs to the *Bright Field*, Riverwalk, and shoreside buildings cost $20 million.

Proximate Cause

National Transportation Safety Board (NTSB) and Coast Guard Investigators discovered severe deficiencies in the main engine's lubricating oil system leading to a loss of system pressure and triggering an automatic engine trip. Although the oil system was outfitted with an alarm that would notify bridge and engineering room crews of falling pressure, the alarm had been calibrated incorrectly. The low pressure situation occurred because the sump was maintained well below the acceptable volume, and alarms indicating low sump levels had been readjusted to allow this practice. The decreased volume caused the sump's capacity to circulate in 1/3 the time it should have taken, so air bubbles entrained in the oil did not have time to dissipate. When the pump drew the air bubbles into the suction, they collapsed, and the collapse of millions of bubbles lowered the overall system pressure. Eventually, pressure fell to unacceptable levels, automatically stopping the engine and leaving the *Bright Field* unable to maneuver through the strong currents which swept it toward the river's left descending bank.

Underlying Issues

Risk Assessment

Statistics show that during a time period from 1983-1993, the Port of New Orleans experienced 15.6 allisions per year. Because of increased river traffic, that number was predicted to rise. According to the U.S. Coast Guard, loss-of-propulsion or loss-of-steering occur 50 times per year, and heavy freighters are the most susceptible to such events, which often lead to allisions. In marine usage, 'allision' refers to a moving ship striking a stationary object. Additional studies from Louisiana State University found that none of the areas along the banks of the Port of New Orleans were allision-free, and the area impacted by the *Bright Field* had experienced 166 allisions in the 10 years prior to the incident. Despite knowledge of these facts, Riverwalk property owners chose to locate tourist attractions, hotels, and restaurants in an area lacking a "crush zone" that could absorb the impact from an allision. Conversely, other Port of New Orleans stakeholders, such as the Audubon Institute, planned a buffer between their structures and the riverbank as protection from marine accidents. If the Riverwalk Marketplace, Hilton Hotel, and One Park Place Condominium garage had also planned for these risks, the damage they sustained may not have been as severe.

Similar arguments can be made for the ships moored along the river's left descending bank that day (Figure 3). Although the left descending bank was found to be at higher risk for allision than the right descending bank, passenger vessels may have been allowed to dock there because the likelihood of an accident was considered low. The *Bright Field* did not impact any of the ships moored in the immediate area, but if the engine had tripped seconds earlier or seconds later, the *Bright Field* may have impacted one or more of the other boats. Consequences would have been lethal for passengers on board. Upon receiving warning of the *Bright Field*'s propulsion loss, crewmembers and passengers on the other vessels panicked. Several attempted to jump from the deck to the wharf because evacuation procedures were disorganized and unclear. The entertainment vessels did not have efficient or effective evacuation processes, reflecting unpreparedness for just such a low probability but high consequence event.

The *Bright Field*'s allision points to incomplete risk assessment not only on the part of the riverfront stakeholders but also on the part of *Bright Field*'s operators. The Mississippi's high water season stretches from October to June, and accident rates are significantly increased during those months. As part of NOBRA, the pilot would have been aware of the risks present in December – the midst of high water season. This knowledge should have led him to discuss vessel operations with the crew more thoroughly before proceeding downriver. Instead of discussing items such as intended speeds, high risk areas, engine control, and crew actions in the event of a malfunction, the pilot asked only one question before assuming his role. Concurrently, the crew and captain should have informed the pilot of (or addressed) the engine troubles that transpired prior to and during the current voyage. Such information may have influenced the pilot's decision to travel at the fastest possible speed. Furthermore, discussing potential risks and appropriate actions in case of an emergency could have enhanced crew coordination and communication when the crisis occurred. It may have raised the option of using the "crash maneuver" override, which was largely ignored once the engine regained power. Although it is difficult to determine whether or not overriding the acceleration limiters would have prevented the mishap, the fact that the crew failed to use all of the tools at its disposal emphasizes the importance of risk assessment and mitigation prior to hazardous operations.

Poorly Maintained Engineering Plant

Investigators from NTSB discovered a range of problems with the *Bright Field* that began as early as 1995. The ship's owners repeatedly ignored messages informing them of the lack of parts and equipment necessary to rectify mechanical problems. This forced the crew to allow components of the main engine to operate until they failed. But in addition to unacceptable owner oversight, crewmembers did not perform adequate preventive maintenance with the resources that were available. For instance, samples of the lubricating oil disclosed 7.6% water content while the allowable content level is 0.2%. Oil filters were extremely dirty, sensors were improperly calibrated, alarms had been readjusted, and safety systems were not routinely tested. The NTSB determined that proper maintenance could have prevented the unexpected engine shutdown.

Aftermath

Because employees and patrons of the docked ships and the Riverwalk marketplace were so accustomed to the sound of ship alarm whistles that they failed to take action in the event of a true emergency, the president of the Port of New Orleans requested all cruise ships to refrain from sounding alarm whistles during drills conducted while moored along the wharf. The Riverwalk marketplace installed three cameras along the banks in order to display river traffic to mall employees. Ships that dock near the Riverwalk regularly were required to obtain additional gangways in order to allow egress from all levels of the ships. In addition, the Coast Guard and Dock Board established a River Front Alert Network, an 800 MHz emergency radio system used to warn patrons, employees, and residents of riverfront properties of potential shipping disasters.

Figure 4: Damage to riverfront property

For Future NASA Missions

As a Flag-of-Convenience vessel, the MV *Bright Field* could easily be viewed as a slipshod operation fraught with failures in maintenance, failures in communication, and failures in accountability. NASA, with its intensive scrutiny, high-caliber maintenance, and strict oversight, seems to stand in stark contrast to the ill-fated freighter. But two vastly different pictures produce lessons with an uncanny resemblance. Comprehensive risk assessment and management are cornerstones to the success of any endeavor, whether it be transporting cargo across the globe or launching satellites across space. NASA's technically complex missions call for low-probability, high-consequence scenarios to be considered with utmost gravity. While designers strive to build redundant and failsafe systems in anticipation of anomalous events, human factors still play a critical role in risk management. The experience of NOBRA's pilot could have desensitized him to the dangers of the high water season. Having successfully navigated hundreds of ships through the Mississippi each year without major incidents, the pilot may have felt it unnecessary to discuss contingency plans with the crew. Likewise, it is critical to ensure that NASA's successes do not cultivate an attitude of complacency. NASA must strive to instill a mindset and culture of safety not only across the Agency, but also throughout the rising commercial sector. The Flag-of-Convenience system was about competition – as of 2007, emerging nations procured the registrations of 66% of the world's freighters – but as evidenced in this case caused an unintended consequence of lower standards. As NASA's move toward commercial craft fosters competition among aerospace companies, it is critical to ensure that we don't suffer from similar unintended consequences related to safety.

Questions for Discussion

- What low-probability, high-consequence scenarios can be associated with your system?
- What have you done to mitigate those risks?
- How have you maintained a culture of safety and awareness in the wake of past success?
- Have you observed early indicators of problems within your system or within its environment?

References

Gianni, Matthew. Real and Present Danger: Flagstate Failure and Maritime Security and Safety. International Transport Worker's Federation, 2008.

Mostert, Noel. Supership. 1976.

National Transportation Safety Board. Marine Accident Report: Allision of the Liberian Freighter *Bright Field* with the Poydras Street Wharf, Riverwalk Marketplace, and New Orleans Hilton Hotel in New Orleans, Louisiana. United States Government, 1998.

United States Coast Guard. Investigation into the Circumstances Surrounding the Loss of Propulsion on the Bulk Carrier *Bright Field* and Allision with the Riverwalk Shopping Complex on December 14, 1998. United States Government, 1997.

SYSTEM FAILURE CASE STUDIES

NSC

NASA SAFETY CENTER

Executive Editor: Steve Lilley
steve.k.lilley@nasa.gov

Developed by: ARES Corporation

Thanks to John Goglia for his insightful peer review.