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THE HERALD OF FREE ENTERPRISE TRAGEDY

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ABSTRACT

The MS Herald of Free Enterprise was one of three vessels built by Schichan Uterwaser AG, Bremerhaven in 1980 for use on the English Channel for Townsend Thoresen, a company that still operates many marine services across Europe. She was registered at the port of Dover, England and operated as a roll on and roll off ferry.

On March 6th, 1987 she left on a non-routine voyage between Zeebrugge, Belgium and Dover, England. The vessel was laden with 80 crewmembers, approximately 459 passengers, 81 passenger cars and 47 freight vehicles. The vessel was under command of captain David Lewry and started the voyage in fair conditions, leaving the mouth of the harbour at 6:24 pm, the vessel capsized four minutes later. As the vessel accelerated to cruising speed water flowed over the hull's bow and through the open loading gates subsequently causing a free surface effect on the main vehicle deck. The rapid capsizing resulted in at least 193 passengers and 38 crewmembers to perish in the frigid water. However more lives would have been lost if the vessel did not happen to come to rest on a sand bank which prevented a complete capsizing and left it in a ninety degree heeled position. The wreckage was located less than a kilometre from the Belgian coastline enabling rescue crew to react quickly however many passengers who survived initial impact were trapped in the half submerged superstructure and succumbed to hypothermia.

Initial reports determined that the catastrophe was a result of human error and a loss of stability suffered in part due to a design defect. Further investigation revealed superstructure design flaws and emergency equipment procedures hampered passenger's evacuation abilities in the vessels half submerged state. The rest of the report will analyze this vessel and the accident, concluding with the recommendations for the future and specific actions from authorities based on factual information.

1 INTRODUCTION

The MS Herald of Free Enterprise was one of three vessels built by Schichan Uterwaser AG, Bremerhaven in 1980. The three sisters were purpose built for service on the English Channel for Townsend Thorensen, a company that still operated many marine services throughout Europe. The MS Herald of Free Enterprise was registered at the port of Dover, England and operated primarily between her registered port and Calais, France as a roll on and roll off (RO/ RO) ferry. Her principal particulars can be found in Table 1 and Figure 1 provides an animation of the general arrangement.

Table 1:Principal Particulars [1]

Dimensions/ Performance	Unit	Value
Overall length	m	131.9
Length b/w perpendiculars	m	121.1
Breadth moulded	m	22.7
Draft	m	5.72
Max operating speed	m/s	11.3
Compliment: crew/ passenger	-	80/ 460

Figure 1: General Arrangement

Up until it's capsizing in 1987 the Herald had operated successfully between Dover, England and Calais, France without any major problems. The Spirit class of vessels was designed to compete with other ferries on this popular route, they were built to accelerate quickly, maintain a high cruising speed and keep a regular schedule. Quick and efficient loading/ offloading of vehicles complimented by higher acceleration capabilities compared to competition resulted in industry competitive schedules.

1.1 Vessel Specifications

Three Sulzer 12 ZV internal combustion engines provided the Herald's power, each powering a controllable pitch propeller via a ratio reduction gearbox. Her electrical capabilities were provided by three internal combustion driven alternators and the bow thrusters were powered by shaft driven alternators. A diesel driven alternator provided emergency power and most engine controls could be operated from both the wheelhouse and the machinery control room. At the time of construction, this vessel was equipped with the latest navigational equipment available [1].

The vessel was a welded steel hull and superstructure, a double bottom from frame 25 to frame 149 and eight decks. The lowest, H deck was sub-divided into 13 watertight bulkheads with four watertight flats dedicated to passenger and store spaces. The space between watertight bulkheads was used for steering gears, machinery space, fuel storage and ballast tanks. The main deck, G, was

enclosed by a full superstructure and was a drive through vehicle deck near the water level with a single weather tight door at stern and double weather tight doors at the bow. It should be noted that weather tight means that the seal is only meant to stop the ingress of water on the weather/ exposed side while a watertight seal implies that there is a possibility of water accumulating on either side. Deck E was a second vehicle deck with weather tight doors fore and aft, and deck D was suspended on the port and starboard sides within this space. The remaining decks housed the accommodations and the wheelhouse was located in a half deck between A and B decks [1]. The herald was built to classification standards that at the time met Merchant Shipping (Passenger Ship Construction) Rules 1980 as well as the SOLAS 1984 regulations [2]. Once construction was complete the Herald was fully outfitted and complied with the most recent regulations corresponding to its launch date and carried all the required lifesaving equipment.

1.2 Main Vehicle Deck

RO/ RO ferries became popular after the end of the Second World War due to their convenience for personal travel. Today, as the number of automobiles on the road steadily increases so will the need for efficient transportation methods. Despite the convenience of the RO/ RO ferry, a serious design defect accompanies the large flat vehicle deck that has to be located near the water level for loading and unloading purposes. Flooding of this area is hard to contain and when a large volume of fluid moves to the low side of this space, the ship's centre of gravity also moves towards the low side. This movement of the centre of gravity brings it closer to the vertical centre of buoyancy and buoyancy force that acts to right the ship thus decreasing the righting moment and increasing its susceptibility to capsizing [3]. This effect has been the cause of numerous ferry disasters despite extensive research into balancing ferry capacity and market competiveness with vessel safety.

The critical failure point on this vessel was the weather tight doors located fore and aft on the main vessel deck, it is important to understand the detail of these doors. In order for water to flood the main vehicle deck one of the weather tight doors must fail. The doors split in the middle and swing open to either side, resting on the side of the ship when open. When closed, the doors are pressed together in the middle and a neoprene seal around the perimeter of the doors is activated by hydraulic rams. The doors were designed to withstand any forces from the oncoming waves and weather during transit and were designed to be as strong as a fully plated bow or stern. In practice, these doors were proven safe and showed no reason to display weakness during operation [2].

2 ACCOUNT OF EVENTS

The rarely used port of Zeebrugge was not ideally compatible with the loading decks of the Herald because of a height discrepancy between the ports loading ramp and the vessel's highest loading deck. In order to rectify this, the bow of the vessel was ballasted elevating the aft deck in line with the ramp. This was a fairly common practice in the ferry industry, but when doing so, extreme care was to be taken to limit high speeds until bow ballast tanks had been fully unloaded [2]. If service to this port had continued the operator had indicated that it intended to outfit the Herald so that this ballasting procedure would not be necessary.

Once the ferry was ready to set sail and the moorings had been dropped, it was standard practice for the assistant Bosun to close the main deck loading and offloading doors. On this day, the assistant Bosun had taken a short break in his room after cleaning up the car deck upon arrival to Zeebrugge. When the departure alarm sounded he was asleep in his room and did not hear the call. The Bosun did not close the main vehicle deck doors. A secondary measure to ensure that the doors were closed required the First Officer to stay on the main deck until the doors were closed, but on the day of

the disaster he had returned to the wheelhouse in an effort to reconcile a strained schedule. Furthermore, to make up lost time, the First Officer ordered the vessel to set sail before the bow ballast tanks had completely emptied from the previously stated unloading procedure. The ferry was steaming through the harbour with the master and deck officers keeping a close eye on the hulls bow because the nose was dipped towards the water line. Records show that as the ferry proceeded through the harbour, speeds were considerably below its capability in order to keep water from flooding over the hulls bow [2]. As the ferry exited the harbour all three engines were set to full speed and the boat forcefully accelerated to a speed of 18 knots. When the ferry reached the 18-knot mark a combination of water flooding, ship squat, dynamic sink age and an increase in bow wave height caused water to enter over the bow hull. At a speed of 18 knots it is believed, through full-scale experiments with the sister ship Pride of Free Enterprise, the bow hull was approximately two meters below the water level [2]. Water poured over the bow hull and through the open bow loading gate, a rapid heeling of 30 degrees to the port side followed. The vessel briefly righted itself before more water accumulated on the port side causing a slow, steady heeling that caused a partial capsizing. The vessel did not fully capsize because it came to rest on a sand bank at a heeling angle of approximately 90 ninety degrees. See Figure 2 below for a photo of the Herald of Free Enterprise in its final resting position.

Figure 2: Resting Position

3 AFTERMATH

This marine accident caused a combination of human loss, environmental damage and significant economic losses for the owner and operator, Townsend Thoresen. Approximately one hundred and ninety three passengers and thirty-nine crewmembers perished, it is suspected that many victims survived the initial impact but were trapped inside the superstructure. Some of the survivors would have drowned and some would have succumbed to hypothermia before rescue efforts could reach them.

3.1 Environmental Impact

Marine accidents can cause a varying amount of environmental damage depending primarily on the contents of the damaged vessel. A certain amount of damage is expected due to operating fluids contained on any vessel however major environmental damage can occur when the cargo contains environmentally harmful substances. The Herald of Free Enterprise was carrying five large cargo trucks containing a combined one hundred and fifty harmful chemicals. Rescue crews found two of these trucks undamaged; the other three had been damaged releasing their contents into the water. Officials with the rescue operations were responsible for identifying what harmful substances were on board, what had leaked and locating the recoverable chemicals. Reports indicate that some of this information was easy to determine but many of the commercial trucks had incomplete waybills and the copies presented by the owners were poorly completed making it impossible to accurately identify chemicals on board [4]. In addition, some trucks were lost overboard in the capsizing and some trucks were in positions that made salvage and containment impossible [2]. It is believed that roughly half of the dangerous chemicals onboard were lost at sea; interestingly the clean up efforts were still deemed a success.

3.2 Economic Impact

The accidents impact on Townsend Thoresen was severe and it took the company years to recover from it. Bad press from the accident affected its business across Europe and caused the company to repaint it's entire fleet from the traditional red hull to a new dark navy blue. Another part of its rebranding effort was removing the "TT" logo from the exhaust pipe and changing the companies name to P&O European Ferries. When the Herald of Free Enterprise was refloated and brought back into Zeebrugge it was believed that it would be repaired and put back into use, however, no buyer came forward. Eventually the boat was sold to a scrap yard in Taiwan [1].

4 INVESTIGATION

The main reason for the capsizing of the Herald was that the loading gates were left open upon departure from the port of Zeebrugge. Human error caused this mistake to occur and when the open gates were complimented with the other circumstances created on March 6th, a catastrophe was unavoidable that evening. The assistant Bosun on duty was asleep when the call went out to indicate that the vessel had dropped her moorings and was beginning its voyage. Complimenting this mistake was the fact that the first officer at the time of the call, had returned to the wheelhouse in an attempt to speed up departure. It is surprising that this critical procedure relied solely on crewmembers communication and had limited redundancy. It was well known that if water entered the main deck than the stability would be drastically compromised. The status of the loading or unloading gates could not be physically observed from the wheelhouse therefore no form of mechanical redundancy existed that could compliment the human communication. If the loading gates had been closed before departure that evening, all the other events that took place on that voyage would not have led to a capsizing. Relying on all crewmembers to do their duty accordingly every voyage works theoretically but when dealing with a critical component such as the loading gates, redundancy should be a required asset.

It was determined that the Herald was also a victim of ship squat during its acceleration period. When a vessel travels in shallow water, low pressure is created between the surface of the hull and seabed due to the higher velocity of water surrounding the ship. This low-pressure field under the boat causes the draft to increase or in other words squat [3]. In the case of the Herald, because it was travelling over a sand bank, a low-pressure area was created and the freeboard of the bow was even less

than anticipated when the crew took into account the partially full bow ballast tanks. After the accident, crewmembers explained that due to the shape of the hull it was impossible to read the draft gauges from on board the ship. The wide body and flare of the stern end of the ship created a situation where the crew could not check over the railing to see if the boat was overloaded or sinking after taking on water [2]. If the crew were able to perform this physical check they would have been able to relay information to the Captain indicating it was not safe to accelerate due to the high draft level of the bow. It was also discovered by the accident review board that there was a large discrepancy between actual weight and waybill weights in the ferry industry. On average the actual weight was found to be thirteen percent more [2]. Therefore, the calculation of vessel draft taking into account weight of cargo was incorrect and the vessel would have been even lower in the water than the crew had calculated.

4.1 Recommendations

The transport safety board completed a thorough investigation of this accident and made recommendations in order to address the general safety of this ferry during operation, loading as well as her life saving ability during an emergency. The primary recommendation stated that there was an obvious need for redundancy in the system responsible for ensuring the loading and unloading gates were closed before departure. The first and foremost method of redundancy for this system is to have a mechanical indicator light installed on a failsafe circuit in a visible area of the wheelhouse. This indicator light would present the status of the vehicle deck doors at all times and a log would record the status of the doors before each voyage. In addition to the main vehicle deck indicator light, an indicator light would be installed to show status of all doors penetrating the main superstructure [2]. Another safety measure brought forward by the board to help those in the wheelhouse monitor condition of the vessel was to install closed circuit televisions (CTV). These CTV's would monitor the major superstructure doors, engine room space and cargo compartments giving the wheelhouse crew the important ability to monitor cargo shifts and evaluate the ships condition.

To address the loading problems experienced by the Herald of Free Enterprise, it was recommended that pneumatic draft gauges be installed as well as freight weighing ramps. The draft gauges would provide crew with accurate information concerning the current vessel draft and the freight weighing ramps would allow crews to use actual weight when calculating the loading condition [2]. At the time of the accident it was industry practice to assume one ton for a vehicle and rely on the declared weight for trucks or other transport vehicles. These assumptions were not always accurate because the declared weight is flawed from human errors, knowing the actual weight would help prevent overloading.

A review of the life saving measures on board the Herald showed that insufficient lighting onboard after the capsizing caused problems for the passengers trying to don lifejackets. Apart from the poor lighting within the superstructure, emergency exits were difficult to find because they were only located at the fore and aft sections. In order to rectify these issues it was recommended that sufficient watertight battery operated emergency lights be installed on all ferries so that routes to exits are illuminated even during power outage and flooding. The primary difficulty passengers had with donning lifejackets was finding them however it was also advised that more attention needed to be given to lifejacket location and instruction of use while at sea [2]. Due to the difficulty of exiting the vessel it was recommended that the traditional slab sided superstructure on ferries no longer be built. A slab sided superstructure only has emergency exits and muster stations along the fore and aft sections restricting immediate escape from middle section and creating bottle necks of traffic at ends. It was recommended that superstructures need to have breakable glass and exits along the side decks in order to make it easier for passengers to navigate towards muster stations.

5 CONCLUSION

The capsizing of the MS Herald of Free Enterprise was a tragic event that resulted in the loss of many lives, damaged the environment and caused the operator great economic hardship. It is truly sad that so often a tragic event must occur before changes are introduced and people re-evaluate the current acceptable practices. As a result of the investigation into this accident extensive measures were taken by major marine authorities in order to improve marine safety. The international marine safety (ISM) code was adopted by many nations after this accident. This code requires that safeguards be established against the safety & pollution risks involved in ship operations while giving flexibility to develop and tailor a safety system to an owner's specific operation. Safety of Life at Sea (SOLAS) implemented new regulations intended to improve monitoring of doors & cargo areas and to improve emergency lighting. Amendments were made to the structural section of the code to increase emergency exits and changes were made to the method for stability assessment in a damaged condition. Finally, the International Marine Organization (IMO) introduced a Formal Safety Assessment (FSA). A FSA can be described as a rational and systematic process for assessing the risks associated with shipping activity and for evaluating the costs and benefits of IMO's options for reducing these risks. This tool is often used to evaluate new regulations or to compare proposed changes to existing standards.

REFERENCES

[1] CJ. Parker, "Herald of Free Enterprise", Maritime Technical Information Facility, pp 2-4, July 1987

[2] Department of Transportation, "The Merchant Shipping Act 1894, mv Herald of Free Enterprise", Report of Court No. 8074 Formal Investigation, Crown Copyright 1987

[3] R.B. Zubaly, "Applied Naval Architecture", Carnell Maritime Press, Maryland, pp 35- 47 1996

[4] T. Jacques, "The Herald of Free Enterprise Accident: The Environmental Perspective", Oil & Chemical Pollution, pp 55-68, 1990