otsi

THE OFFICE OF TRANSPORT SAFETY INVESTIGATION

safe and reliable transport services for new south wales

Ferry Safety Investigation Report

Circular Quay

20 February 2004

'Lady Herron ' – Collision with wharf

Investigation Report

Passenger Transport Act 1990

Office of Transport Safety Investigation

The Australian Transport Safety Bureau's

report of the investigation

into the Sydney Ferries accident involving

the collision of the ferry

Lady Herron

at Circular Quay on 20 February 2004

Lady Herron

This report was produced by the Australian Transport Safety Bureau (ATSB) for the Office of Transport Safety Investigations (OTSI).

The objective of an investigation is to determine the circumstances surrounding any accident, serious incident or safety deficiency to prevent the recurrence of similar events.

The information in OTSI investigation reports is provided to promote transport safety and in no case is it intended to imply blame or liability. However, an investigation report must include sufficient factual information to support the analysis and conclusions. Some information may reflect on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation.

Every endeavour is made to balance the use of information that may imply adverse comment, with the need to properly explain what happened, and why, in a fair and unbiased manner.

Readers are advised that Transport Safety Investigations are conducted for the sole purpose of enhancing transport safety. Investigation reports are confined to matters of safety significance and may be misleading if used for any other purpose.

Contents

1.0 Executive summary

At 0942:58 on the morning of 20 February 2004, the Sydney ferry, *Lady Herron* collided with number five wharf at Circular Quay. At the time of the accident, the crew were conducting an emergency engine control training evolution as part of a type recertification process for the master who was controlling the vessel. His recertification was being conducted under the direct supervision of *Lady Herron*'s regular master, who was an approved training master for the vessel. The training involved the engineer manually driving the vessel's main engine from the machinery control room in response to telegraph orders from the wheelhouse.

The training was proceeding routinely immediately prior to the collision as the vessel approached its berth on the western side of number four wharf. The recertifying master had ordered 'half astern' to slow the vessel and this movement brought the vessel to a complete stop short and wide of its berth.

To move the ferry bodily towards the berth the recertifying master then chose a manoeuvre that would swing the stern towards the berth while moving the ferry ahead. He recalled that he used either full or half engine revolutions ahead and full starboard rudder, which was an aggressive manoeuvre. The vessel accelerated rapidly and turned to starboard. When the engine was stopped, approximately 7 seconds later at 0942:38, *Lady Herron* was making headway at approximately 6 knots and rapidly closing on number five wharf. The recertifying master then sought to stop the vessel by ringing 'full astern'.

Neither of masters on the bridge nor the engineer provided a confident account of what happened in the next 20 seconds. The recertifying master stated that he rang 'full astern' twice immediately prior to the collision. If this is the case, for some reason which remains unclear, the engineer failed to comply with these orders. Analysis of the vessel's propeller wash shown on videos from wharf security cameras indicates that there was no astern movement prior to the ferry impacting the wharf. Had the engineer made a 'full astern' movement in the 20 seconds before the collision it is likely that the vessel would not have collided with the wharf, or if it had, that the impact would have been far less severe.

Tests conducted after collision showed the main engine control system to be functioning correctly in both the wheelhouse and the emergency control modes.

The collision caused significant damage to the vessel and the wharf infrastructure and although there were no injuries to the passengers, crew or bystanders, there was potential for the consequences to have been far more serious.

The collision was caused by a number of factors relating to the management of the vessel and the decisions and actions of the vessel's crew. These factors included the lack of guidance or procedures relating to the type recertification process, the failure of Sydney Ferries to adequately assess and manage the risks associated with the emergency engine control training and an inadequate response to past incidents. Other causal factors included the engineer's failure to respond to the telegraph orders for 'full astern' movements in the 20 seconds before the collision and the regular master's initial decision to conduct the emergency engine control drill in the confines of Circular Quay. The recertifying master's selection of an aggressive handling strategy to correct the vessel's position wide and short of the berth is also implicated.

The investigation has identified a number of safety actions. It is recommended that Sydney Ferries progress these safety actions through its safety management systems. These safety actions relate to,

- the assessment of the risks associated with emergency engine control drills
- the review of the handling practices adopted by masters when manoeuvring using emergency engine control
- the provision of an immediate, or open channel, form of communication between the bridge and the MCR where appropriate
- further development of the type rating training system and
- the consideration of the merits of fitting data logging equipment aboard all their vessels.

The report also recommends that the Waterways Authority should consider reinstituting the Major Incident Review Committee to assist in analysing the factors relating to significant accidents and incidents with a view to making appropriate safety recommendations.

2.0 Methodology

In accordance with OTSI requirements the investigation was conducted by the ATSB according to principles similar to those set out in Australian Standard AS 5022-2001, Guidelines for Railway Safety Investigation.

The report's terms of reference were to:

1. Identify the contributory factors which led to the accident;
2. Identify whether the incident type might have been anticipated and assess the effectiveness of the STA risk management strategies adopted;
3. Assess the adequacy of the emergency response to the incident as it affected the safety of all persons involved; and,
4. Advise on any matters arising from the investigation that would enhance the safety of ferry operations.

The objective of the investigation was to determine the circumstances surrounding the accident and provide information to prevent the recurrence of similar events.

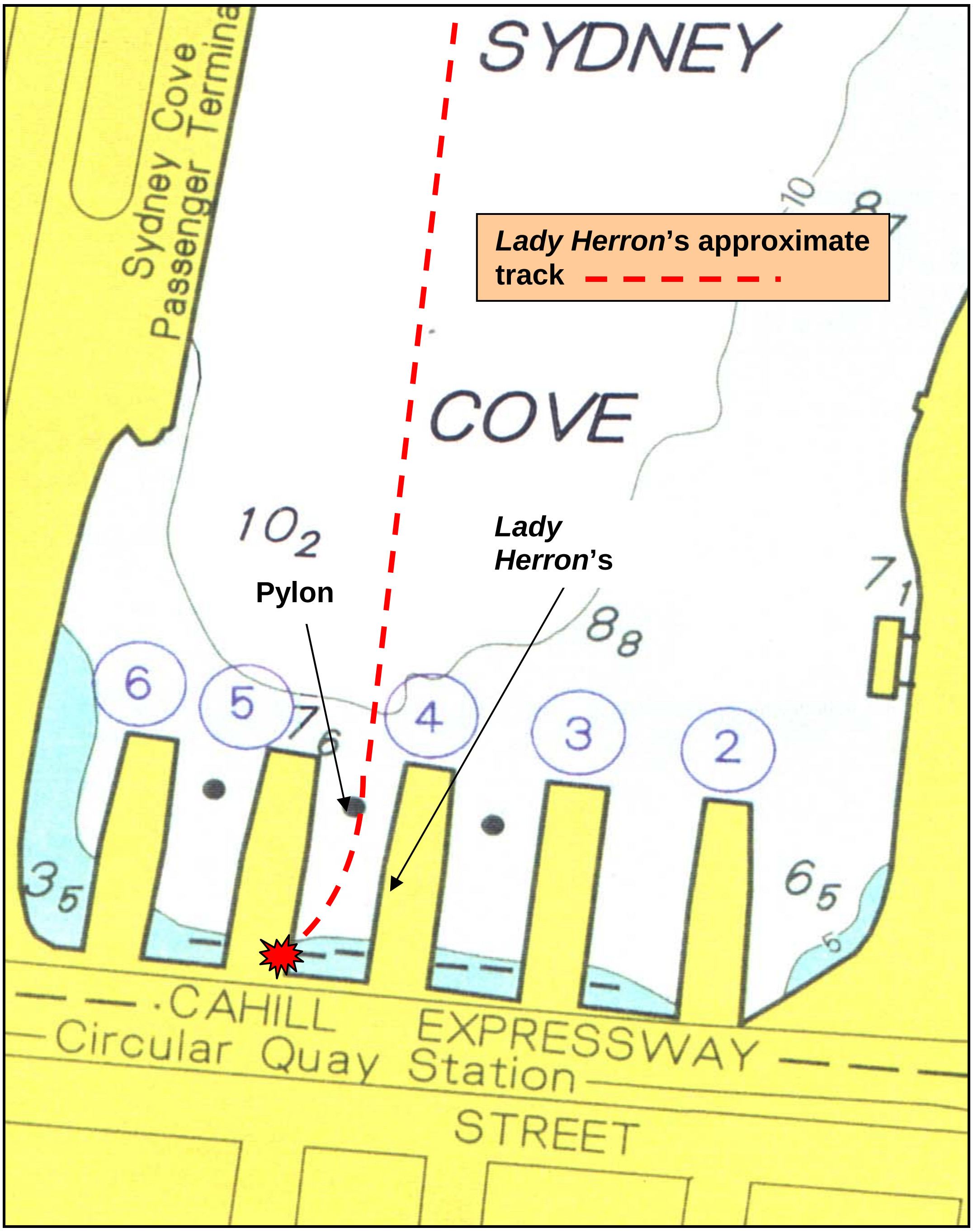
A systemic investigation approach was adopted to identify both human and organisational issues. The investigation has identified and analysed the issues relevant to the terms of reference and has recommended a number of safety actions.

The format adopted by this report is to present the factual information surrounding the accident, the analysis of those facts and the conclusions reached.

3.0 Factual information

3.1 Overview

At 0942:58 on 20 February 2004, the Sydney Ferries vessel *Lady Herron* collided with the eastern side of number five wharf, Circular Quay. The vessel had just completed a scheduled run from Taronga zoo and was in the process of berthing on the western side of number four wharf. There were approximately 15 passengers on board and a crew of five. *Lady Herron* sustained some damage above the waterline on the port side and the wharf, backboard and wharf superstructure were damaged in the accident. There were no injuries to the passengers, crew or the bystanders on the wharf.



3.2 The accident

At 0555 on 20 February 2004, the crew of *Lady Herron* started duty for a 13.5 hour shift. The usual crew of a master, engineer and a general purpose hand (GPH) was supplemented by a master undergoing 'Lady Class' type recertification and an additional general purpose hand. The recertifying master was to be in control of the vessel under the direct supervision of the vessel's regular master.

The vessel's first service was operated at 0625 from Circular Quay to Mossman. This journey included a stop at Cremorne Point, an open ended wharf. *Lady Herron* then completed four scheduled services to Taronga Zoo without incident.

At 0930 the *Lady Herron* departed from Taronga Zoo wharf for the fifth time that day for the 15 minute journey to its berth on the western side of number four wharf at Circular Quay. There were approximately 15 passengers on board.

Prior to arriving at Circular Quay the two masters decided, as part of the type rating assessment, to berth the vessel using emergency control.

The engineer was informed of this plan and approximately 500 metres off the berth, engine control was passed to the engine room where the engineer was standing-by in the machinery control room (MCR). Control of the main engine was then successfully tested by the master by ordering a 'slow astern' movement. The recertifying master then ordered an ahead movement to bring the vessel to the berth.

At 0942, as *Lady Herron* approached its berth on the western side of number four wharf, the recertifying master ordered 'half astern' on the bridge telegraph to slow the vessel and then 'stop'. These orders were carried out by the engineer and *Lady Herron* was brought to a stop in the water adjacent to the pontoon at the end of number four wharf. The vessel had stopped about 8 metres short and 2.5 metres off the berth on its port side. The time was 0942:30.

The recertifying master could see that the vessel was wide of the berth and needed to more forward and to port. He then applied full starboard rudder and ordered either 'full ahead' or 'half ahead' (he could not recall which) on the wheelhouse telegraph. His intention was to move the vessel forward and at the same time swing its stern into the wharf so the general purpose hand (GPH) could pass a mooring line ashore.

The engineer responded to the 'ahead' order and as *Lady Herron* moved forward, its speed increased and it started to turn to starboard.

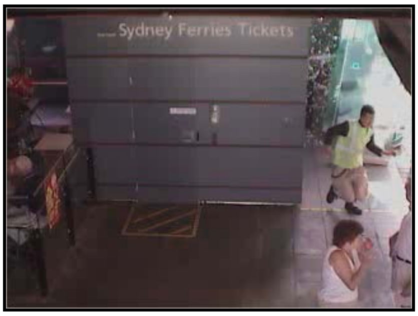
The GPH observed that *Lady Herron* paused for a second after stopping wide of the berth, then moved off, which he interpreted as being for the purpose of manoeuvring closer to the berth. Instead, the vessel accelerated away from the berth, by which time it was too late and too far for him pass a mooring line ashore.

The recertifying master then rang 'stop' on the wheelhouse telegraph and the engineer responded to the order for 'stop'. *Lady Herron* continued to move ahead at an estimated speed of six knots and swing to starboard. The recertifying master then said he rang ‘full astern’ but the vessel continued to move ahead, he then said he rang ‘stop’ and ‘full astern’ a second time but the vessel continued to move ahead and swing to starboard.

The GPH could see that the vessel was going to collide with the wharf and ran into the saloon area in the passenger cabin and called out ‘hold on tight’, ‘hold on tight’.

At 0942:58, *Lady Herron* collided with number five wharf near the southern end of the eastern berth and the adjacent timber back board.

Several people were seated in the café area on number five wharf approximately two metres from *Lady Herron*’s point of impact. They had no warning of the impending collision and so did not have time to evacuate.



Sequence of five frames from a security camera showing *Lady Herron*'s impact with number five wharf

A man was standing beside the glass panels adjacent to the ticket booth at number five wharf when *Lady Herron* hit. The impact resulted in some of the panels shattering and the person ran from the scene to avoid the flying glass.

A woman and her child were on the public concourse area at the front of number five wharf and were showered with glass from the damaged structure.

On board *Lady Herron*, the GPH checked the welfare of the passengers and determined there were no injuries. The master and engineer initiated a damage assessment then, after resuming wheelhouse control, manoeuvred the vessel back to number four wharf where the passengers were disembarked.

3.3 Injuries

There were no reported injuries to passengers, crew or people on the wharf.

3.4 Loss or damage

The *Lady Herron* received damage to the shell plate and frames on the port side, estimated at $80 000.

The building on number five wharf in way of the ticket box sustained significant damage in the collision. Two of the steel portal frame columns supporting the roof structure were severely damaged and required replacement. A steel frame over the ticket box and some of its glass security screens and the timber wharf fender, timber back board and piles also sustained damage. Damage to the wharf infrastructure was estimated at $98 000.

Damage to Lady Herron's bow

Number five wharf building and back board damage

Number five wharf, damage to ticket booth and roof support structure

3.5 Workers involved

3.5.1 Master

The master was 45 years old and was certified as a master class IV. He had 20 years experience as a Sydney Ferries master and held type ratings on five classes of vessels. He had completed 'Professional Development for Masters' training in April 2002. On the day of the accident he was permanently rostered as one of *Lady Herron*'s masters and had started work at 0555 for a 13.5 hour shift. The master had completed a 13.5 hour shift on the vessel the previous day and had had two rostered days off prior to that.

3.5.2 Recertifying Master

The recertifying master was 58 years old and had master class V certification which he had held for 18 years. He had completed 'Professional Development for Masters' training in September 2002. At the time of the accident he was operating First Fleet class catamarans but had been the master of *Lady Heron* many times in the past. His last time permanently rostered on the vessel was 18 months previously.

On the day of the accident he had started work at 0555 for the recertification process which was expect to last about 6 hours. He had had a rostered day off on 15 February and had been rostered on duty the subsequent four days between the hours of 0505 and 1320.

3.5.3 Engineer

The engineer was 61 years old and was certified as a marine engine driver class III. He had 18 years experience as a Sydney Ferries engineer and had worked on the *Lady Herron* for the previous four years. He had completed a *Lady Herron* type rating on 3 February 2004.

At the time of the accident he was permanently rostered as a *Lady Herron* engineer and was partnered with the same master. Like the master the engineer had completed a 13.5 hour shift the previous day after two days rostered off duty and had started work at 0555 for a 13.5 hour shift.

The engineer stated that he was not taking any medication which could have affected his ability to manoeuvre the engine at the time of the accident.

3.6 Fatigue

The fatigue index scores for *Lady Herron*'s crew members were calculated using the Fatigue Audit InterDyne (FAID) software program using their work roster for the seven days prior to the accident. The FAID program is primarily a rostering tool which takes account an individual's duration and timing of work and break periods (including circadian effects) and the human limitations of sleep recovery over the preceding seven day period to calculate a fatigue index score for a given time. When used as an investigation tool the resultant fatigue scores may be used as a guide to indicate what effect fatigue may have had on an individual's performance.

Based on their rostered hours of duty for the previous seven days, *Lady Herron*'s master and engineer both had fatigue scores of 53 and the recertifying master had a score of 62.5.

3.7 Health and fitness

Sydney Ferries masters and engineers require a medical examination every five years when they revalidate their certificates of competency. All of the crew involved in the accident had current medicals and there were no issues relating to medications or illicit drugs.

Both masters and the engineer were breath tested by Water Police after the collision with negative results for alcohol.

3.8 Vessel information

3.8.1 'Lady' class ferries

Lady Herron is one of two double ended Lady Class vessels operated by Sydney Ferries on the Inner Harbour Service. Each vessel has a wheelhouse at each end which contains duplicated systems for steering and engine control. These vessels were designed to operate at dead end wharves where turning the vessel is not possible.

Built by the State Dockyard at Carrington Slipway in Newcastle, *Lady Herron* was delivered in 1979. The vessel is constructed of steel and is 38.71 metres in length, has total breadth of 9.38 metres and draught of 2.06 metres. *Lady Herron* has a displacement of 287 tonnes and can carry up to 552 passengers. The normal crew of three includes the master, engineer and one general purpose hand. The normal operating speed is 11 knots.

Lady Herron is under New South Wales Waterways Authority survey and is classed as a 1E vessel with an exemption to operate in the proclaimed 1D area of Port Jackson.

3.8.2 Vessel details

There were no vessel defects recorded at the time of the accident which were relevant to the collision at number five wharf Circular Quay. *Lady Herron* was sea trialled after the accident and all control functions were found to be operating correctly.

3.8.3 Vessel manoeuvring system

Lady Herron is equipped with a single 403 kW 4-stroke main engine which drives the fixed pitch propellers at each end of the hull. The main engine drives a clutch/reduction gearbox arrangement at each end of its crankshaft. Each gearbox is coupled to a propeller shaft which drives one of the two fixed-pitch propellers. The propellers are unidirectional, ie. they turn only one way, and the clutches are interlocked so that only one propeller may be operated at any time.

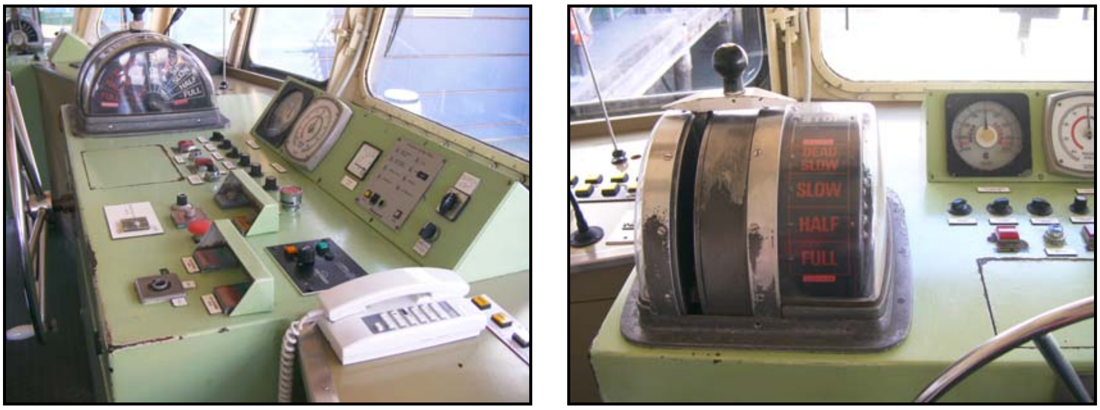
Moving from an 'ahead' movement to an 'astern' movement involves reducing the main engine speed to idle, disengaging one clutch and engaging the other clutch. Varying propeller thrust (ahead or astern with respect to the direction of travel) corresponding with 'dead slow', 'slow', 'half' or 'full' speed orders, is achieved by varying the main engine speed.

The vessel is steered using the rudder at the opposite end to the wheelhouse which is in use. The rudders are located astern of each propeller on the centreline of the vessel. An hydraulic solenoid valve, operated by a key switch in each wheelhouse, is used to lock the non-operational rudder.

3.8.4 Engine control modes

There are two modes for controlling *Lady Herron*'s engine speed and propulsion direction.

Wheelhouse control is the normal control mode where engine speed and propulsion direction are directly controlled by the master using the telegraphs in the wheelhouse. When manoeuvring using wheelhouse control, both of the clutches and the main engine speed are controlled by an automated system linked to the wheelhouse telegraphs. The telegraphs transmit electrical signals to a pneumatic system in the engine room which controls the clutches and provides speed setting air to the main engine governor. When using wheelhouse control, changing propulsion direction (ie. a movement from ahead to astern) normally involves a time delay of around four seconds while the control system reduces the engine speed to idle, disengages one clutch and engages the other clutch.



Wheelhouse forward console, engine telegraph

Emergency control is intended for use in the event of a failure of the wheelhouse control system. Emergency control is achieved by passing control to the machinery control room (MCR) where the engineer manually ‘drives’ the main engine using the clutch, and main engine speed controls in response to the telegraph commands given by the master.

The emergency control procedure requires the engineer to acknowledge the master’s order on the MCR telegraph before he executes the command. The telegraphs, both in the MCR and in the wheelhouse, are fitted with bells which ring until the telegraph position is matched on both telegraphs.

The emergency control process takes longer to achieve the desired engine movement than the automated wheelhouse control system. In addition, while the engineer is manoeuvring from the MCR in the engine room, he is blind to the vessel’s situation.

It is an operational requirement for the engineer to be standing-by in the MCR, ready to take over propulsion control, during critical vessel operations such as berthing.

Machinery control room, engine telegraph and clutch/engine speed controls

3.8.5 Changing over control

Changing over the engine controls from the wheelhouse to the machinery control room or vice versa involves a number of steps. The wheelhouse console is fitted with 'Bridge Control' and 'Engine Room Control' request buttons/indicator lights and a buzzer and a 'Stand-by' button. The control selector switch is located on the MCR manoeuvring console together with 'Wheelhouse Control' and 'Engine Room Control' indicator lights and a buzzer.

If the master decides to change over control to the engine room while the vessel in en-route he will normally actuate the 'Stand-by' button to ensure that the engineer is in the MCR. The master must then bring the wheelhouse telegraph to 'stop' and press the 'Engine Room Control' request button which causes the 'Engine Room Control' indicator lights in the wheelhouse and MCR to flash and buzzers to sound. The engineer will then change over the control selector switch to take control in the engine room. The buzzers then stop and the 'Engine Room Control' indicator lights remain lit.

In the event that control is in the engine room and the master decides to take control in the wheelhouse, he would press the 'Wheelhouse Control' request button which causes the 'Wheelhouse Control' indicator lights in the wheelhouse and MCR to flash and buzzers to sound. The engineer should then move the engine room telegraph to 'stop', the engine speed and clutch controls to the idle/neutral positions, and change over the control selector switch. The 'Wheelhouse Control' indicator lights then remain lit and the buzzers stop. Depending on the position of the telegraph and engine controls, changing control to the wheelhouse may take up to 10 seconds.

3.8.6 Wrong way alarm

Lady Herron is equipped with a 'wrong way' alarm that operates in the emergency control mode. An audible warning sounds, on the bridge and in the MCR, if the engineer moves the clutch control lever to engage the wrong clutch ie. the direction opposite to the telegraph order.

3.8.7 Digital emergency announcements

Lady Herron is equipped with a push button information broadcast system, which is capable of playing pre-recorded announcements to passengers at the press of a button on the wheelhouse control panel. The system is described in the vessel operations manual.

Message No. 3 is described as the ‘alert for impending incident/danger’ and contains the following message:

> *Attention passengers! We are currently experiencing some difficulties. It is important to remain seated of if standing, hold onto something secure. Please listen carefully for instructions from the crew.*

Message No. 4 is described as ‘incident has occurred’ and contains the following message:

> *Attention passengers! An incident has occurred. Please remain calm and follow all instructions from the crew.*

3.9 Wharf details

The Circular Quay wharfs are owned by the Sydney Foreshores Authority. There are five finger wharves at Circular Quay (numbered 2 to 6 from east to west) where Sydney ferries routinely berth to embark and disembark passengers. All of the wharves are ‘dead-end’ wharves.

There were large timber backboard structures attached to timber piles, positioned approximately five metres from the public area at the end of the wharf. The backboards are intended to arrest a collision with the dead end of the wharf.

3.10 Environmental factors

On February 20, a high tide was predicted in Sydney at 1.90 metres at 0914. At the time that *Lady Herron* collided with number five wharf at 0942, the tide had not started to ebb and so there would have been no significant tidal flow which would have contributed to the accident. Indeed the master reported that wind and current had no effect on the berthing operation.

The height of tide when *Lady Herron* made contact with the wharf was a factor in the amount of damage sustained by the wharf building. The vessel was floating relatively high with respect to the wharf and it appears from the damage to the wharf structures that the bow of the vessel hit the steel portal frames supporting the roof of the wharf building before it made contact with the timber facings of the wharf.

3.11 Recorded information

Lady Herron was not equipped with a data logger or event recorder at the time of the collision. There is no evidence, other than the statements of the crew, as to the sequence of events aboard the vessel. Circular Quay is equipped with a number of security video cameras. A number of the cameras were in positions which captured the some video evidence of *Lady Herron*’s approach to Circular Quay and the collision with number five wharf.

Table 1: Timeline of events & vessel manoeuvring based on CCTV data.			
Time Minutes	Time Seconds	OCR monitor 1	CQ5 cam 7
0942	05	LH approaches W4	
	07	REV wake appears	
	30	LH pauses at W4	
	30	REV wake stops	
	31	FWD wake appears	
	38	FWD wake stops	
	57	FWD wake appears	
	58	Impact with W5	Impact with W5
0943	05	FWD wake stops	LH drifts backward
	41		LH stops drifting back
0944	10	FWD wake appears	
	11		LH drifts forward
	21	FWD wake stops	
	30		Forward drift reverses
	31	Exhaust smoke appears	
	32	LH moves toward W4	

3.12 Identified safety management systems

Sydney Ferries have an integrated Quality, Safety & Environmental management system based on the ISO 14000 standard and the International Safety Management (ISM) code. Implementation of the system started on 1 July 2002 in response to a recommendation of the 'Taylor' report[1].

The management system is described in three levels of documentation. Level one consists of the Quality, Safety & Environmental Policy/Objectives Manual. Level two is the Quality, Safety & Environmental Procedures Manual. Level three consists of a number of functional shore and ferry procedures and operating instructions, which support the level two Quality, Safety & Environmental Procedures.

The level three document, Fleet Instructions Manual (FIM) contains general operational procedures for the whole fleet with vessel specific procedures contained in a Vessel Operations Manual for each vessel or class of vessels.

Section 2.6 of the Fleet Instructions Manual (FIM) (level three) provides instructions on vessel manoeuvring, which includes planning and conducting approaches, training in approaching wharfs, and contingency plans for control failures. Section 5.2 of the FIM contains instruction for the operation of the safety and information message system.

[1] The Taylor report is a review of Sydney Ferries operations carried out by the Chief Executive of the Waterways Authority, Mr Matthew Taylor, assisted by Mr Peter Medlock and his associates. The report was commissioned by the Minister of Transport after a spate of ferry accidents early in 2001.

3.13 History of similar occurrences

There have been a number of relevant incidents involving ferries colliding with wharves in the recent past. Some of these collisions have been the result of mechanical failures including three incidents involving *Lady Street* in 2002 (May, August and October) and one involving an engine control system failure on *Lady Northcott* in June 2003. In the *Lady Northcott* incident emergency engine control was implemented by the crew after a failure of the wheelhouse telegraph system. The vessel was safely manoeuvred alongside causing minimal damage and no injury to the passengers.

An incident involving the Manly ferry *Collaroy* on 18 August 2002, is particularly relevant as it is similar to the collision involving *Lady Herron* on 20 February.

The *Collaroy* incident involved a collision with Manly wharf after the master had decided to conduct an emergency engine control drill during a berthing manoeuvre. Manly wharf is a dead end wharf, the master was not under the supervision of a training master and there were passengers aboard the ferry at the time.

The incident was investigated by the Waterways Authority and their report stated:

> In the course of this evolution, both propeller clutches disengaged from the propulsion gearboxes for about 40 seconds. As a result, the vessel had to be manoeuvred in an unusual manner, using the Engineer in the Machinery Control Room (MCR) to operate the vessel's propulsion on telephone instructions from the Ferrymaster on the bridge. This was to prevent it from striking the backboards at the shore end of the wharf. During a later stage in the incident, however, the ferry swung against a set of two protecting piles, causing some damage to them. The vessel was eventually secured alongside the disembarkation location at the wharf, where full control was then regained without further incident.

The Waterways Authority investigation report made conclusions including:

> The master's decision to conduct such a drill while attempting to make a berth at a dead-end wharf while on a scheduled service with passengers on board is questionable. He maintained that he had delegated authority to do this and that opportunities to carryout necessary safety drill practices did not exist. Sydney Ferries should define the requirements and conditions of such drills in their Fleet Instructions Manual.

The Waterways Authority also made the several recommendations arising from the incident including that:

1. Sydney Ferries consider instructing Ferry Masters not to conduct drills during passenger services;
2. Sydney Ferries consider facilitating planned emergency drills using Ferries allocated from time to time to such duty;
3. Sydney Ferries consider whether Ferry Masters and Engineers have adequate knowledge or require remedial training in relation to the operation of their Ferries in emergency situations;…

Sydney Ferries response to the Waterways Authority recommendations included:

1. It is not practical nor do we have the resources to restrict drill times to non passenger times. We have implemented training which requires Masters to carry out drills when approaching wharves under the supervision of a training Master or they can test emergency back-up systems whilst away from the wharves at a suitable point during their passage to and from Manly.
2. Sydney Ferries has a comprehensive drill program and training program which is part of a Type Rating system.
3. We have concentrated some training on emergency back-up systems and this is ongoing.

3.14 Training for masters

3.14.1 Type Rating

All Sydney Ferries crews including masters, engineers and GPHs, are required to hold the appropriate type rating for the vessel they are employed on. The level two Quality, Safety & Environmental Procedures Manual contains a procedure for 'Familiarisation, Training and Assessment Programs' (PROC64.06.01). This procedure sets out the general requirements in respect of personnel training including type rating and revalidation for ferry crews including masters and engineers.

Chapter 7 of the FIM is intended to provide procedures for the familiarisation and training of staff, including type rating, but it had not been developed at the time of the accident. Similarly, chapter 6 of the Lady Class Vessel Operations Manual (VOM) is intended to provide detailed instructions on type rating training and assessment but this section had not been developed at the time of the accident.

Despite the lack of specific procedures in the quality management system at the time of the accident, Sydney Ferries did have a documented process for the initial type rating *Lady Herron*'s masters. The system is based on a document titled 'Observation Checklist for Lady Herron Masters Operations' which sets out a competency based assessment and is required to be conducted by either the designated Training Master and/or a qualified Check Master. The checklist is designed for use with the vessel's Operations Manual and the initial type rating process takes up to a week of training to complete.

There are a number of references in the observation checklist to the operation of the vessel in emergency control mode. The preamble in the observation checklist includes the following:

> **Verbal Instructions to the Trainee**: For this assessment you are required to be observed performing all the operations on the Lady Herron vessel. The observations will include:…
>
> - Vessel handling and Seamanship in normal and emergency conditions.

One of the checklist questions in the 'Vessel Handling' section of the assessment document is, 'Demonstrate the ability to operate the vessel in emergency/backup modes?' and further in the 'Main Engine & Steering Controls' section, 'Describe and demonstrate back up mode of operation of engine controls?'.

The observation checklist is primarily designed for initial type assessment and does not contain any guidance with respect to where and when it was appropriate to conduct emergency engine control training.

3.14.2 Type Recertification

Type rating qualifications for masters and engineers require annual revalidation assessment. To maintain a type rating masters and engineers are required to have worked 24 shifts on the relevant vessel type in the previous 12 months with at least six of the shifts in the previous 3 months.

Sydney Ferries masters normally work on one class of vessel, but tend to maintain their type ratings for other classes of vessels. If a master has not completed the required number of shifts on a vessel for which they are type rated they may renew the rating, (prior to it expiring) in a recertification process. This process requires the recertifying master to partner a training master on the class of vessel for which recertification is required and be assessed on their operating competency. The recertification process is not specifically documented but is based upon the initial type rating assessment checklist.

3.14.3 Bridge resource management (BRM)

In 2002 Sydney Ferries provided one-off 'Professional Development for Masters' training for its masters. The training was conducted over five days at the Australian Maritime College in Tasmania and included elements of Bridge Resource Management such as communications and briefings, challenge and response, and authority and assertiveness.

The training was conducted in the context of accident prevention and used several case studies with the aim of introducing the concepts of good bridge resource management practices. The training was reportedly well received by the masters. The company's quality management system does not contain any BRM policy or on-going training program.

3.15 Emergency response actions

Neither of the two emergency announcements was activated by the crew during or after the collision.

On board *Lady Herron*, the GPH checked on the welfare of passengers and determined there were no injuries. The master and engineer initiated a damage assessment then, after resuming wheelhouse control, manoeuvred the vessel back to number four wharf.

The on-shore emergency response was initiated by a Sydney Ferries manager who happened to be at the front of number five wharf at the time of the accident. The manager advised Ferry Control and arranged for staff to close and barricade the damaged wharf.

Waterways Authority officers and water police attended the site and the Waterways Authority commenced an investigation.

4.0 Analysis

4.1 The collision

Lady Herron collided with number five wharf at Circular Quay at 0942:58 on the morning of 20 February 2004. At the time of the accident, the crew were conducting an emergency engine control training evolution as part of a type recertification process for the master who was controlling the vessel. His recertification was being conducted under the direct supervision of *Lady Herron*'s regular master, who was an approved training master for the vessel. The regular master indicated that emergency engine manoeuvring was a required part of the recertification process and that he had conducted this type of training during berthing manoeuvres at Circular Quay in the past.

Both masters and the engineer were appropriately qualified and highly experienced. However, the recertifying master was operating with *Lady Herron*'s engineer and not his usual colleague. The training was proceeding routinely as the vessel approached its berth on the western side of number four wharf until the recertifying master ordered 'half astern' to slow the vessel. This movement brought the vessel to complete stop short of the berth rather than a normal approach, which would have been to coast the vessel into the berth at slow speed. The vessel was also further off the berth than would have been the case in a 'normal' approach and was very close to the pylon located between number four and five wharves.

The recertifying master may have misjudged the approach or the engineer's response to the telegraph orders was quicker than he had anticipated. To move the ferry bodily towards the berth he then chose a manoeuvre that would swing the stern towards the berth while moving the ferry ahead. He recalled that he used either full or half engine revolutions ahead, an aggressive manoeuvre. The rapid movement ahead meant that the general purpose hand did not have sufficient time to pass a mooring line although the vessel's stern did move towards the wharf. The recertifying master then put the telegraph to 'stop' and this was answered by the engineer.

When the engine was stopped, approximately 7 seconds later at 0942:38, *Lady Herron* was making headway at approximately 6 knots (estimated by the master) and continued to turn towards the eastern berth on number five wharf. The recertifying master then sought to stop the vessel by ringing 'full astern'. To this time the manoeuvre had proceeded as he had anticipated.

Neither of masters on the bridge nor the engineer provided a confident account of what happened in the next 20 seconds. It seems, however, that the recertifying master did not receive an acknowledgment of the astern movement in the time he either wanted or expected. This could be because the forward movement was excessive and he had not allowed sufficient time for the response, or the engineer was slower than usual in responding, or for some unknown reason did not respond.

Without data logger evidence, it is not possible to reliably determine the telegraph orders made by the recertifying master or the engine control inputs made by the engineer. The recertifying master stated that he rang 'full astern' twice immediately prior to the collision. If this is the case, for some reason, which remains unclear the engineer failed to comply with these orders. Analysis of the vessel's propeller wash shown on the CCTV videos indicates that at no stage after the 'half' or 'full' ahead movement which produced the wash visible between 0942:31 and 0942:38, was there an astern movement prior to the ferry impacting the wharf. In fact some wash appears at the vessel's stern immediately prior to the collision at 0942:57 to indicate an ahead movement. Had the engineer made a 'full astern' movement in the 20 seconds or so after 0942:38 it is likely that the vessel would not have collided with the wharf, or if it had, the impact would have been far less severe.

In the absence of any other evidence, the most probable explanation is that the engineer, who was below deck and had no realisation of where the ferry was relative to the berth or what was happening above, was confused by the contradictory engine movements.

In many ship bridge/engine room telegraph procedures, immediate emergency action may be indicated by 'double rings', ie. moving the telegraph rapidly through the range of engine movements. This is a method for communicating the need for urgent action on the part of the engineers. This may be also be supplemented by a talk-back system or telephone contact. There were no such procedures formal or otherwise on board Lady Herron and the vessel was not equipped with a talk-back system.

Tests conducted after collision showed the main engine control system to be functioning correctly in both the wheelhouse and the emergency control modes. As there was no failure of this equipment, the actions and/or omissions of the crew must be examined in the context of the accident and also the risks associated with conducting this type of training when berthing at dead end wharves with passengers aboard. Similarly if the exercise had been better planned, or the regular master had interceded when it would have been reasonable to do so, the collision may have been prevented or at least its effects mitigated.

There have been other instances where vessels have collided with the wharf while conducting emergency engine control training in the past which have been investigated by the Waterways Authority. The adequacy of Sydney Ferries response to these investigations and recommendations is also implicated in the *Lady Herron* collision.

The collision caused significant damage to the vessel and the wharf infrastructure and although there were no injuries to the passengers, crew or bystanders there was potential for the consequences to be far more serious. It was a matter of considerable luck that none of the bystanders on the wharf or in the café were injured by the impact or the flying debris.

4.2 Actions of the master

Lady Herron's regular master was in command of the vessel at the time of the accident. He was responsible for the safety of the vessel, its crew and passengers regardless of who was actually controlling the vessel. The recertifying master was acting under his direct supervision and instruction. The decision to conduct the berthing using emergency engine control was the regular master's and it was also his prerogative to take control of the vessel at any time if he felt that it was necessary to do so.

The regular master had recertified a number of other masters on *Lady Herron*, without incident, over the previous weeks including the day before. He indicated that it was his preference to conduct the emergency engine control drill at an open ended wharf although he had conducted the drill in Circular Quay in the past. There had been an opportunity to conduct the training when *Lady Herron* berthed at Cremorne Point, an open ended wharf, earlier in the morning but the master had elected not to do it at the time.

During the lead up to the berthing at Circular Quay, there is no evidence that the two masters and the engineer discussed the manoeuvre in any detail, nor was any contingency plan discussed. When *Lady Herron* stopped adjacent to the pontoon at the end of number four wharf berth it must have been evident to the regular master that the recertifying master had misjudged the manoeuvre as the vessel was wide and short of the berth. The vessel's position at this point of time required correction using finer engine control than could reasonably be expected using emergency control and it would have been logical for the regular master to abort the exercise at this point and return to wheelhouse control.

Similarly when the recertifying master made the decision to correct the vessel's position using a large ahead movement and full starboard rudder, there was an opportunity for the regular master to challenge the manoeuvre and suggest a more conservative approach. In the event, the master did not intercede and remained passive.

In the 20 seconds or so before the collision, the master expected that the astern order by the recertifying master would be carried out by the engineer. He had no reason to become unduly alarmed until it became apparent, some seconds later, that the engine had failed to go astern. He could see that the recertifying master had made a second order for 'full astern' and was waiting for the engineer to carry out the order. There was no reason for him to believe that the engine was not going to go astern and probably less than ten seconds at this point to consider any action to either avert the collision or limit the damage.

There was insufficient time to change the engine control back to the wheelhouse (an action performed by the engineer) and there was probably insufficient time to use the bridge telephone to call the engineer as this action requires the master to pick up the telephone, dial, and then wait for the engineer to pick up the telephone in the MCR. The master could have taken the helm and steered the vessel more towards the back boards between number four and five wharves but he did not consider this action and with the engine stopped at the time, the rudder would have had limited effect.

The master did not operate the passenger announcement system or sound the whistle in the final seconds before the collision. Had he done so it may have helped to minimise the risk of a passenger injury or injury to the bystanders on the wharf. His preoccupation with the vessel's situation at the time probably accounts for why he did not take this action.

4.3 Actions of the recertifying master

The recertifying master had considerable past experience in handling *Lady Herron* albeit around eighteen months previously. In the three hours or so prior to the accident, *Lady Herron*'s regular master had assessed the recertifying master's ability to handle the vessel as 'quite good'.

The CCTV video show's *Lady Herron*'s approach to its berth on number four wharf clearly. The vessel approaches number four wharf quite quickly and slows with a large astern engine movement. When it stops at 0942:30 it is lying far enough from the wharf to be almost in contact with the pylon located between number four and five wharves. The approach is not the usual one adopted by most masters and it appears that the recertifying master may have been concerned that he was going to collide with the pylon.

The recertifying master's subsequent use of a 'half ahead' or 'full ahead' order after 0942:30 in combination with full starboard rudder to swing the vessel's stern towards the berth was an aggressive manoeuvre. The vessel only needed to move in and ahead a short distance. In the circumstances, with the engine being manoeuvred manually with longer times to achieve movements, a more cautious approach would have been prudent. When the vessel started to accelerate and turn to starboard the recertifying master stated that he rang 'stop' and then 'full astern'. The engine was stopped but not put astern and at this point, and, given the vessel's headway, there was little time in which he could take any corrective action.

The recertifying master stated that he then rang 'stop' and 'full astern' again which indicates that he was increasingly concerned about the situation of the vessel and needed an astern movement as quickly as possible. He was unsure why the initial astern movement had not been made and in the absence of any other information thought that there may have been a control failure in the engine room. He had no immediate way of either taking control of the engine or signalling his concern to the engineer as there was probably insufficient time to use the telephone to call the control room. His only method of communicating the urgent need for the astern movement was the telegraph.

In the final seconds before the impact the recertifying master did not attempt to steer the vessel away from number five wharf. The risk to the passengers and bystanders could have been minimised, when it became apparent to him that the collision was inevitable, by steering the vessel more toward the backboard between number four and five wharves. Like the master, the very short period of time in which the events took place, and his preoccupation with the engine orders, probably accounts for why he also did not consider/take these actions.

4.4 Actions of the engineer

The engineer was at the engine manoeuvring console in the machinery control room at the time of the accident. The machinery control room is inside the engine room which is located below the passenger cabin. While in the

MCR he could not see the outside environment and had no way of knowing the situation of the vessel or its position in relation to the wharves.

The engineer had participated in emergency engine control drills during the recertification of several masters over the preceding days and was very conversant with the procedure. The evidence is that he responded promptly to telegraph orders up to time of the recertifying master's request for full astern at about 0942:40. Although he could not remember receiving any specific telegraph orders after the accident, both of the masters recall astern movement orders during the 20 seconds or so prior to the collision. The engineer offered no explanation as to why he did not make an astern movement in this critical time period.

There is a possibility that the engineer was confused by the recertifying master's quick succession of telegraph orders ie. 'stop', 'full astern', 'stop', 'full astern' immediately before the collision. The master may have manipulated the telegraph more frequently than the engineer could have acted on the orders. The apparent ahead movement immediately prior to the collision is indicative of this possible confusion.

The 'Wrong Way' alarm will sound if the wrong clutch is engaged in response to a telegraph order, ie. the ahead clutch is engaged when the telegraph has been set to an astern order. This alarm would not have sounded in the 19 seconds or so between 0942:38 and 0942:57 as the video of the vessel's wake suggests that the engineer had not engaged either clutch in response to the telegraph commands. The alarm should have operated in the second before the collision when there was an apparent ahead movement.

The engineer had no cues as to the urgency of the final astern movements and after the accident stated that a 'full astern' movement was relatively common and so he would not have considered it an unusual request. Passing an urgent message using the conventional telephone system would have taken too long considering the situation of the vessel. An immediate or 'open' line of communication between the MCR and the bridge, in the form of a 'talkback' system, could have been used to alert the engineer to the vessel's perilous situation and thus prompted an urgent astern movement in the short period of time before the collision.

4.5 Vessel handling

It was apparent from the evidence given by the two masters and the engineer that it was common practice, when manoeuvring the ferries in berthing operations to use maximum ahead and astern movements. While different vessels require different handling strategies and vessel schedules may dictate that these manoeuvres need to be carried out as efficiently as possible, this style of vessel handling leaves little margin for error. This is especially the case when manoeuvring in confined areas. When the recertifying master ordered either 'half' or 'full' ahead at 0942:30 it was an inappropriate handling strategy. The regular master's tacit approval, at the time, indicated that he did not consider the manoeuvre unusual. Under the circumstances, a more moderate approach probably would have achieved the desired result in the same time period and it would have provided more time for the general purpose hand to pass the mooring line ashore and for the engineer to respond to the subsequent telegraph orders.

The Fleet Instructions Manual contains general guidance in relation to 'Vessel Manoeuvring' (FIM 02.6) under the heading 'Conducting the approach or Departure' including:

> The vessel should be navigated at a safe speed and maintained at a safe distance from navigational hazards or other vessels in the area throughout the approach or departure...

The Vessel Operations Manual for *Lady Herron* also provides some relevant guidance in regard to emergency engine control:

> As this operating mode is provided to give a safe "get you home" option after a major control failure, it is important to navigate with extreme caution, and at safest possible speeds.

On *Lady Herron*, the training procedure increases the risk in that it replaces direct control of the engine by the master, with the less predictable responses of an additional human operator, who has very poor situation awareness due to his lack of contact with outside environment.

There is little doubt that the ferry masters have a great deal of skill handling their vessels which comes from, typically, long experience and the repetitious nature of the vessel operations. However, the recertifying master's use of a large ahead movement prior to the collision was a factor. This large ahead movement was not 'extremely cautious' and caused the vessel to accelerate rapidly in the confined space between the wharves and thereby reduced the time available to recover the situation.

The engineer's remark that it was not unusual to see 'full astern' orders during emergency engine control drills is also concerning. Full astern orders at these times should convey a sense of urgency to the engineer and should not be used routinely.

4.6 Bridge Resource Management

The application of sound BRM principles can form an important defence against situations where the decisions or actions of a single individual lead to an adverse event. BRM training was introduced primarily to reduce the risk of single person error instigated accidents and is a now requirement for all Australian deck officers on SOLAS vessels. While BRM has been developed primarily for SOLAS vessels, some of the principles may also be applied to Sydney Ferries operations.

Critical ferry operations, like berthing, require ferry crews to work as a coordinated team. For the most part these operations are conducted so frequently as to become routine. There are times, however, when conditions and circumstances dictate that routine approaches must be modified. The master, in particular, must be aware of any additional risks to his vessel and have appropriate contingency plans ready to mitigate these risks as they arise.

On the morning of 20 February, *Lady Herron*'s master decided to conduct the emergency engine control drill while berthing at Circular Quay. The regular master had performed a large number of similar exercises while recertifying masters over the preceding weeks and, to him, the exercise had probably become somewhat routine. He did not specifically brief or plan the exercise with the master who was being recertified or the engineer. There appeared to be an expectation that as the recertifying master was experienced in handling the vessel, and had demonstrated his competence in the preceding hours, that any particular advice or warnings were unnecessary. Similarly, the engineer had performed the operation many times in the past and had proven his competence to the regular master. During the subsequent events, the regular master did not challenge the recertifying master's actions when the risk to the vessel could have been mitigated.

Two of the fundamental tenants of BRM are the principles of planning ahead and challenge and response. Both of the masters on *Lady Herron*'s bridge had undergone 'Professional Development for Masters' training which included these elements of Bridge Resource Management however they did not apply these principles in the lead up to the collision. The routine nature of the emergency engine control training evolution probably meant that neither master was particularly cognisant of the additional risks to the vessel that the procedure represented.

4.7 Fatigue

While it is not possible to conclude that fatigue had any effect on the performance of *Lady Herron*'s crew at the time of the accident some discussion is warranted. *Lady Herron*'s regular master and engineer work shifts of up to 13.5 hours including the day before the accident. Both men also travel a considerable distance to work, (approximately one hour and fifteen minutes for the master and two hours for the engineer) and this time spent travelling in addition to adding to their overall level of fatigue, also limits their time at home between shifts and thus their opportunity to sleep. It is useful in the context of this investigation to consider what impact travel time may have had on the level of crew fatigue.

In 2002 a shiftwork and fatigue study[2] of Sydney Ferries masters and engineers was conducted by DNV. The report included some discussion of the impact of travelling times including:

> Adding a long shift onto a long commute increases the likelihood and extent to which fatigue will impact the performance of employees. Therefore, long commutes added to long shifts are likely to lead to the increased risk of fatigue-related incidents.

[2] Shiftwork and Fatigue Study prepared for State Transit Authority of New South Wales, Det Norske Veritas, December 2002.

When using the FAID system to develop crew rosters, the usual practice is to input only rostered hours of duty. While the fatigue index scores generated by FAID provide an objective quantitative measure, which is a useful guide to an individual's fatigue at a given time, the results must be used carefully when deciding whether or not fatigue was a factor in an accident. *Lady Herron*'s crew fatigue scores (for the time of the accident) calculated using only their rostered hours of duty for the previous week show that neither of the masters nor the engineer had a fatigue score which is close to the designated high range (80–100). The regular master's and the engineer's scores were both 53 and the recertifying master's was 62.5.

When taking into account travel time to and from work, the fatigue scores are higher. In this instance the regular master's score was 67 and the engineer's 75 at the time of the accident. The recertifying master's score was relatively unchanged as he lived close to work. The regular masters and the engineer's scores, while still below the high range, are significantly higher but still not at a level where it is possible to conclude that fatigue was likely to be factor in their actions and decisions at the time of the accident.

4.8 Vessel type training

At the time of the collision, the recertifying master was undergoing type recertification under the supervision of the regular master who was a designated training master for *Lady Herron*. The regular master was following the vessel type rating checklist and was assessing the recertifying master's competency in the specified elements. The type rating checklist requires candidate masters to demonstrate their competence at manoeuvring the vessel in emergency control however it does not stipulate when and where this operation is appropriate. The type rating checklist was not specifically supported by other guiding documentation either in the Fleet Instruction Manual or the Vessel Operations Manual as these sections had not been developed at the time. The lack of this guidance was causal in the accident as *Lady Herron*'s master felt that it was up to his discretion when and where the training could be conducted.

The Fleet Instructions Manual contains some general guidance in relation to training in the 'Vessel Manoeuvring' (FIM 02.6) section under the heading 'Conducting the Approach or Departure' including:

> The Master shall always be in control of the vessel during the approach or departure. Training in approaching/departing wharves for crew other than Masters shall only be conducted as part of a Company's approved training program. The trainee, as a minimum requirement, shall hold a valid Master Class v-Certificate of Competency and training shall be conducted under the supervision of an approved Master.

Lady Herron's regular master was complying with this general instruction as the training was being conducted under his supervision and the recertifying master was appropriately qualified.

Conducting emergency engine control drills during berthing operations at open ended wharves involves less risk than dead end wharves as in the event of a loss of control the vessel may be steered into open water. *Lady*

Herron's schedule at the time of the accident provided very few opportunities to conduct this drill at an open ended wharf. When the master decided not to do the drill when the vessel berthed at Cremorne Point earlier in the morning he missed his chance to conduct the drill with considerably less risk.

Lady Herron's master had recertified a number of masters in the preceding weeks (approximately nine in the previous five or six weeks). This process places an additional burden on the master as he must retain overall control of the vessel while assessing the recertifying master's operation of the vessel and provide feedback on his performance. It is possible that this additional workload affected the master's actions or decisions in the time before the collision.

4.9 Risk management

Emergency engine control training is designed to prepare the crew for an emergency when there is a failure of the automated bridge control system. While a failure of the bridge control system is a rare event, it has happened in the past, (eg. *Lady Northcott*, June 2003), and as with all back up systems some level of practice must be allowed in its use, otherwise if forced to use it, the requisite skill will be missing.

In choosing to exercise the emergency system the risk profile of the berthing procedure is altered from the norm. Because it is not the normal procedure the master involved will not be as competent and skilful as with bridge control. While the risk of the automated engine control system failing is removed, a new risk, the master/engineer interface is introduced. In the case of the engineer, the sequence of response to bridge commands is also not as well practiced and there is always the risk of an inadvertent wrong way manipulation, although a sustained wrong-way command is defended against by a wrong-way alarm system. When exercising the emergency procedures at a dead end wharf there is also the added hazard of no escape route if things go wrong.

The size of the Sydney Ferries fleet and service requirements dictates that emergency engine control training is conducted on vessels which are in service. The additional risk associated with conducting such a drill during berthing, when the risk to the vessel is already greater, particularly with passengers on board, may not be justified by the safety benefit. To some extent, the risks of this type of training can be reduced by conducting the training under the direct supervision of an experienced master and by using an open ended wharf. *Lady Herron*'s regular master made the decision to conduct the emergency engine control drill at Circular Quay in the absence of any specific policy or guidance in the company procedures aside form the need to conduct the training under his supervision. The *Collaroy* incident in August 2002, in particular, should have led to some objective assessment of the practice.

The ISM Code requires that operational risks are assessed and critical operations have specific procedures. In compliance with the Code the objectives stated in the Sydney Ferries safety management system are to:

a) Provide for safe practices in ferry operations and a safe working environment.

b) Establish safeguards against all identified risks; and

c) Continuously improve safety management skills of personnel ashore and onboard ferries, including preparing for emergencies related to both safety and environmental protection.

The conduct of emergency engine control drills while berthing was an identifiable risk and the incidents in the past should have led to the development of a safe policy and procedures relating to the practice.

There is evidence that Sydney Ferries' response to past investigations and recommendations by the Waterways Authority has not been adequate. While some changes to operational procedures have been made, these have been specific to vessel types and it appears that the wider issues have not been adequately addressed. The risks associated with emergency engine control drills need to be assessed across the whole fleet and appropriate guidance provided for all ferry masters.

In the past the Waterways Authority has had a Major Incident Review Committee comprised of various experts and interested parties which examined the implications of marine incidents. This committee has not been convened for some time. It would benefit Sydney Ferries operations and the wider marine industry to develop and perpetuate recommendations using this forum.

4.10 Passenger announcements

Lady Herron's Vessel Operations Manual contains post collision emergency instructions, but nothing on what to do in the event of an impending collision.

The pre-recorded emergency announcement was generally defined as the method of warning passengers of an emergency, including collision. The announcement was verbose and did not convey a sense of urgency to passengers, such as that which would be desirable when preparing for an impending collision with a wharf or other vessel.

To a large extent, the crew were responsible for using their own initiative to identify the need for, and selecting a means of, warning passengers and those on shore of an impending collision.

In the short period of time before *Lady Herron* collided with the wharf, neither of the two masters activated the emergency announcement, despite its easy one-touch operation. This reinforces the expectation that humans under the stress of an unfolding emergency are unlikely to reliably carry out the desired behaviour unless that behaviour has been firmly established through repetitive training.

The GPH took immediate action to warn the passengers, who fortunately were few in number, to hold on. However there was no warning to those on shore and the persons seated in the café at wharf five were seen in the CCTV images to have had no warning of the impact which was to occur just two metres from their table.

5.0 CONTRIBUTING FACTORS

Reason's model of accident causation (Reason, 1990, 1991, 1997)[3] suggests that serious industrial accidents are best understood by analysing the complex interrelationship between organisational processes, local task and environmental conditions, and the actions of the people directly involved. The model describes how latent organisational deficiencies allow or create conditions that predispose errors or violations, and how unsafe acts combine with local triggering events to produce a potential accident. However, an accident only occurs when the defences designed to prevent such an occurrence are inadequate. Reason's model can be applied to provide a structured framework for sorting, simplifying and mapping the dynamic relationship between the contributing factors in an accident or incident.

5.1 Absent or failed defences

Defences are the 'last minute' measures designed to prevent an accident or its consequences in the face of preceding technical or human failures. They include technology, such as detection or control systems, work processes or procedures, or human awareness of and/or response to a threat. The absent or failed defences identified in this investigation are:

- The lack of an immediate, or open channel form of communication between the bridge and the MCR prevented the master's notifying the engineer of their concern in the final seconds before the collision;
- The failure of the regular master to apply good resource management principles in planning the training exercise or by challenging the actions of the recertifying master may also have contributed to the collision;
- The routine use of 'full astern' movements during emergency engine manoeuvring drills in the past meant that the engineer did not recognise the 'urgency' of the command; and,
- Neither master activated the passenger warning system or the vessel's whistle prior to the collision to warn the passengers and bystanders of the impending collision.

5.2 Individual and team actions

Individual and team actions are the things that people did or failed to do – usually errors or violations – that triggered the accident. They are a normal part of everyday operations in all industries, and result from natural human limitations in combination with conditions inherent in the task or workplace.

[3] Reason, J. (1990). *Human Error*. New York: Cambridge University Press.

Reason, J. (1991). Identifying the latent causes of aircraft accidents before and after the event. *Proceedings of the 22nd ISASI Annual Air Safety Seminar,* Canberra, Australia. Sterling, VA: ISASI.

Reason, J. (1997*). Managing the risks of organizational accidents.* Aldershot, UK: Ashgate.

The actions by an individual or team that contributed to this accident were:

- The regular master's initial decision to conduct the emergency engine control drill in the confines of Circular Quay;

- The regular master's failure to intercede when the recertifying master selected an aggressive handling strategy to correct the vessel's position in relation to the berth;

- The recertifying master's decision to use an aggressive berthing strategy rather than more conservative engine movements;

- The recertifying masters multiple telegraph orders in the 20 seconds or so before the collision which may have confused the engineer; and,

- The engineer's failure to respond to the telegraph orders for 'full astern' movements in the 20 seconds before the collision.

5.3 Task, environmental and human conditions

The conditions existing immediately prior to an accident or incident influence how people act, frequently increasing the likelihood of an error or violation being committed. These conditions involve the task itself (for example, complexity, workload), the environment (for example, temperature, lighting, noise), people's physical or mental states, and social, cultural or life circumstances.

A multitude of task, environmental and human conditions can be identified following any accident. It is important to distinguish between those that contributed to the event and those that may be otherwise interesting, but were not part of the accident chain. Relevant conditions in this accident are:

- In absence of any other guidance, *Lady Herron*'s regular master felt that he had the discretion to conduct the emergency engine control drill where and when he thought it was appropriate;

- The type recertification process adds significantly to the work load of the regular master. He had completed a large number of type re-certifications in the weeks preceding the accident;

- *Lady Herron*'s schedule included very limited opportunities to conduct the emergency engine control at safer 'open ended' wharves;

- The accepted practice of using large engine movements when manoeuvring the vessel in confined areas; and,

- The engineer's lack of situational awareness when manually manoeuvring the engine in the MCR.

5.4 Organisational factors

Organisational factors influence the conditions under which people work. They result from management decisions, systems, processes and cultural influences. They in turn produce task and environmental conditions, which may lie dormant and undetected for many years before combining with local conditions and human actions (errors and/or violations) to breach the system's defences.

The investigation identified that the following organisational factors contributed to this accident.

- The type recertification process was inadequately documented as there was no guidance for the regular master relating to when and where it was appropriate to conduct emergency engine control drills;
- The risks associated with conducting emergency engine control drills had not been adequately assessed by Sydney Ferries; and,
- There had not been an adequate response to similar incidents in the past.

5.5 Additional findings

This section lists findings on additional system deficiencies that, while not contributing directly to this accident, are nonetheless significant and in need of corrective action.

- A data logger on board *Lady Herron* capable of recording telegraph and engine settings, would have been of considerable assistance in determining the sequence of events leading to the collision.

6.0 Recommendations

The following recommendations are made with a view to preventing similar incidents in the future.

1. Sydney Ferries should assess the risks associated with the practice of emergency engine control drills across their fleet with a view to providing appropriate guidance to masters as to when and where the training it is to be conducted.

2. Sydney Ferries should review the handling practices adopted by masters when manoeuvring using emergency engine control and ensure 'full astern' movements are reserved for emergency use.

3. Sydney Ferries should ensure that their vessels are equipped with an immediate, or open channel, form of communication between the bridge and the MCR where appropriate.

4. Sydney Ferries should fully develop their type rating training system and include adequate vessel specific guidance for their training masters in respect of the requirements relating to type recertification training.

5. Sydney Ferries should consider fitting data logging equipment aboard all their vessels to record relevant data, including engine control settings, to aid in the analysis of accidents and serious incidents.

6. The Waterways Authority should consider reinstituting the Major Incident Review Committee to assist in analysing the factors relating to significant accidents or incidents with a view to making appropriate safety recommendations.