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OFFICE OF TRANSPORT SAFETY INVESTIGATION

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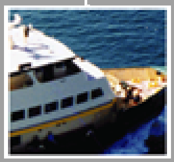

FERRY SAFETY INVESTIGATION REPORT

COLLISION OF THE *LOUISE SAUVAGE*
ROSE BAY WHARF

12 MAY 2004

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ROSE BAY WHARF

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OTSI File Ref: 02129 **30 June 2005**	**Office of Transport Safety Investigation** **Level 22, 201 Elizabeth Street** **Sydney NSW 2000**

The Office of Transport Safety Investigation (OTSI) is an independent NSW agency whose purpose is to improve transport safety through the investigation of accidents and incidents in the rail, bus and ferry industries.

Established on 1 January 2004 by the *Transport Administration Act 1988*, the Office is responsible for determining the causes and contributing factors of accidents and to make recommendations for the implementation of remedial safety action to prevent recurrence.

OTSI investigations are conducted under powers conferred by the *Rail Safety Act 2002* and the *Passenger Transport Act 1990*. OTSI investigators normally seek to obtain information cooperatively when conducting an accident investigation. However, where it is necessary to do so, OTSI investigators may exercise statutory powers to interview persons, enter premises and examine and retain physical and documentary evidence. Where OTSI investigators exercise their powers of compulsion, information so obtained cannot be used against those persons providing information in criminal or civil proceedings.

OTSI investigation reports are submitted to the Minister for Transport for tabling in both Houses of Parliament. Following tabling, OTSI reports are published on its website www.otsi.nsw.gov.au

Information about OTSI is available on its website or from its offices at:

Level 22, 201 Elizabeth Street
Sydney NSW 2000
Tel: (02) 8263 7100

PO Box A2633
Sydney South NSW 1235

The Office of Transport Safety Investigation also provides a Confidential Safety Information Reporting facility for rail, bus and ferry industry employees. The CSIRS reporting telephone number is 1800 180 828.

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GLOSSARY OF TERMS AND ABBREVIATIONS

EPA	Environmental Protection Agency
DNV	Det Norske Veritas
Ferry	A vessel which seats more than 8 adult persons
ICAM	Incident Cause Analysis Method
ITSRR	The Independent Transport Safety and Reliability Regulator
MAX	Monitoring, Alarm and Control System
NSW	New South Wales
OTSI	The Office of Transport Safety Investigation
PLC	Programmable Logic Controller
PTA	*Passenger Transport Act 1990*
Public Passenger Service	The carriage of passengers for a fare or other consideration by means of a vessel within any New South Wales waterway
SMS	Safety Management System
STA	State Transit Authority
TAA	*Transport Administration Act 1988*
Taylor Report	A report commissioned by the Minister for Transport in 2001 and prepared by the Waterways Authority, titled 'Independent Review of the Operations of Sydney Ferries including a Report on the Technical Review of the JetCat Class of Ferries'.

EXECUTIVE SUMMARY

At 6.00PM on 12 May 2004, the Sydney Ferries Supercat class vessel *Louise Sauvage* collided with the North wharf at Rose Bay in Sydney Harbour NSW. The crew reported that the vessel had suffered a failure of the steering system at a critical stage of the approach to the Rose Bay STA (South) wharf, its berthing destination.

Earlier that day, the *Louise Sauvage* experienced a failure of its steering system. As the defect was not confirmed during shipyard testing and sea trials, the *Louise Sauvage* was returned to service.

Based on the failure of the steering system in the early afternoon of 12 May 2004, the level of disassembly of the steering system that had taken place before OTSI could inspect the vessel after the accident and the absence of reliable data recording of vessel parameters, the investigation concluded that the most likely cause of the collision was the failure of the steering system. However, technical investigations by both Sydney Ferries and OTSI have failed to establish what caused the steering system failure.

However, the ability of the crew to manage the Rose Bay failure was complicated by the following contributory factors:

- The tendency for rudders to creep out of alignment contributed to the habitual use of the Emergency Steering (hydraulic failure) mode.
- Training and procedural information, as contained in the Vessel Operations Manual Supercat Class, was inaccurate or incomplete.
- The Type Rating system, in concert with crew drill requirements, was not effective in providing ongoing assessments of the general operational competency of crew.
- Sydney Ferries had made initial efforts to implement Bridge Resource Management. However, the tenets of Bridge Resource Management had not extended to all operational staff or been incorporated in all procedures and checklists.
- A contingency plan was not developed and communicated by the Master prior to commencing daily operations or prior to approaching the Rose Bay wharf.
- Sydney Ferries had not implemented all recommendations made by the Waterways Authority during 2001 in a report titled 'Independent Review of the Operations of Sydney Ferries including a Report on the Technical Review of the JetCat Class of Ferries' (herein referred to as the Taylor Report).
- Sydney Ferries did not have a formalised system for managing operational risk.
- The emergency response was well managed by the vessel's crew. However, the tone and content of the automated emergency messaging system was inadequate to convey the necessary sense of urgency to passengers during an operational emergency.
- The NSW Maritime Authority did not perform a Failure Mode and Effect Analysis of the Supercat's directional control system.
- The decision by the NSW Maritime Authority not to require the performance of a Failure Mode and Effect Analysis of the directional control system was not supported by a robust safety assessment process.

The investigation has made the following safety recommendations to the responsible entity.

Sydney Ferries is to:

- Resolve the inaccuracies in the Supercat Operations Manual.
- Review automated emergency announcements.
- Install data recorders on all vessels.
- Rectify the tendency of Supercat rudders to creep out of alignment.
- Install an effective auxiliary steering system to Supercat vessels and rename the emergency steering switch.
- Implement contemporary Crew Resource Management.
- Implement a more rigorous crew training and performance monitoring regime.
- Implement a more contemporary risk management framework.
- Review the recommendations made by the Waterways Authority during 2001 in the Taylor Report.

NSW Maritime Authority is to:

- Conduct an audit to test Sydney Ferries' implementation of the recommendations made by the Waterways Authority during 2001 in the Taylor Report.
- Perform a Failure Mode and Effects Analysis of the Supercat's directional control system in order to validate the Sydney Ferries modifications to the steering system.
- Introduce internal processes to ensure that all exemptions from safety requirements are supported by a documented equivalent safety determination.
- Ensure that design standards are promulgated for ferries utilised for public passenger services. These design standards should ensure that an appropriate analysis is performed to establish that two effective independent means of steering exist. The secondary or emergency steering gear should be capable of being brought speedily into action.

PART 1. INTRODUCTION

Appointment

Date of incident:	12 May 2004.
Location:	Rose Bay, New South Wales.
Details of incident:	Supercat class vessel *Louise Sauvage* operated by Sydney Ferries collided with the Northern Wharf at Rose Bay, New South Wales.
Type of investigation:	Ferry Safety Investigation, pursuant to Section 46B of the *Passenger Transport Act, 2002.*
Investigator:	The Office of Transport Safety Investigation.

Terms of Reference

1.1 The terms of reference set out by the Chief Investigator, Office of Transport Safety Investigation (OTSI) required the investigator to:

a. Identify the factors, primary and contributory, which caused the accident;

b. Identify whether the accident have been anticipated and assess the effectiveness of the STA risk management strategies adopted;

c. Assess the adequacy of the emergency response to the incident as it affected the safety of all persons involved; and

d. Advise on any matters arising from the investigation that would enhance the safety of ferry operations[1].

Methodology

1.2 The objective of the investigation is to determine the circumstances surrounding the incident and provide information to prevent the recurrence of similar events.

1.3 The investigation is not intended to attribute blame or liability. However, all relevant factual information is included to support the analysis and conclusions. Some information may reflect on the performance of individuals and organisations and how their actions have contributed to the outcomes of the matter under investigation.

1.4 A systemic approach was adopted to identify immediate, long-term and organisational issues. The investigation has identified and analysed the issues relevant to the terms of reference and made a number of recommendations.

[1] The *Passenger Transport Act 1990* defines a ferry as a vessel which seats more than 8 adult persons and includes a vessel of any class prescribed by the regulations for the purposes of this definition.

1.5 The format adopted by this report is to present the factual information surrounding the accident, individual and team actions, task and environmental conditions and organisational factors. The Incident Cause Analysis Method has been used to support the analysis of factual information and develop safety recommendations.

PART 2. FACTUAL INFORMATION

Overview

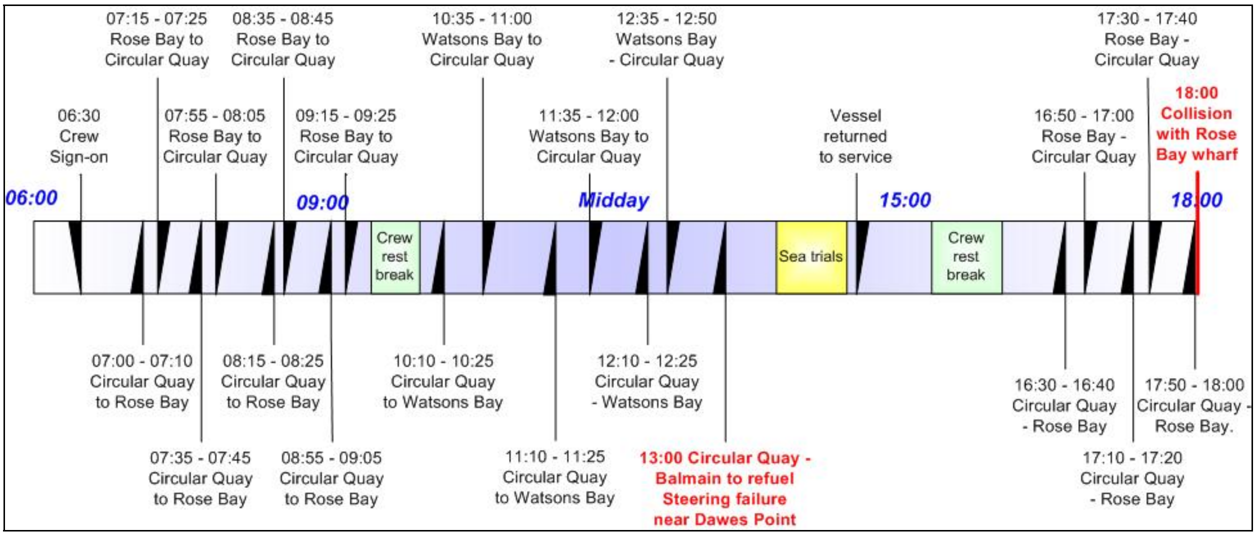

Figure 1 – Crew & Vessel Operations, 12 May 2004.

2.1 The Sydney Ferries crew for the Supercat ferry *Louise Sauvage* resumed duty at 6.30AM on 12 May 2004, after a Rostered Day Off. The crew consisted of a Master, Engineer and General Purpose Hand. Consistent with the practices of Sydney Ferries, the crew was rostered to operate the *Louise Sauvage* for the entire shift.

2.2 These rostering practices place crews on duty for periods up to 14 hours, with rest breaks being provided during the shift. The crew had taken the rostered rest breaks up to the time of the incident described in 2.3 and 2.4 below.

2.3 The ferry's operation, as outlined in Figure 1, was reported as normal, until approximately 1.00PM when the *Louise Sauvage* was proceeding from Circular Quay to the Balmain Shipyard facility to refuel.

2.4 Based on maintenance records and recorded radio transmissions, when the *Louise Sauvage* was abeam Dawes Point, the Master advised the Engineer that the vessel had suffered a loss of steering control. With the Master stationed at the centre control station, both rudders on the vessel made a gradual 30 degree turn to port, independent of the steering commands initiated at the steering joystick. Due to low traffic levels within Sydney Harbour, there was no immediate threat of collision.

2.5 At the time of the steering failure, the Master commenced immediate recovery action that included the selection of "emergency steering" control. This function, controlled from the centre control station, enables the Master to isolate the port or starboard rudder from the main steering control system. This action enabled partial steering to be regained. The Master then cycled the emergency steering control from emergency to normal and determined that normal steering control was again available. Sydney Ferries Control and the Sydney Ferries Marine

Engineering Superintendent were both advised, by radio, of the incident immediately.

2.6 The vessel continued its trip to the Balmain shipyard at reduced speed and under a close watch for further control inconsistency.

2.7 Upon arrival at the shipyard, the vessel was inspected by two Sydney Ferries fitters. As neither fitter held an electrical qualification, the inspection was confined to hydraulic and mechanical components. Despite extensive observations by the vessel Engineer and the fitters, no obvious defects were discovered.

2.8 Following the inspection, the Marine Engineering Superintendent authorised a trial of the vessel to determine serviceability. A forty minute trial was conducted locally by the same operating crew and comprised a set of various steering manoeuvres. There was no occurrence of steering failure during this trial and the vessel returned to Circular Quay at 3.00PM in readiness to resume its scheduled services.

2.9 A crew rest break was taken between the time the vessel returned to Circular Quay and the commencement of the 4.30PM Rose Bay service.

2.10 Both the 4.30PM and 5.10PM Circular Quay to Rose Bay and return services were completed without incident.

Collision sequence

2.11 At 5.50PM, the *Louise Sauvage* departed Circular Quay on a direct service to Rose Bay. This service had one hundred and sixty passengers on board. The vessel was being operated by the same crew that had been operating it since commencing services that morning.

2.12 The *Louise Sauvage* entered Rose Bay in darkness, tracking South West of Shark Island at a cruising speed of approximately twenty four knots. The weather conditions at the time were clear, with a steady South / South Westerly wind of 20 to 25 knots and a choppy water surface in a normally sheltered area.

2.13 Berthing facilities at Rose Bay consist of two timber wharves. Sydney Ferries operates from the State Transit Authority (STA) wharf which is the Southernmost of the two wharves.

2.14 As the Master made the approach to the STA wharf, he slowed the vessel to approximately 10 knots and transferred engine throttle control from the Centre Control Station to the Port Control Station of the bridge. The Port Control Station has both primary steering and throttle controls which replicate those at the Centre Control Station. A similar station is located on the starboard wing. The purpose of these additional control stations is to provide enhanced visibility for the Master during berthing. See Figure 2.

2.15 The Master positioned himself at the Port Control Station. As part of the berthing manoeuvre, he initiated a starboard turn to align the *Louise Sauvage* with the Southern wharf. The Master stated that he received no response from the steering input and immediately advised the Engineer. At this time the Engineer was seated adjacent to the Centre Control Station and the General Purpose Hand was on the main deck preparing for the berthing operations.

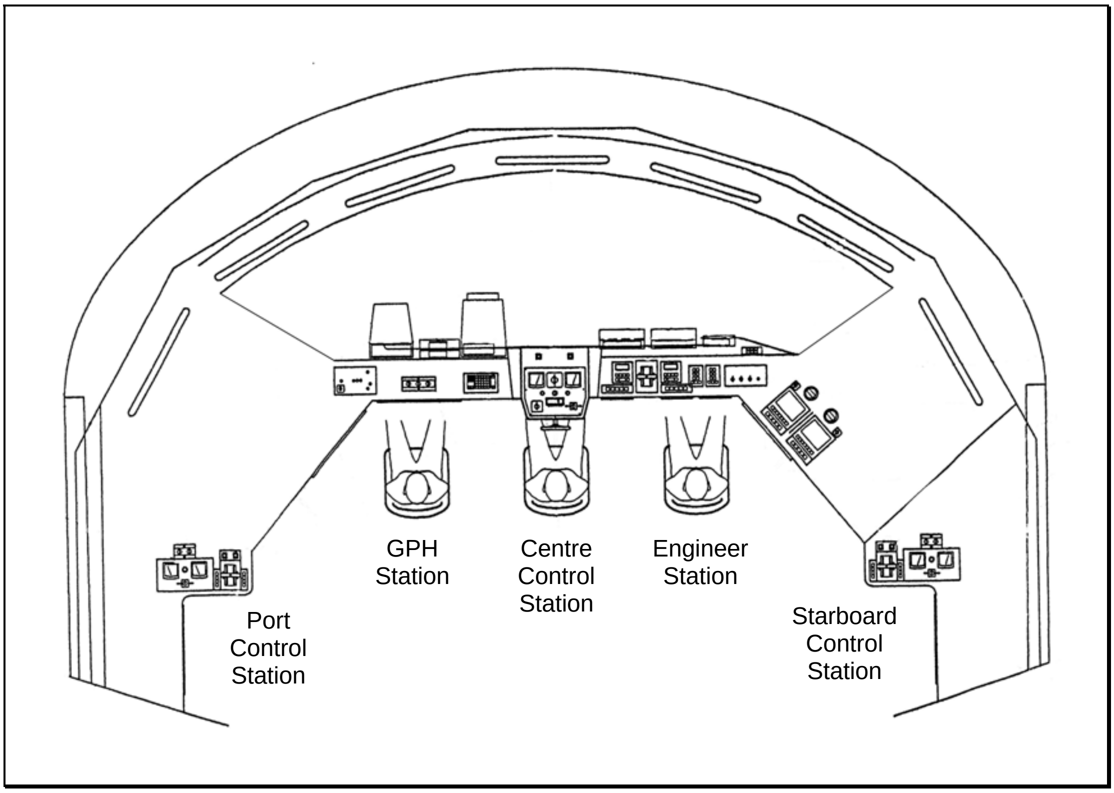

Figure 2 – Plan view of Supercat Bridge

2.16 The Engineer sought confirmation from the Master of steering failure and requested permission to select the emergency steering mode. The Engineer selected emergency steering. The Master ordered a starboard turn. The Engineer, using the joystick at the centre control station, initiated a turn of approximately ten degrees to starboard. Shortly after, the vessel collided with the North wharf at an intercepting angle of approximately forty five degrees.

2.17 An aerial view of Rose Bay, along with the prevailing winds, and the intended and actual course is shown at Figure 3.

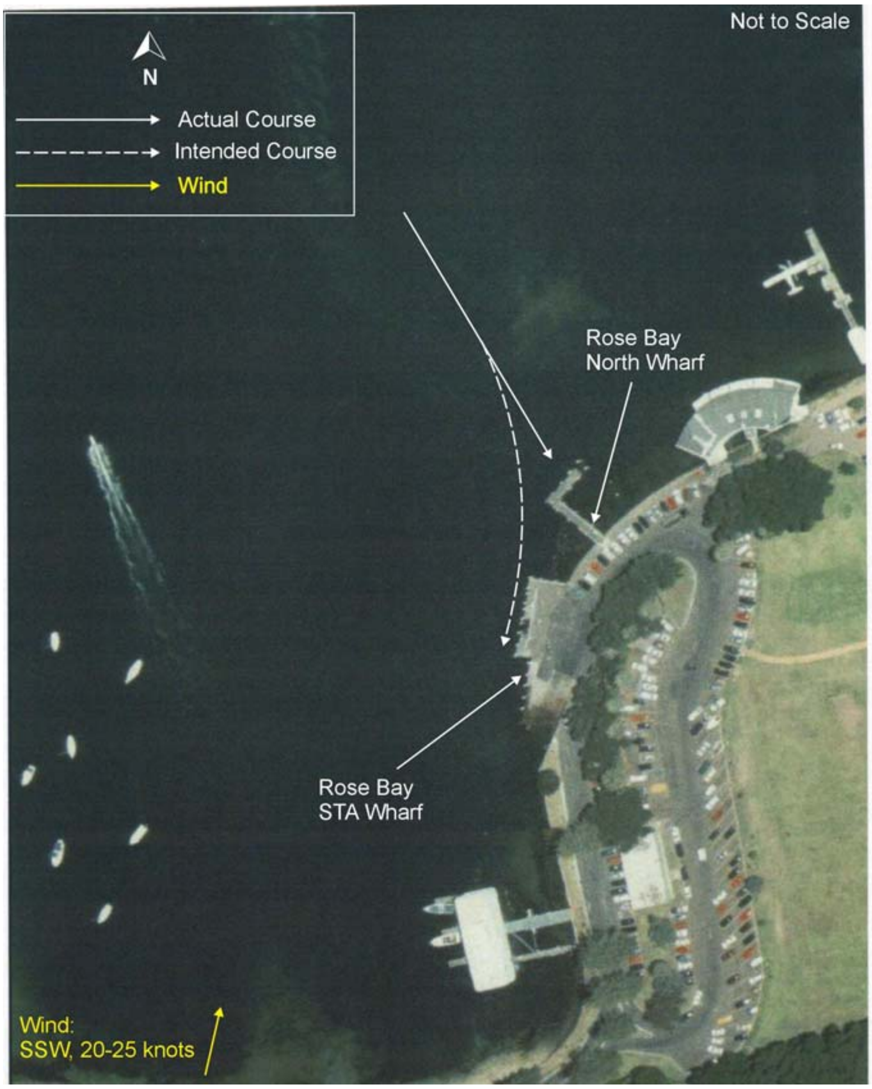

Figure 3 – Aerial View of Rose Bay

2.18 The impact of the collision was buffered by the progressive collapse of the timber structure as well as the climbing angle of the vessel as it rode up the staircase of the wharf. This collision sequence caused the vessel to be held tight by the forward metal sponson structure upon the timber pylons of the wharf.

Post Accident

2.19 The Engineer initiated manual passenger safety advisory announcements via the public address system and took immediate steps to ensure the integrity of the vessel structure.

2.20 He later arranged for all passengers to relocate to the stern, thereby raising the height of the bow in relation to the pylons. Five minutes later, the vessel was freed from the wharf structure due to numerous applications of astern power.

2.21 The vessel then berthed at the STA Wharf (South) and the passengers disembarked.

2.22 Following the accident, the *Louise Sauvage* returned to the Sydney Ferries shipyard at Balmain. Subsequent maintenance activity focussed on the steering system and included inspection and testing by: Sydney Ferries, the manufacturer of the steering system and an independent maintenance provider. The vessel was then subject to numerous sea trials. None of the above inspection and test activities were able to identify or reproduce the steering defect.

People

Passengers

2.23 Approximately 160 passengers were aboard the Vessel at the time of collision.

2.24 The crew advised that two passengers reported minor injuries at the time as a result of the collision. Additional reports of injuries were made to Sydney Ferries subsequent to the collision.

Crew

2.25 The crew comprised a Master, Engineer and General Purpose Hand.

2.26 The Master had held a valid Master Class IV Certificate of Competency since February 1994. He was initially type rated on the Supercat class of ferry on 24 November 2000 and has since maintained currency on that class of vessel. In addition, the Master had completed a course in Bridge Resource Management on 6 March 2002.

2.27 The Engineer had held a valid Marine Engine Drivers Grade II Certificate of Competency since November 2002. He gained a Supercat Type Rating on 22 December 2003.

2.28 The General Purpose Hand was issued with a General Purpose Hand Endorsement on 21 November 2003.

Medical and toxicology information

2.29 A breath test was performed by the NSW Police of all crew members immediately after the accident. The results of this test returned a negative reading for alcohol.

2.30 The time at which the accident occurred is generally acknowledged within the ferry industry as not a fatigue danger zone.

Environmental Factors

Environmental factors

2.31 Weather conditions at the time of the incident were:
- South/South-westerly wind of 20 to 25 knots.
- The area was in darkness.
- Visibility was good; there was no atmospheric moisture and wharf lighting was operational.
- Water surface was choppy in what is normally a sheltered area.

2.32 The working environment within the ferry was consistent with normal operations, including:
- Low levels of lighting within the Bridge.
- No indication of tension between crew members.
- No unruly passengers.
- Crew were familiar with the task, having arrived at Rose Bay wharf six times earlier that day.

2.33 Boating traffic levels at Rose Bay were light. Accordingly, there had been no need for the *Louise Sauvage* to alter course during the approach to Rose Bay.

Vessel Information

General

Figure 4 – Supercat class of vessel

2.34 The *Louise Sauvage* was launched in March 2001, being the third in a series of Supercat class ferries to be built by ADI Limited at Garden Island, Sydney.

2.35 The *Louise Sauvage* is capable of carrying a maximum of 250 passengers and three crew comprising of a Master, Engineer and General Purpose Hand.

2.36 Generic design features are articulated by rules promulgated by the NSW Maritime Authority or in the instance of vessels such as the *Louise Sauvage*, a classification society. In the instance of the Supercat class of vessel, Det Norske Veritas High Speed, Light Craft, Naval Surface Craft standards have been used as the basis for the design standard for the vessel's hull and machinery. The applicable elements of this standard have been articulated by the Det Norske Veritas classification standard 1A1 LC R5(aus) Passenger EO.

2.37 The remaining aspects of the vessel are considered by the NSW Maritime Authority as part of issuing a Certificate of Survey. The Certificate of Survey permits operations within a defined area. In the case of the Supercat class of vessel, it is permitted to operate within the plying limits of the Class 1E Survey area.

2.38 NSW Maritime Authority Class 1E permits operations on Port Jackson to the west of a line between Green Point and Georges Head. Rose Bay is within the survey area.

Steering System Overview

2.39 The steering system is considered to be part of the hull and machinery for the purposes of design approval and survey inspections. It is a basic principle that *"… craft be provided with at least two alterative means for steering. The second, auxiliary one, needs however not to be designed for all operational speeds and conditions, but must be capable of steering the craft at navigable speed."* In addition, *"a single failure in one of the steering systems is not to render the other one inoperative."* [2] An acceptable method of meeting this requirement is to consider the combination of rudders and differential propulsive thrust as two alternative means of providing directional control.

2.40 If the vessel does not have two systems to control the rudders then the Det Norske Veritas standard requires:

- The steering system to consist of two identical power units one of which is capable of operating the steering system while the other power unit is out of operation, and
- The steering system to have the facility to readily isolate a single failure in steering system piping.

2.41 To allow the design of the Supercat to meet the basic principle of a craft having an auxiliary steering system, reliance is placed on the use of differential propulsive thrust as a method of maintaining directional control of the vessel.

2.42 The propulsion system fitted to the Supercat provides two independently operated propellers. The speed and direction of rotation of each propeller can be varied using the throttle controls at the centre and wing control stations. Sea trials performed during the return to service of the vessel confirmed that it is possible to maintain directional control using differing propeller speeds and/or direction.

[2] Det Norske Veritas Standard for High Speed, Light Craft and Naval Surface Craft

2.43 To provide a basis for the generation of training, operational and maintenance programs and documentation relating to the directional control system, Det Norske Veritas standards require a Failure Mode and Effect Analysis to be performed for the lead craft of a class and revalidation of the analysis for craft of the same design and equipment.

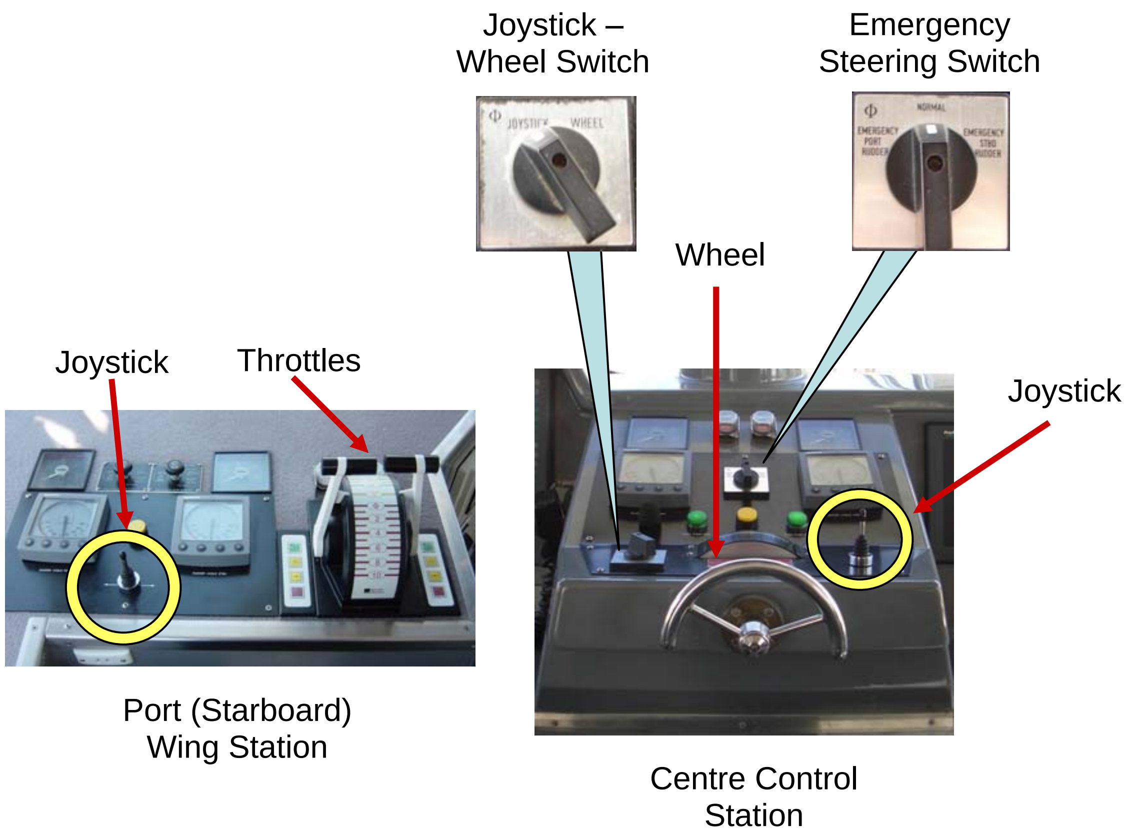

Figure 5 – Bridge Controls

Rudder System Operation

2.44 Inputs to the primary steering system are made by a joystick located at each control station within the bridge.

2.45 In addition to the primary steering system for activating rudders, a number of other means also exist for rudder control. These include a steering wheel, Emergency Steering Switch and manual operation at the rudder system Hydraulic Valve Assembly.

2.46 The steering wheel is operated from the centre control station. This system provides a method for a crew member to activate both rudders. Discussion with a number of Sydney Ferries personnel indicated that the steering wheel is rarely used as it results in sudden rudder displacement and provides poor tactile feedback to the Master.

2.47 To allow switching between Joystick and Wheel steering, a Joystick – Wheel switch is installed at the centre control station. See Figure 5.

2.48 Also installed at the centre control station is an Emergency Steering Switch. This switch when selected to port or starboard isolates a portion of the steering system hydraulic piping.

2.49 Pressurised hydraulic fluid is provided by one of two engine driven hydraulic pumps. The engine that is started first provides the ‘in service’ pump, while the second engine to be started provides the ‘stand by’ pump. In the event that the ‘in service’ pump loses pressure, the ‘stand by’ pump will commence supply of pressurised hydraulic fluid to the Hydraulic Valve Assembly. Depending on the mode of steering that is selected, the Hydraulic Valve Assembly directs fluid to one or both rudder actuators. See Figure 6 for a simplified schematic of the rudder control system.

2.50 Joystick steering is the primary steering method and is effected by any one of three joysticks located at the wing control stations and centre control station. The joysticks are active at all times when the vessel is in operation, provided that the Joystick – Wheel switch is in the Joystick position. Movement of the joystick activates solenoids within the Hydraulic Valve Assembly, resulting in movement of the port and starboard rudders.

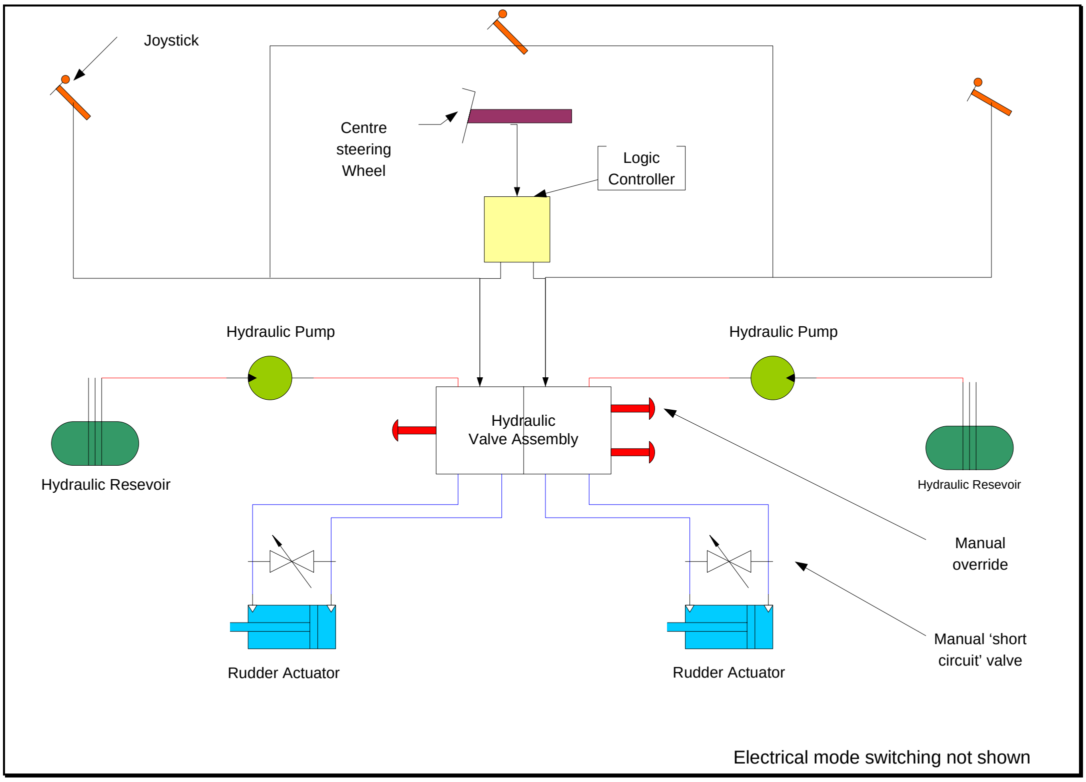

Figure 6 – Simplified rudder system schematic

2.51 Wheel steering is activated when the Joystick – Wheel switch is placed in the Wheel position. Wheel steering is an optional method of steering the vessel and was not intended to fulfil the role of an auxiliary steering system or to ensure the Supercat class of vessel complies with the Det Norske Veritas standards. Steering using this system is effected from the steering wheel at the centre control station. The wheel operates a potentiometer that provides an electrical input to a Programmable Logic Controller. The Programmable Logic Controller provides electrical signals to activate solenoids on the Hydraulic Valve Assembly, resulting in movement of the port and starboard rudders.

2.52 Emergency steering facilities exist for two types of failure; hydraulic or electrical. Hydraulic failure is applicable when the integrity of one hydraulic system fails, whereas electrical failure is used when the electrical power is not being supplied to the steering system.

2.53 In the event of a hydraulic failure, the applicable hydraulic system may be isolated by moving the Emergency Steering Switch to the Port or Starboard position. This action results in a large portion of hydraulic fluid piping and a rudder actuator being isolated. The Hydraulic Valve Assembly then directs pressurised hydraulic fluid to the remaining rudder.

2.54 In the event of an electrical failure, the Engineer may be positioned at the Hydraulic Valve Assembly located within the port hull. After establishing communication with the Master, the Engineer, using the manual override facility on the Hydraulic Valve Assembly, may select a rudder and the rudder direction. This facility results in the actuation of one rudder only. This steering configuration is intended to allow the vessel to ‘limp’ to a suitable berthing facility.

2.55 OTSI witnessed sea trials that were conducted after the accident but prior to the vessel resuming normal services. These trials identified that rudders fitted to the Supercat class regularly creep out of alignment. The long standing nature of this problem was confirmed by comments from Sydney Ferries staff and a review of maintenance records. To correct rudder misalignment, the Emergency Steering (hydraulic failure) configuration is frequently used.

2.56 Also identified during the above trials was that when the Emergency Steering (hydraulic failure) mode of the steering system was used, the isolated rudder would lock in the position it was in at the time the Emergency Steering switch was activated. Further testing during sea trials proved that a rudder isolated, when fully displaced, would remain in the fully displaced position. This characteristic reduced the effectiveness of the remaining operational rudder.

2.57 The Vessel Operations Manual Supercat Class, section 3.2 states that when emergency steering is selected an automatic short circuit valve will open, allowing oil to flow from one side of the rudder actuator to the other, resulting in the isolated rudder following the operational rudder.

2.58 A manually operated valve is located at each rudder actuator, to ‘short circuit’ the hydraulic flow from one side of the actuator to the other. This short circuit allows the rudder to follow the prevailing water flow, thus reducing drag.

2.59 Despite the contents of the Supercat Operations Manual described in 2.57 above, inspection of the *Louise Sauvage* and review of the steering system technical drawings could not identify an automatic short circuit valve being fitted to the Supercat class of vessel.

Steering Monitoring Systems

2.60 The Supercat class of vessel is fitted with a Monitoring, Alarm and Control System (MAX). The MAX system monitors several vessel parameters including hydraulic pressure and electrical power supply to the steering system. See Figure 7.

2.61 The MAX system also has the capability to provide data recording for up to one week of vessel operations. Hard copy of the recorded data was provided by Sydney Ferries and was found to contain a number of recordings. The recordings were unable to be reliably interpreted due to the high degree of variability of vessel parameters. The data recording feature of the MAX system was further tested during subsequent sea trials and information retrieved from the system was found to be sporadic and inconclusive.

2.62 Due to the Original Equipment Manufacturer of the MAX system no longer trading, combined with Sydney Ferries not holding the required intellectual property for the MAX system, the investigation was unable to conclude if the unreliable recording was due to a limitation of the MAX system's design.

2.63 In addition to the MAX system, a separate Steering System Alarm Panel is located on the bridge. This alarm system monitors hydraulic pressure, hydraulic fluid levels and electrical power supplies to the steering system. This panel provide an aural and visual warning to the crew in the event of a malfunction.

MAX Bridge Display

Steering System Alarm Panel

Figure 7 – Steering Monitoring Systems

Emergency Announcements

2.64 The Supercat class of vessel is fitted with a Passenger Address system for making manual passenger announcements. A Safety and Information Messaging System is also provided for making automatic boarding, disembarking and emergency messages to passengers.

2.65 Controls for both systems are located above the centre control station.

2.66 The alert for an impending incident is:

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

2.67 Following an incident, the following message is to be broadcast:

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

2.68 The Safety and Information Messaging System was not used to alert passengers of the impending danger; rather manual announcements were made. These announcements told the passengers to brace themselves as the vessel was about to collide with the wharf.

2.69 Investigations into other recent occurrences involving Sydney Ferries vessels also noted that automatic passenger announcements were not used to alert passengers of impending danger.

Organisations

Sydney Ferries

2.70 Sydney Ferries is defined as a State Owned Corporation by the *State Owned Corporations Act 1989*.

2.71 The objectives of Sydney Ferries are defined by the *Transport Administration Act 1988* and include the delivery of safe and reliable Sydney ferry services in an efficient, effective and financially responsible manner.

2.72 Section 53D of the *Passenger Transport Act 1990*, requires persons involved in public passenger services[3] by means of a ferry, to develop and implement a Safety Management System by 1 January 2005.

2.73 Sydney Ferries commenced implementation of an integrated Quality, Safety & Environmental management system on 1 July 2002. This system is consistent with the International Standard for quality management systems ISO 9001:2000 and the International Safety Management (ISM) code.

2.74 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. Level three documents include the:

- Fleet Instruction Manual (FIM)
- Vessel Operations Manual Supercat Class (VOMSC)

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[3] The *Passenger Transport Act 1990* defines a public passenger service as the carriage of passengers for a fare or other consideration by means of a vessel within any New South Wales waterway.

- Maintenance Management Instructions Manual (MMIM)

2.75 Section 2.6 of the Fleet Instruction Manual provides instructions on vessel manoeuvring. This section of the manual outlines the requirements for the vessel's Master to plan the approach to wharves considering matters such as weather conditions, traffic conditions and vessel handling characteristics.

2.76 Section 2.6 continues to require the Master to develop and communicate contingency plans prior to approaching a wharf. Examples of possible contingency plans are detailed within this section of the manual and include use of emergency steering according to the Vessel Operations Manual. The Master is to ensure that appropriate personnel are stationed to implement contingency plans.

2.77 Sydney Ferries requires all Masters, Engineers and General Purpose Hands to hold a type rating before being permitted to operate on a particular class of vessel.

2.78 Training toward a type rating can only proceed once a prospective crew member has completed general induction and job specific training. The content of the type rating training includes the Vessel Operations Manual and a practical assessment.

2.79 A type rating for Masters and Engineers is valid for a 12 month period. At the end of this 12 month period the type rating may be revalidated if the crew member has been employed on the applicable class of vessel for 24 shifts within the previous 12 months and at least six of those shifts have been completed within the previous three months. In the event that the Master or Engineer is unable to meet these criteria, retraining is provided.

2.80 Separate to the Type Rating system, is the requirement for crew to perform regular drills. These drills provide scenario based rehearsals of the procedures associated with the following events:

- Unlawful Act
- Bomb Threat
- Explosion
- Fire
- Anchoring
- Person overboard
- Flooding
- Person injured
- Abandon ship
- Grounding

2.81 While the drills program is part of the overall competency management regime for operational crew the content of the drills program is focused on incident management, rather than incident prevention.

2.82 Bridge Resource Management is consistent with contemporary safety practices which acknowledge that a well performing team is more effective at identifying and treating operational errors. At the time of this incident, Sydney Ferries had commenced a program to introduce Bridge Resource Management to their operations. As a part of this process, Masters had received Bridge Resource Management training. This training had not extended to other crew members or shore based operational staff.

2.83 Maintenance requirements of the Supercat class of vessel are detailed in the Technical Maintenance Plan.

2.84 The Technical Maintenance Plan was first issued in July 2002 and details the maintenance tasks that need to be performed on Supercat vessels, and the frequency of those tasks.

2.85 The Technical Maintenance Plan requires the emergency steering to be tested prior to vessel start up. The Vessel Operations Manual Supercat Class requires testing of the joystick and wheel steering as a part of the start up checklist. These checks were performed prior to the vessel commencing operations on the day of the accident.

2.86 The risk management system employed by Sydney Ferries does not articulate identified risks and controls in a cohesive and cross-functional manner such as a risk register or similar document.

NSW Maritime Authority

2.87 The NSW Maritime Authority's predecessor, the Waterways Authority, was created on 1 July 1995 under the *Ports Corporatisation and Waterways Management Act 1995.* The NSW Maritime Authority was established on 1 September 2004 and performs its functions under the authority of a number of Acts including the *Marine Safety Act 1998* and the *Commercial Vessels Act 1979*.

2.88 The NSW Maritime Authority is one of a number of state based maritime regulators within Australia. In an effort to provide for national consistency, the Uniform Shipping Laws Code (USL Code) has been established. This code provides generic standards for maritime safety.

2.89 Within NSW the relevant portions of the USL Code are enacted by the *Commercial Vessels Act 1979* and supporting Regulations.

2.90 The *Commercial Vessel (Certificates of Competency and Safety Manning) Regulation 1986* provides for the NSW Maritime Authority to issue Certificates of Competency for Masters, Marine Engine Drivers and General Purpose Hands.

2.91 To acquire a Certificate of Competency an applicant must have completed a recognised training program, have achieved a defined level of practical experience, completed a medical examination and have passed an examination from the NSW Maritime Authority.

2.92 The NSW Maritime Authority may also revalidate, audit and take compliance related action against safety personnel such as Masters and Engineers.

2.93 The *Commercial Vessel (Permits) Regulation 1986* provides for the NSW Maritime Authority to issue vessel permits in the form of Certificates of Survey.

2.94 For a Certificate of Survey to be issued, the vessel is assessed in accordance with the USL Code or the standards issued by a classification society, such as Det Norske Veritas.

2.95 In general terms, when a vessel is being assessed against a Classification Society Standard, the survey of the vessel is broken down into three portions –

Hull, Machinery and Safety Equipment. In the case of the Supercat, the NSW Maritime Authority and Det Norske Veritas agreed on the areas of responsibility each organisation would fulfil in certifying the Supercat. Resulting from this agreement, the NSW Maritime Authority accepted responsibility for Safety Equipment and the performance of a Failure Mode and Effect Analysis of the Supercat's directional control system.

2.96 As the minimum standard within the USL Code had no specific requirement to perform a Failure Mode and Effect Analysis of the directional control system, and based on experience with other catamarans operating in NSW, the NSW Maritime Authority deemed that the analysis was not required.

2.97 Det Norske Veritas issued a construction certificate as a statement that the Supercat class of vessel met the design standard. The NSW Maritime Authority accepted this construction certificate as a certification for all aspects of the vessel's hull and machinery meeting the Det Norske Veritas requirements.

2.98 Periodic audit and revalidation of vessels is performed when a Certificate of Survey is renewed. In addition, the NSW Maritime Authority may institute compliance regimes in the form of deficiency notices, or suspension or cancellation of a Certificate of Survey.

2.99 The NSW Maritime Authority and the classification society usually perform survey inspections concurrently.

2.100 The *Louise Sauvage* was issued with a Certificate of Survey on 5 May 2003. The Certificate of Survey expired on 23 March 2004, 51 days before the collision. However, as a matter of policy the NSW Maritime Authority will not seek to immediately remove a vessel from service upon expiry of the Certificate of Survey, unless there is an immediate safety concern. The subsequent Certificate of Survey was issued on 21 June 2004.

2.101 In 2001, the Minister for Transport directed that the NSW Maritime Authority's predecessor, the Waterways Authority, conduct an independent review into Sydney Ferries following four incidents involving Sydney Ferries vessels. This report was titled 'Independent Review of the Operations of Sydney Ferries including a Report on the Technical Review of the JetCat Class of Ferries' (herein referred to as the Taylor Report). It recommended to Sydney Ferries:

- *"A comprehensive safety management plan should be developed to address Sydney Ferries' full duty of care to passengers, staff and the public. This plan should bring together safety responsibilities under both maritime and OHS legislation."*
- *"Management should ensure that a comprehensive hazard management program is in place throughout the organisation and supported by a comprehensive inspection and audit regime."*
- *"A training and development strategy should be developed, implemented and maintained … it should encompass the type rating approach currently being developed for the Supercat vessels. It should be used as the basis for a structured training and assessment process to ensure that all crews on every vessel are given the opportunity to gain the required skills and experience and can then demonstrate their on-going competency to operate the vessel effectively."*

- *"Continuous competency assessment and upgrading should be a key component of the training and development strategy."*

2.102 Legislative mechanisms within the *Passenger Transport Act 1990* for the regulation of maritime organisations were amended on 1 January 2004. This amendment requires ferry operators to have implemented a Safety Management System by 1 January 2005. The NSW Maritime Authority may also direct a ferry operator to make changes to their Safety Management Systems. This power is further supported by a ferry operator being guilty of an offence if they have not implemented a Safety Management System or complied with a direction from the NSW Maritime Authority. To support these revised legislative arrangements, the NSW Maritime Authority implemented an audit program of ferry operators in January 2005.

Det Norske Veritas

2.103 A classification society is an entity that promulgates international standards for vessel design, approves vessel design and performs survey inspections to ensure that a vessel meets its intended design standards.

2.104 Classification societies are regulated by the International Association of Classification Societies.

2.105 As an approved classification society, Det Norske Veritas issued a Classification Certificate on 9 October 2000 stating the hull and machinery, including the steering system, met the applicable rule requirements. Excluded from these requirements was the need to perform a Failure Mode and Effect Analysis, as this task had been included in the NSW Maritime Authority's scope of work.

2.106 To achieve compliance with the applicable requirements, joystick steering was identified as the primary steering system. To meet the intent of the design standard for a vessel to have two methods of steering, Det Norske Veritas had assumed that the use of differential engine thrust would fulfil the role of the alternate means of directional control.

2.107 During recurrent survey inspections, Det Norske Veritas have subsequently performed survey inspections of Hull and Machinery.

2.108 The survey inspection involves testing the steering system during sea trials. The test regime takes into account traffic levels. Due to traffic levels and the operating environment within Sydney Harbour, modest vessel manoeuvres are used to test the Emergency Steering (hydraulic failure).

PART 3. ANALYSIS

3.1 The analysis of this accident examines the events that occurred aboard the vessel, organisational factors and the regulatory environment. The outcome of this examination will identify the organisational factors and the absent or failed defences that contributed to the causes of the incident.

3.2 Trouble shooting and testing performed on the *Louise Sauvage's* steering system was unable to reproduce the reported fault. Further, data recording equipment was of little assistance in establishing the steering failure.

3.3 The investigation concluded that it was highly probable that the primary cause of the collision with the wharf at Rose Bay was the failure of the *Louise Sauvage'* steering system. This conclusion was reached because:

- After the accident, the steering system had been partially disassembled in the course of trouble shooting to determine the cause of the steering failure.
- There was a steering failure earlier that day.
- Consistent accounts by the operating and maintenance crew.

On-board factors

3.4 The timing of this steering failure was during the final approach to the Rose Bay wharf. The close proximity of the vessel to the wharf, combined with a limited manoeuvring area, increased the need for timely activation of alternate steering controls. The timeliness of initiating avoiding action was limited by the Master being stationed away from any alternate means of steering and the need for the Engineer to request and confirm commands from the Master regarding the operation of the Emergency Steering system.

3.5 The need for the Engineer to request and confirm instructions from the Master is indicative of a contingency plan not being in existence prior to the approach to the Rose Bay wharf. The requirement to develop and communicate a contingency plan prior to the approach to a berthing facility is contained in the Fleet Instruction Manual.

3.6 In terms of human error, research has shown that routine violation[4] is common and two factors appear to be important in shaping habitual violations, namely:

- The natural human tendency to take the path of least effort, and
- A relatively indifferent environment, i.e., one that rarely punishes violation or records observance.

3.7 Everyday observation shows that if the quickest and most convenient path between two task-related points involves transgressing an apparently trivial and rarely-sanctioned safety procedure, then it will be violated routinely by the operators of the system[5]. The translation of contingency plans into daily operations could not be expected due to the following factors:

[4] Routine Violation denotes a deliberate deviation from a safe operating practices where the breach of procedure has become implicitly accepted, as a normal activity.
[5] *Human Error*, James Reason, Cambridge University Press, 1999, Page 196.

- High frequency of berthing operations.
- Absence of periodic competency assessments, due to the automatic revalidation provisions of Type Ratings.
- Absence of consolidated pre-berthing procedures.
- Absence of contingency plan development and communication from the start-up checklist.

3.8 The initiation of steering inputs using the Emergency Steering (hydraulic failure) system was problematic. It was identified subsequent to the accident that the Emergency Steering switch isolates a portion of hydraulic piping and locks the isolated rudder into a fixed position. This may have rendered the steering less effective because the isolated rudder could be acting against the operational rudder.

3.9 The options available to maintain directional control of the vessel were to use differential propulsion or use the steering wheel. Instead the Emergency Steering (hydraulic failure) steering mode was used. It is understandable that the crew would have instinctively considered using this steering mode in these circumstances due to:

- Crews being very familiar with the Emergency Steering switch, due to the need to realign rudders that have crept out of alignment.
- Erroneous information contained within the Vessel Operations Manual Supercat Class, stating that an automatic short-circuit valve will open allowing the isolated rudder to follow the prevailing water flow.
- Crew being trained on the content of the Vessel Operations Manual Supercat Class.

3.10 The defences to treat the impact of a steering failure were procedural and revolved around a contingency plan being in existence. Standard operating procedures in the form of checklists did not prompt Masters to ensure that contingency plans were developed and communicated before performing a berthing manoeuvre or commencing daily operations. In addition, regular competency checking on the general operational performance of crew had been bypassed due to the automatic revalidation of Type Ratings.

3.11 A final layer of defence may have been added if Crew Resource Management had been incorporated into the Sydney Ferries operation. Had this been the case, all crew would have been encouraged and expected to challenge a Master who had not developed and communicated a contingency plan for a steering failure.

Organisational factors

Design

3.12 Due to the need for the Master to be stationed at a wing control station to carry out berthing manoeuvres, he was placed in a position where the only means immediately available to him to steer the vessel was the use of the propulsion system. However, procedures contained in the Vessel Operations Manual Supercat Class guided the Master to use the Emergency Steering. As a result the Master became reliant on other crew members to initiate immediate corrective action, using other methods of steering, in the event of a steering system failure.

3.13 Compounding the reliance on other crew members to initiate immediate steering system inputs, was the limited manoeuvring space that was available at the Rose Bay wharf, along with a steering isolation function that was titled, and portrayed as, an Emergency Steering function.

3.14 In the instance of the Supercat class of vessel, the design standard in the form of Det Norske Veritas classification standards considered the use of the propulsion system as a means of auxiliary steering. The communication of this fact and translation into operational procedures and training programs would normally be initiated through the performance of a Failure Mode and Effect Analysis.

3.15 Due to the agreed scope of work between Det Norske Veritas and the NSW Maritime Authority, the NSW Maritime Authority carried responsibility for the performance of the Failure Mode and Effect Analysis. However, based on previous experience with catamarans operating in NSW and the USL Code not requiring such an analysis, the NSW Maritime Authority determined that it was not required.

3.16 This decision may have appeared reasonable in 1999. However, due to the subsequent proliferation of risk management practices since then, it would not represent best practice if a similar decision was made in 2005 without the support of a rigorous safety assessment.

Training

3.17 The ability of the crew to manage a steering failure in this circumstance was limited by the implementation of timely and appropriate action.

3.18 The timeliness of implementing corrective action was limited by the absence of a contingency plan. Central to the avoidance of error, trapping errors and mitigating the consequences of errors is the inculcation of the principles of contemporary Crew Resource Management. Refer to Annex A for an overview of contemporary Crew Resource Management.

3.19 Sydney Ferries had provided training to Masters on the principles of Bridge Resource Management[6]. However, this training had not been extended to all vessel and shore based operational staff.

3.20 A key element of trapping operational errors is a common understanding between all crew members of the actions that will be implemented once an error or malfunction has taken place. An operating crew that practices the concepts of Crew Resource Management would have been encouraged and expected to challenge a Master who had not developed and communicated a contingency plan.

3.21 As a result of the ability for Masters and Engineers to automatically revalidate their Type Rating and notwithstanding the periodic conduct of emergency drills, Sydney Ferries did not perform a periodic assessment of the general crew competence and operational practices. Ongoing assessments of general

[6] Bridge Resource Management is a predecessor to contemporary Crew Resource Management.

competence would have provided Sydney Ferries with the opportunity to reinforce the need to develop and communicate contingency plans along with the principles of Crew Resource Management.

3.22 The ability of the crew to implement appropriate corrective action was also limited by the misleading training information provided by the Vessel Operations Manual Supercat Class. This manual provided information to the crew that when the Emergency Steering Switch is selected to port or starboard an automatic 'short-circuit' valve would operate allowing the isolated rudder to follow the prevailing water flow. As identified during the sea trial referenced at 2.55 and 2.56 above and following a review of technical data, activation of this switch will lock the isolated rudder into a fixed position.

3.23 The Taylor Report identified at 2.101 above, recommended to Sydney Ferries: *"A training and development strategy should be developed, implemented and maintained … it should encompass the type rating approach currently being developed for the Supercat vessels. It should be used as the basis for a structured training and assessment process to ensure that all crews on every vessel are given the opportunity to gain the required skills and experience and can then demonstrate their on-going competency to operate the vessel effectively."* and *"Continuous competency assessment and upgrading should be a key component of the training and development strategy."*

3.24 In light of the above, it is evident that Sydney Ferries have retained its traditional Type Rating system. The Type Rating system allowed for automatic revalidation and has not been expanded to capture upgraded skills such as Crew Resource Management in the assessment regime. It is therefore evident that Sydney Ferries have not fully implemented the above recommendation.

Procedures

3.25 The Fleet Instruction Manual contains the procedures for the development and implementation of a contingency plan. This procedure was found to be comprehensive and highlights the importance of contingency planning and crew coordination. However, prompts for crew to develop and communicate contingency plans were not provided by the checklists that support vessel operations.

3.26 The integrity of this procedure is compromised by erroneous material in the Vessel Operations Manual Supercat Class. Specifically, the procedure states that the Master should consider a number of actions including the use of the Emergency Control System according to the Vessel Operations Manual.

3.27 This procedure, in concert with the placarding within the vessel and information contained in the Vessel Operations Manual Supercat Class, has titled and portrayed the use of the Emergency Steering switch as an effective means of steering the vessel. The impact of this procedural information was to cause the crew to use ineffective corrective action when they could have used the wheel steering control at the centre control station.

Risk Management

3.28 As was identified at 3.15 and 3.16 above, a Failure Mode and Effects Analysis had not been performed on the vessel's directional control system. Such an analysis would have identified the limitations of the vessel's directional control system. Knowing the limitations of the vessel would have allowed complementary procedures and training programs to be developed.

3.29 The ongoing presence of erroneous procedural and training information, when combined with poor competency assessment practices, are indicative of a Risk Management System that is not providing an integrated perspective across the entire operation.

3.30 Notwithstanding the above, the possibility of a steering failure during approach to a wharf has been contemplated due to the Fleet Instruction Manual section 2.6, providing for the use of the Emergency Steering system as a contingency during operations.

3.31 Had a more mature risk management system been in existence, a cohesive suite of defences would have existed to ensure that:

- Contingency plans were habitually developed and communicated before approaching a wharf, or entering a critical phase of operations.
- The limitations of the vessel were known and the crew were provided with accurate training and procedural information.
- A comprehensive competency assessment and audit regime existed to monitor the effectiveness of the implemented risk treatments.

3.32 The absence of a mature risk management system allowed a lack of comprehensive hazard identification and cohesion between administrative and engineering based risk treatments.

3.33 The Taylor Report prepared by the Waterways Authority in 2001 recommended that Sydney Ferries *“Management should ensure that a comprehensive hazard management program is in place throughout the organisation and supported by a comprehensive inspection and audit regime.”*

3.34 Due to the absence of cohesion between reliable engineering and administrative risk treatments, combined with the inability of Sydney Ferries to articulate the identified hazards and risk treatments, it is apparent that Sydney Ferries have not implemented this recommendation.

Maritime regulation

3.35 The NSW Maritime Authority is the primary maritime safety regulator within NSW. To support this activity it relies on a number of nationally and internationally recognised standards. Reliance on these standards is consistent with the levels of mutual recognition that exist between the Australian States.

3.36 In the case of the Supercat class of vessel, internationally recognised standards, in the form of classification society rules, were used to articulate the technical design standard for the hull and machinery of the vessel. This included the steering system. Normally, these standards require a Failure Mode and Effect

Analysis. One of the functions of the Failure Mode and Effect Analysis would be to check the failure modes of the various steering systems and their interaction with the propulsion system. The data produced by this analysis would have provided Sydney Ferries with a foundation to develop and publish appropriate contingency plans, supported by a training program, for Masters to consider in the event of a steering failure.

3.37 The scope of the NSW Maritime Authority's activities was varied on 1 January 2004 with an amendment to the *Passenger Transport Act 1990*. Prior to this amendment, the NSW Maritime Authority regulated the maritime industry through the licensing of crew, design approval and survey inspections of vessel, and rules for navigation. With effect from 1 January 2005 the NSW Maritime Authority acquired the ability to direct changes to a ferry operator's Safety Management System.

3.38 To give effect to this expanded role, NSW Maritime has commenced independent audits of the Safety Management Systems employed by ferry operators.

3.39 The characteristics of the Safety Management System are defined by Section 53D of the *Passenger Transport Act 1990*. These provisions require ferry operators to identify any significant risk that may arise from providing a public passenger service, along with the controls that are to be employed by the operator to manage the risks and to monitor safety outcomes.

3.40 The collision of the *Louise Sauvage* at Rose Bay exemplifies the need for effective Safety Management Systems, in conjunction with risk management systems, in providing a safe transport service. Had Sydney Ferries had a risk management system in place, the risk controls that were employed would have had greater cohesion and effectiveness. Such cohesion and effectiveness could have prevented the occurrence of this incident.

Emergency Response

3.41 The actions of the crew in managing passenger disembarkation and ensuring vessel integrity were effective in containing the number of injuries and preventing the collision with the wharf escalating into a more significant event.

3.42 The Supercat class of vessel is fitted with a Safety and Information Messaging System. This system has the capacity to provide automatic emergency messages to passengers to warn them of impending danger. However, throughout this event, the automatic announcement system was not used. In its place manual announcements were made by the Engineer.

3.43 The decision to make manual announcements was positive, in that the content and tone of the automatic announcement is passive and does not fully convey the urgency of an impending collision. Conversely, the use of the automatic announcement feature would have reduced the number of tasks the crew needed to perform during a period of high workload.

PART 4. FINDINGS

4.1 In the absence of reliable data recording of vessel parameters, which would indicate otherwise, the investigation concluded that it was highly probable that the primary cause of the collision with the North wharf at Rose Bay was the failure of the *Louise Sauvage'* steering system. This conclusion was reached because:

- After the accident, the steering system had been partially disassembled in the course of trouble shooting to determine the cause of the steering failure.
- There was a steering failure earlier that day.
- Consistent accounts by the operating and maintenance crew.

4.2 Despite technical inspections and trials, it is significant that the cause of the steering failure could not be determined, nor could the failure be replicated.

4.3 The ability of the crew to manage the failure in Rose Bay was compounded by the contributory factors listed below.

Contributory factors

4.4 The tendency for rudders to creep out of alignment contributed to the habitual use of the Emergency Steering (hydraulic failure) mode to correct rudder creepage.

4.5 Training and procedural information, as contained in the Vessel Operations Manual Supercat Class, was inaccurate and did not consider the use of the differential propulsive thrust for maintaining directional control. The consequence of this inaccuracy was crew understanding that the Emergency Steering (hydraulic failure) mode provided an effective means to steer the vessel.

4.6 The Type Rating system, in concert with crew drill requirements, was not effective in providing ongoing assessments of the general operational competency of crew.

4.7 Sydney Ferries had made initial efforts to implement Crew Resource Management. However, the tenets of Crew Resource Management had not extended to all operational staff or been incorporated into all procedures and checklists.

4.8 A contingency plan was not developed and communicated by the Master prior to commencing daily operations or prior to approaching the Rose Bay wharf.

4.9 Sydney Ferries had not fully implemented all recommendations made by the Taylor Report prepared by the Waterways Authority in 2001. These recommendations related to safety plans, risk management, training and development and competency assessments.

4.10 As a Failure Mode and Effect Analysis had not been performed, the limitations of the directional control system were not well understood. This level of understanding did not provide a sound basis for the development and implementation of operational procedures and training regimes.

4.11 The NSW Maritime Authority did not have a robust safety assessment process to support an exemption from the Det Norske Veritas requirement to perform a Failure Mode and Effect Analysis of the directional control system.

Risk Management Strategies

4.12 Sydney Ferries did not have a formalised system for managing operational risk.

Emergency Response

4.13 The emergency response was well managed. However, the tone and content of the automated emergency messaging system was not adequate to convey the necessary sense of urgency to passengers during an operational emergency.

PART 5. RECOMMENDATIONS

Sydney Ferries

5.1 Resolve the inaccuracy of the Vessel Operations Supercat Class Manual in relation to the functionality of the Emergency Steering (hydraulic failure) system (refer finding 4.5).

5.2 Reassess the content, tone and utility of automatic emergency messages (refer finding 4.13).

5.3 Incorporate data recording facilities, synchronised to an accurate and reliable time base, into all vessels engaged in public passenger services. Such recording facilities as a minimum should provide a reliable recording of vessel (refer finding 4.1):

- Heading;
- Track;
- Ground speed;
- Steering inputs;
- Active control station;
- Rudder / thruster position;
- Source of hydraulic pressure to the steering system;
- Pressure of hydraulic fluid available to the steering system;
- Status of electrical power supplies to engine and directional control systems;
- Throttle position;
- Engine speed, and
- Clutch and gearbox position.

5.4 Rectify the rudder system fitted to the Supercat class of vessel to resolve the tendency of rudders to creep out of alignment (refer finding 4.4).

5.5 Modify the steering system fitted to the Supercat class of vessel to provide the Master with an immediately available, reliable and effective auxiliary steering system available at all three control stations. This modification should also retitle the Emergency Steering switch to be more reflective of its isolation function (refer finding 4.10).

5.6 Implement contemporary Crew Resource Management. Implementation of this program should be extended to all operational crew and be incorporated into all processes having an impact on maritime safety (refer findings 4.7 & 4.8).

5.7 Amend the Type Rating system to remove the ability for operational crew to automatically renew a Type Rating; rather the Type Rating should be dependent on the periodic and successful demonstration of competence (refer finding 4.6).

5.8 Develop and implement a contemporary risk management system; one that identifies operational safety hazards that emanate from vessel design and operations, the operating environment, organisational objectives and ensures a cohesive suite of reliable controls have been implemented (refer finding 4.12).

5.9 Review the recommendations made by the Taylor Report to ensure that all recommendations have been duly considered and implemented (refer finding 4.9).

NSW Maritime Authority

5.10 Conduct an audit to test Sydney Ferries' consideration and implementation of the recommendations made by the Taylor Report in 2001. Testing within the audit should examine the appropriateness of Sydney Ferries Safety Management System for the size and complexity of their operation, and translation of the Safety Management System into operational practice (refer finding 4.9).

5.11 Perform a Failure Mode and Effects Analysis of the Supercat's directional control system, to validate the Sydney Ferries response in relation to finding 4.10.

5.12 Introduce internal processes to ensure that all exemptions from safety requirements are supported by a documented equivalent safety determination (refer finding 4.11).

5.13 As the flag authority, ensure that design standards are promulgated for ferries utilised for public passenger services. These design standards should ensure that an appropriate analysis is performed to establish that two effective and independent means of steering exist. The secondary or emergency steering gear should be capable of being brought speedily into action (refer finding 4.10).

Appendix A – Contemporary Crew Resource Management

Crew Resource Management (CRM) is the effective use of all available resources to achieve safe and efficient operations. The objective of contemporary CRM training is to enhance communication, teamwork, and threat and error management competencies. Emphasis is placed on the non-technical aspects of individual and team performance, including instruction on the limitations of human performance, the nature of error, and the mitigation and management of error.

Knowledge and experience about CRM built up in recent years by the use of facilitative training techniques has led to attempts to define optimum CRM performance by the use of behavioural markers. The successful development of behavioural markers helps to define more clearly the cognitive and interpersonal skills required for good CRM and also allows for a standard approach towards assessment, feedback and further training of individual crew members.

The origin of Crew Resource Management (CRM) lies in the aviation industry, where in the early 1980's it was initially developed as "cockpit resource management" training. The principles of CRM have now been extended from the cockpit to other elements of the aviation system such as the aircraft cabin and the maintenance hangar. It is recommended training by the International Civil Aviation Organization (ICAO). Typically CRM takes the form of an initial training course followed by regular recurrent training. This is complemented by subsequent monitoring of CRM skills within the flight simulator and on the line.

Contemporary CRM focuses on the development of threat and error management competencies based on the core CRM elements of Company safety culture, standard operating procedures, and organisational factors; information acquisition and processing; situation awareness; workload management; human error and reliability; communication and co-ordination; leadership and team behaviour synergy; decision making; stress and stress management; fatigue; vigilance; cultural factors; automation, and the philosophy of the use of automation.

The aim of CRM is to reduce the frequency and severity of errors for crew. It sees human error as ubiquitous, inevitable and a valuable source of information. For CRM to be accepted as a safeguard for human limitations there must be organisational recognition of the inevitability of human error. This is a recognition that organisational policies need to reflect an acknowledgement of the limitations of human performance. This does not imply that the organisations should become more tolerant of violations or accept wilful violation of their rules and procedures.

Crew Resource Management focuses on the human component and tries to ensure that the safest and most effective people are working in the system. It recognises that culture plays a significant role in determining the response of various participants to various styles of CRM training. It is important that CRM training is tailored to fit the culture – national, organisational, vocational – of the target population. When CRM is explained with reference to the concept of human error, the goals of CRM are to:

- reduce the likelihood of error;
- trap errors before they have an operational effect; and
- mitigate the consequences of error.

Instruction in CRM has as its basis formal instruction in the limitations of human performance. This includes communicating the nature of errors and slips as well as demonstrating the negative effects of fatigue, work overload and emergencies.

Specific behavioural techniques or markers are used to enhance overall situational awareness and safety. These techniques include cross-checking and verification of communication, preparation, planning and vigilance, speaking up to express concerns and sharing a mental model of the situation. Correct application reduces the likelihood of an error occurring or trapping an error before it has operational impact. These techniques along with effective group decision making, and the recognition that they are not immune from the effects of stress, can equip crews to react effectively to those errors which may threaten the safety of operations.

The principles of crew resource management are being applied increasingly in other industry domains with workplaces where teamwork and the management of threats and errors are vital. Examples are surgical teams, maritime organizations (bridge resource management) and the rail industry.[7]

[7] M. Nendick, *Contemporary Crew Resource Management*, OTSI, 2005.