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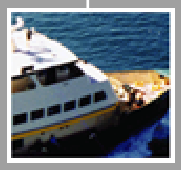


FERRY SAFETY INVESTIGATION REPORT

COLLISION OF THE MANLY FERRY *COLLAROY* NUMBER 2 WHARF, CIRCULAR QUAY

19 SEPTEMBER 2005

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OTSI File Ref: 04202

13 April 2006

Office of Transport Safety Investigations
Level 21, 201 Elizabeth Street
Sydney NSW 2000

The Office of Transport Safety Investigations (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.

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The Office of Transport Safety Investigations 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

AMSA	Australian Maritime Safety Authority
Backboards	Timber buffers comprising heavy beams set on frames supported by piles driven into the seabed, adjacent to dead end berths used by vessels securing at locations such as Circular Quay and just clear of the pedestrian concourse breastworks
Bow	Front area of vessel
BHP	Brake Horse Power. An engine power output rating distinct from Shaft Horse Power SHP
Bridge	The location from which the Master exercises control of the vessel. This location is also sometimes referred to as the “Wheelhouse”
CCTV	Closed Circuit Television equipment used for surveillance and recording
CPP	A Controllable Pitch Propeller has the thrust resulting from its constant rotation varied ahead or astern by pitch adjustment from a remote location, such as a vessel’s bridge control console
CRM	Crew Resource Management. Training designed to ensure the use of all available resources to achieve safe and efficient operations by enhancing communication, teamwork and the capacity to respond to emergencies.
Ebb	Periodic reduction of seawater level due to decreasing tidal forces
EPA	Environmental Protection Agency
Evolutions	Ferry crew training drills and procedures undertaken by SFC as programs forming part of its safety management system (SMS)
FAID	Fatigue Audit InterDyne™ is the name given to a range of fatigue risk management software, developed by InterDynamics Pty Ltd
Fendering	In this case, the medium used to reduce or absorb the force of impact caused by the collision of a ferry with the Northern ends of the wharves at Circular Quay.
FERP	Ferries Emergency Response Plan
Ferry	A vessel which carries more than 8 adult persons, as defined by the *Passenger Transport Act NSW 1990*
GPH	A General Purpose Hand, or Deckhand, is a duly qualified crewmember not engaged in navigational or engineering duties
GRN Radio	GRN is the New South Wales Government Radio Network in which channels are allocated to various government departments.

ICAM	Incident Cause Analysis Method
ISM Code	International Safety Management Code .The purpose of this Code is to provide an international standard for the safe management and operation of ships and for prevention of pollution at sea. Promulgated by the International Maritime Organisation IMO
ITSRR	The Independent Transport Safety & Reliability Regulator NSW
Knot	Unit of speed - one nautical mile per hour - about 1.85 km/h.
kW	Kilowatt
Lloyds Register	One of the international ship classification societies. Ship Classification is a system for safeguarding life, property and the environment at sea. Society approval entails verification of a vessel's criteria against a set of requirements during its design, construction and operation for purposes such as insurance
MCR	Machinery Control Room (a manned space below deck adjoining the vessel's engine room)
NSW	New South Wales
OTSI	The Office of Transport Safety Investigations
Pontoon	In this case a covered floating extension attached to the northern end of Wharf No 2 Circular Quay for ferry passenger access
PTA	*Passenger Transport Act NSW 1990*
Port	The left-hand side when facing forward on board a vessel
Public Passenger Service	The carriage of passengers for a fare or other consideration by means of a vessel within New South Wales waterways
RPM	Revolutions Per Minute of running equipment and machinery
Sheltered Waters	Ferry operational limits as defined by the NSW Maritime Authority
SOPs	Standard Operating Procedures that allow various users from a range of agencies to conduct business in a transparent manner
SMS	A safety management system managed by SFC as a series of programs forming part of its compliance with NSW Maritime Authority requirements and meeting standards contained in references such as the ISM Code
Starboard	The right-hand side when facing forward on board a vessel
Stern	Rear area of vessel
TAA	*Transport Administration Act 1988*

Taylor Report	A report commissioned by the Minister for Transport in 2001 and prepared by the then Waterways Authority, titled “Independent Review of the Operations of Sydney Ferries”
USL Code	The Uniform Shipping Laws Code is the current national maritime standard reference for various safety matters relating to vessel construction, equipment, crewing and operation
VOM	The Vessel Operations Manual is the reference for the current instructions and information issued by Sydney Ferries Corporation carried on board ferries for each class of vessel in operation
‘X-Y Lever’	Ferry propulsion control devices fitted at each navigational station console that set propeller and rudders to provide longitudinal and transverse thrust as ordered by the vessel’s master

EXECUTIVE SUMMARY

Background

The accident which is the subject of this investigation report occurred on 19 September 2005, at which time the Office of Transport Safety Investigations (OTSI) was completing an investigation into a similar accident also involving the Manly Ferry *Collaroy* that had occurred on 4 March 2005. OTSI's investigation report into the March 2005 incident was released in November 2005.

Concurrently, OTSI was investigating an accident involving the Manly Ferry *Narrabeen* which occurred on 26 May 2005. The report into that accident was released in March 2006. In response to those accidents, OTSI initiated, and continues to conduct, a Systemic investigation into the *Freshwater* Class of vessels which make up the Manly Ferry fleet.

As a result of the accident investigated in this report, and the recommendations contained in the report into the March 2005 collision, the *Collaroy* was taken out of service. OTSI has been advised by Sydney Ferries Corporation (referred to as "Sydney Ferries") that subject to the results of further risk assessment, the replacement of some components in the propulsion control system and revised crewing arrangements, *Collaroy* may be brought back into service in late April 2006.

This report reiterates a number of the findings and recommendations that were made in relation to the accident which occurred in March 2005. Sydney Ferries has initiated programs of remedial action in response to OTSI's November 2005 report, but these programs are as yet not completed.

The findings and recommendations contained in this report are designed to reinforce and expand the requirements previously specified and to inform Sydney Ferries' decision in relation to the projected reintroduction of the *Collaroy* into service.

The Accident

At 1:16pm on Monday 19 September 2005, the *Collaroy*, a *Freshwater* Class vessel operated by Sydney Ferries, was on approach to its berth at No.3 West Wharf at Circular Quay, when it deviated from its course and struck the Northern end of the pontoon at No.2 Wharf.

The *Collaroy* was not severely damaged but the pontoon and its roof sustained significant damage and required substantial repair.

None of the approximately 150 passengers or six crew onboard was injured.

Findings

In relation to those matters prescribed by the Terms of Reference as the principal lines of inquiry, OTSI finds as follows:

a. ***Causation.***

i. The collision occurred when *Collaroy* failed to respond to the Master's initial propulsion control instructions and a number of back-up and recovery measures either failed or were ineffective.

ii. The collision was initiated when an electronic component in the vessel's propulsion control system malfunctioned, for a period of about 35 seconds, rendering both the primary and back-up propulsion control systems inoperable from *Collaroy's* bridge. Approximately three minutes elapsed between the onset of the failure and the collision, during which time the Master was unable to regain propulsion control.

iii. The Master's actions to regain control were limited by his mis-interpretation of the nature of the malfunction and his lack of familiarity with an important procedure that would have allowed him to revert to another form of control that was not affected by the malfunction.

b. ***Effectiveness of the Emergency Response***.

i. When confronted with the loss of propulsion control, the Master had limited options available to him in the confines of Sydney Cove and recognising the imperative to stop, the Master decided to let go an anchor. However, the process of deploying the anchor was delayed by the combined effects of two factors:

- the requirement to physically muster the GPHs since one of the electronic means of communication normally used for such purposes did not function and the other had been left ashore, and
- the GPHs' lack of familiarity with the required procedures.

Once deployed, the anchor proved to be ineffective in halting the *Collaroy's* forward momentum.

ii. The Master could have arrested *Collaroy*'s momentum by directing the Engineer to assume control of propulsion from within the Machinery Control Room (MCR), but did not do so because he was unfamiliar with the related procedures, as was the Engineer.

iii. The difficulties in communication which arose from defective and missing equipment, and the lack of familiarity with the procedures required to revert to MCR control and to deploy the anchor, were reflective of ineffective defect reporting and management; incomplete equipment checks; inadequate training and uncoordinated Crew Resource Management.

iv. Both the Master and the Helmsman left the bridge and became involved in the actions to deploy the anchor, which meant that the bridge was unattended immediately prior to, and at the moment of, the collision.

v. The Master initiated a prolonged sounding of *Collaroy*'s whistle to alert others of his predicament, but did not activate a pre-

recorded warning message as was required by standard operating procedures.

vi. Duty personnel at Circular Quay from both Sydney Harbour Control and Sydney Ferries acted quickly and efficiently to evacuate passengers from another ferry that was berthed at an adjacent wharf as soon as the alarm was raised. They also assisted *Collaroy*'s crew to secure the vessel and cordon the area to minimise the possibility of environmental damage. They alerted other response agencies, including the NSW Maritime Authority, which responded quickly and efficiently.

vii. While the crew were promptly breath tested by the NSW Water Police for the presence of alcohol, the conduct of drug and alcohol testing by Sydney Ferries did not occur within the timeframe specified in their Drug and Alcohol Policy.

c. ***Effectiveness of Sydney Ferries' Risk Management Strategies****.*

i. *Collaroy's* propulsion control system is unique within Sydney Ferries and the risks associated with the operation of the vessel had not been fully anticipated by Sydney Ferries.

ii. Not all of *Collaroy's* crew had undergone recent emergency training and the particular contingency that occurred had not been the subject of recent training.

iii. Sydney Ferries' has an expectation that the Master and Helmsman will be present on the bridge at all times when a vessel is underway, but this was not formally articulated until after this incident.

d. ***Other Safety Matters***.

i. A number of matters identified in previous OTSI reports, viz., the fitment of data loggers to all Sydney Ferries' vessels; the

upgrading of safety backboards at Circular Quay and Manly Wharves and the upgrading of CCTV capabilities, remain unresolved but are the subject of approved planned works.

Recommendations

In order to prevent a recurrence of this type of accident, the following remedial safety actions are recommended for implementation by the organisations specified below:

a. Sydney Ferries Corporation

i. Undertake a thorough risk assessment in order to determine whether it should continue to operate the *Collaroy* in its current configuration.

ii. As long as the *Collaroy* continues to remain unique in its class, take action to ensure its uniqueness is fully understood by all personnel required to either operate or maintain the vessel.

iii. Ensure that recently introduced instructions for amended propulsion mode changeover procedures are reflected in VOMs and are being adhered to by crew.

iv. Ensure that all changes to operating instructions are underpinned by proper risk assessments; are formally advised to those who are required to implement the instructions and are the subject of appropriate training.

v. Ensure that planned maintenance inspections of safety-critical equipment, such as propulsion control electrical relays and bridge VHF and UHF communications radios, are being completed and that any reported defects are rectified in a timely manner.

vi. Review the content and delivery of emergency training, ensuring that crews are well versed in the actions required to overcome control failures.

vii. Act to reinforce Crew Resource Management throughout its organisation.

viii. Issue a formal policy requiring an appropriately qualified master and GPH to be present at all times on the bridge of *Freshwater* Class vessels during their operation.

ix. Review the utility of its extant pre-recorded emergency broadcast messages.

b. NSW Maritime Authority

i. Review the risk assessments that underpin any plan/s that Sydney Ferries might develop to return *Collaroy* to service.

ii. Monitor the actions being taken within Sydney Ferries to improve training and Crew Resource Management

PART 1 INTRODUCTION

Notification and Response

1.1 At 1:51pm on 19 September 2005, the Office of Transport Safety Investigations (OTSI) was notified by the Office of the Minister for Transport that one of Sydney Ferries' vessels, *Collaroy*, had collided with No.2 Wharf at Circular Quay at about 1:16pm.

1.2 Based on the information provided by the reporter, the Chief Investigator directed the deployment of OTSI Investigating Officers to the incident site.

Initiation of Investigation

1.3 As a result of the primary evidence collected by the OTSI Investigating Officers at the incident site, the Chief Investigator initiated a Ferry Safety Investigation in accordance with s46BA of the *Passenger Transport Act 1990.*

1.4 On 20 September, the Chief Investigator notified all Directly Involved Parties (DIP) that OTSI was investigating the collision and requested that an officer be nominated in each organisation to act as the point of contact for all inquiries made by the appointed OTSI Investigator in Charge. The Terms of Reference for the Investigation were provided to the DIPs with this notification.

Terms of Reference

1.5 The Chief Investigator established the following Terms of Reference to determine why the accident had occurred and what to do to prevent recurrence:

a. establish why the accident happened and what caused it;

b. ascertain whether this type of accident had been, or should have been, anticipated and whether there were appropriate contingency plans in place to manage the related risk/s;

c. assess the effectiveness of emergency actions that were initiated in response to the accident;

d. advise on any matters arising from the investigation that would enhance the safety of ferry operations, and

e. make recommendations to prevent, or at the very least minimise the potential for, recurrence of this type of accident.

Interim Factual Statement

1.6 An Interim Factual Statement notifying OTSI's investigation and describing the incident in terms of what had happened was published on the OTSI website on 30 September 2005.

Methodology

1.7 The methodology adopted for this investigation is based on the Incident Cause Analysis Method (ICAM) and involves the process of:

a. Collection of primary physical evidence at the incident site;

b. Collection of witness evidence;

c. Collection of documentary evidence;

d. Collection of other relevant and/or corroborating evidence, including results of technical inspections and/or test results;

e. Analysis and interpretation of evidence;

f. Determination of those factors which:

i. contributed directly to accident causation;

ii. contributed indirectly to accident causation, and

iii. are relevant safety issues but did not contribute to accident causation;

g. Establishing the cause of the accident, and

h. Determining recommendations to improve safety and prevent recurrence.

1.8 The underlying feature of the methodology is the Just Culture principle with its focus on safety outcomes rather than the attribution of blame or liability.

Consultation

1.9 In keeping with the Just Culture principle, on 17 March 2006 the Draft Report was reviewed by representatives of Sydney Ferries and NSW Maritime in order to verify the factual information; scrutinise the analysis, findings and recommendations, and provide any advice that would contribute to the accuracy and completeness of the Investigation Report.

1.10 The Draft Report was amended where necessary to reflect those matters that were agreed, and subsequently on 28 March 2006, a copy of the Amended Draft Report was forwarded to the Chief Executives of Sydney Ferries Corporation, the NSW Maritime Authority and the Independent Transport Safety and Reliability Regulator (ITSRR) as Directly Involved Parties (DIP) for any additional comments before compilation of the Final report.

1.11 The Chief Investigator considered all representations made by DIPs and where appropriate, reflected their advice in this Final Report. On 10 April 2006, the Chief Investigator informed DIPs which matters from their submissions had been incorporated in this Final Report and where any proposal was not included, the reasons for not doing so.

Investigation Report

1.12 This report describes the collision which occurred at No 2 Wharf at Circular Quay on 19 September 2005 and explains why it occurred. The recommendations that are made are designed to contribute to the maintenance of safe ferry operations and to minimise the potential for a recurrence of this type of accident.

PART 2 FACTUAL INFORMATION

Before the Collision

2.1 At 12:45pm on 19 September 2005, the Manly ferry *Collaroy,* a *Freshwater* class vessel operated by Sydney Ferries, departed Manly on one of its daily scheduled services to Circular Quay. *Collaroy* was carrying approximately 150 passengers and had been operating without incident since 6:30am that day. Its crew consisted of a master, an engineer and four general-purpose deckhands (GPHs).

Collision Sequence

2.2 *Collaroy's* approximate track into Sydney Cove is as indicated in *Figure 1*

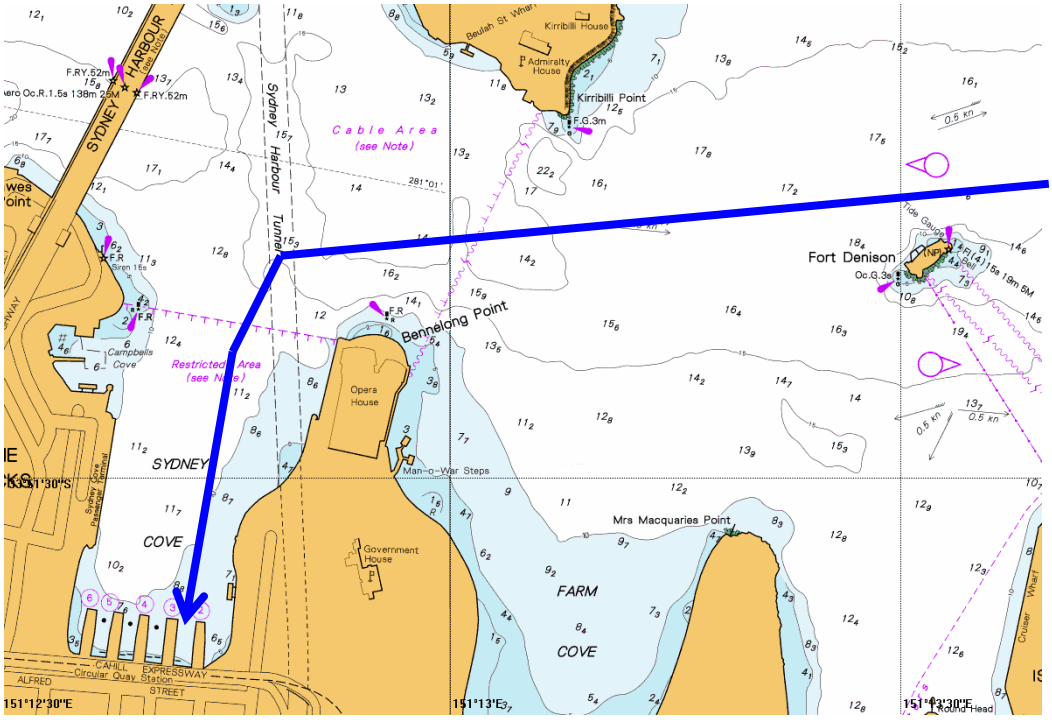

Figure 1 Extract from Chart Aus 202 showing *Collaroy's* approximate track

2.3 Data from *Collaroy*'s onboard Honeywell Monitoring System and a surveillance camera ashore, confirm that the vessel entered the Cove at below the maximum permitted limit of eight knots (14.8km/hr). The

Master reported switching from **Sailing** mode to **Manoeuvring** mode, in readiness for berthing at No.3 West Wharf, as he passed the Opera House. However, there was no corresponding indication on his instrumentation to confirm that he was in **Manoeuvring** mode. The Master also noted that the illuminated power percentage setting readout on his console went blank and that a channel indicator on one of his radios was not functioning. Shortly afterwards, a recently installed anchor alarm also appeared to fail to respond when the Master attempted to activate it, and he concluded that there had been a significant power failure. The Master contacted the Engineer, located in the Machinery Control Room (MCR), who advised that he too had noted indications on the MCR instrument panel that were consistent with a control failure having occurred at the bridge console. The Engineer advised the Master to reset the main control system by **Keying Out** and then **Keying** back **In**, which he did, but to no effect. The Master then switched to **Back-up** propulsion control, again to no effect.

2.4 Confronted with a loss of control and concerned by the presence of passengers embarking on Sydney Ferries' *Golden Grove* at No 2 West Wharf, the Master sought to arrest *Collaroy's* momentum by letting go an anchor. However, the Master had difficulty in communicating with the GPHs to alert them to this requirement and consequently was concerned by the amount of time it was taking to deploy the anchor. Notwithstanding the absence of the Helmsman, who had left the bridge to muster the GPHs, the Master left the bridge to personally supervise this procedure, but before doing so sounded a warning signal on *Collaroy's* whistle alerting Sydney Ferries' staff ashore to the emergency. The Master did not return to the bridge until after the collision.

2.5 The vessel's anchors are located at the rear of the ferry and a range of preparatory actions are required before they can be released. After some delay, the port anchor at the stern was let out but it had very limited effect as it trailed, rather than held, and *Collaroy's* bow subsequently struck the Northern edge of the pontoon at No.2 Wharf with sufficient force to cause substantial damage to its structure, as indicated in *Figure 2*. Upon returning to the bridge, the Master found that the controls were responding normally and was able to secure *Collaroy* alongside No.3 East Wharf.

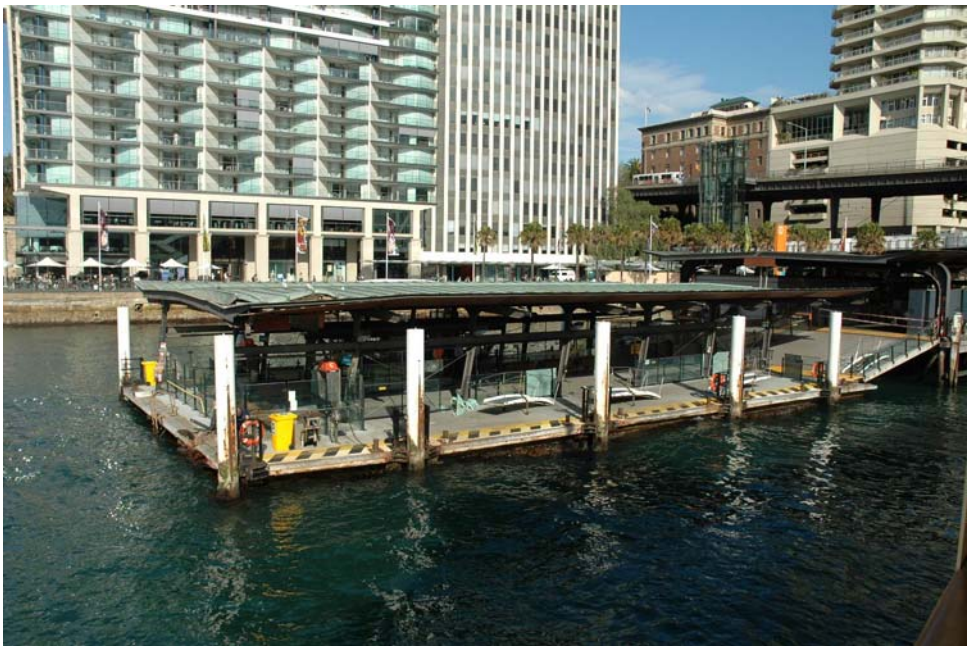

Figure 2 Damage to the Pontoon and Roof at No.2 Wharf

Collision Location

2.6 Circular Quay is Sydney's busiest wharf facility. It is sited at the Southern end of Sydney Cove and comprises five, 78.5 metre long, pile-supported piers and pontoon wharves, aligned North-South, providing both access and egress to ferry and charter vessel passengers. More than ten vessel movements may occur in Sydney Cove concurrently and in recent years, there has been an increase in both traffic frequency and the size of vessels operating therein. Significantly, Circular Quay is less than 300 metres wide at its Southern end, imposing manoeuvre limitations in response to emergency

situations. The point of impact of the collision is shown in diagrammatic representation at *Figure 3*.

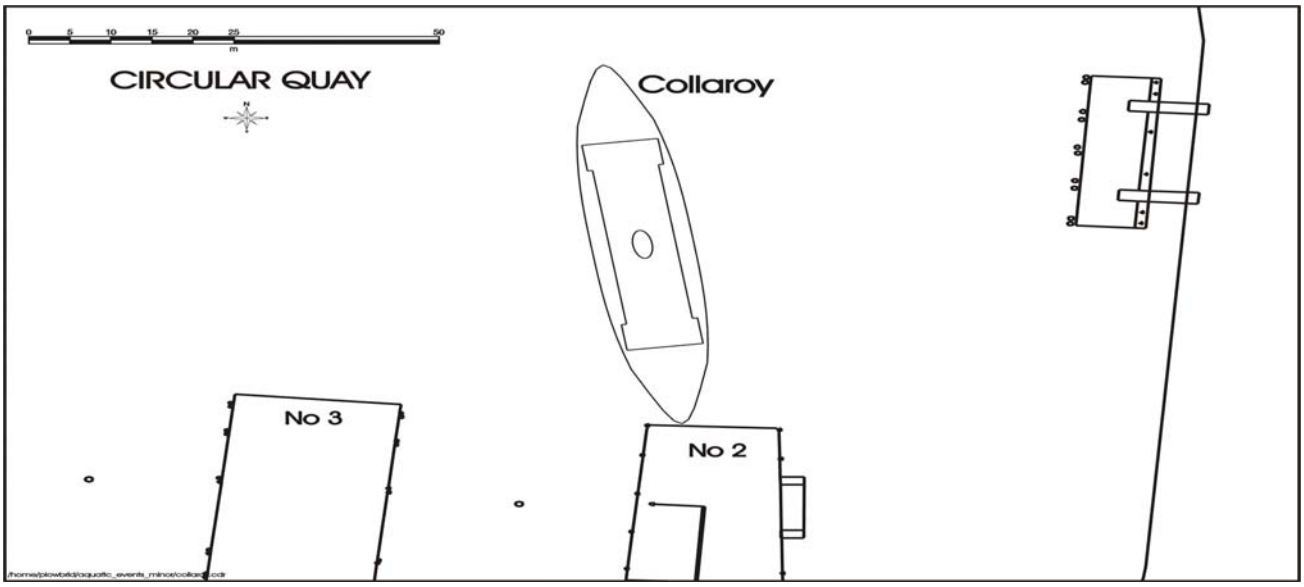

Figure 3 Collision Point of Impact at No 2 Wharf

Meteorological and Environmental Information

2.7 The height of tide was about 0.5 metre at the time of the incident, with low water predicted at 2:58pm. The Master advised that he enjoyed unrestricted visibility and that his handling of the *Collaroy* was unaffected by any current or wind during its transit within Sydney Cove.

Emergency Response

2.8 Immediately after berthing, *Collaroy*'s crew, helped by Sydney Ferries' duty personnel at Circular Quay, assisted passengers to disembark and checked on their welfare before commencing a series of inspections to establish the extent of damage to the vessel and the pontoon. Sydney Ferries also informed a number of emergency services and agencies of the incident, but omitted to contact OTSI until some time after it had occurred.

Damage

2.9 *Collaroy* sustained minor distortion to its skin plating in the bow area above the water line. However, Sydney Ferries' operations were affected for a number of weeks while No.2 Wharf was being repaired. A subsequent decision to withdraw *Collaroy* from service, which remains in force at the time of publishing this report, has had a more significant impact on Manly ferry service operations.

Injuries

2.10 There were no reported injuries as a result of the collision.

Vessel Information

2.11 *Collaroy* is one of four *Freshwater* Class vessels operated by Sydney Ferries. It is 69.5 metres long and 13 metres in beam. *Collaroy* has a 'double-ended' configuration, with a centre-line propeller and rudder fitted at both ends, allowing the ferry to be operated on return trips from Sydney to Manly without having to turn around. *Collaroy* is propelled by two 2238kW (3000BHP) Daihatsu marine diesel engines, only one of which is normally in use during routine service. Its normal service speed is 14 knots; it has a displacement of 1140 tonnes and has a maximum carrying capacity of 1100 passengers. A schematic of the vessel is shown at *Figure 4.*

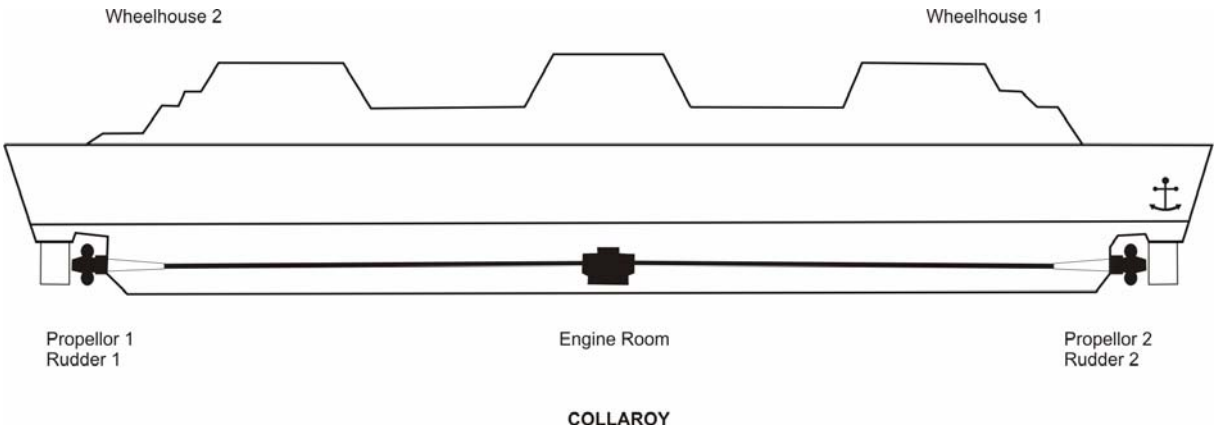

Figure 4. Diagrammatic Representation of the *Collaroy*

2.12 *Collaroy* is the last of the four *Freshwater* Class vessels acquired by Sydney Ferries and came into service in 1988. The other three vessels in the Class, *Freshwater, Queenscliff* and *Narrabeen* entered service in the period 1982-1984 and are fitted with a *Lips* propulsion control system, manufactured in Holland. *Collaroy* is fitted with a *Kamome* propulsion control system, manufactured in Japan, and at the time, this system was considered to be superior to the *Lips* system. However, the *Lips* system was progressively upgraded commencing in the late 1990's, in response to the manufacturer's unwillingness to continue to support what it considered to be a dated system. However, Sydney Ferries decided to retain the *Kamome* system, as fitted to the *Collaroy*, because the system was considered to be functioning efficiently and its manufacturer was prepared to continue to support the system. The projected cost and time required to effect an upgrade or replacement of the *Kamome* system were also considerations in the decision to retain it.[1] The upgraded *Lips* system is now considered by Masters and Engineers to be superior to the *Kamome* system and *Collaroy* remains unique within its Class.

2.13 *Collaroy's* Master controls the vessel from one of two identical enclosed bridges on the vessel's superstructure. In addition, the Master can also control the vessel from external bridge wing control stations, on both the starboard and port sides, at both ends. The centre console station is shown at *Figure 5.* Control can also be exercised by the engineer in the MCR, as indicated in *Figure 6*.

[1] The projected cost was approximately $1m and *Collaroy* would have been required to have been off-line for a minimum of six months. At the time of writing this report, Sydney Ferries was awaiting a consultant's report before determining whether it will now upgrade or replace the *Kamome* system.

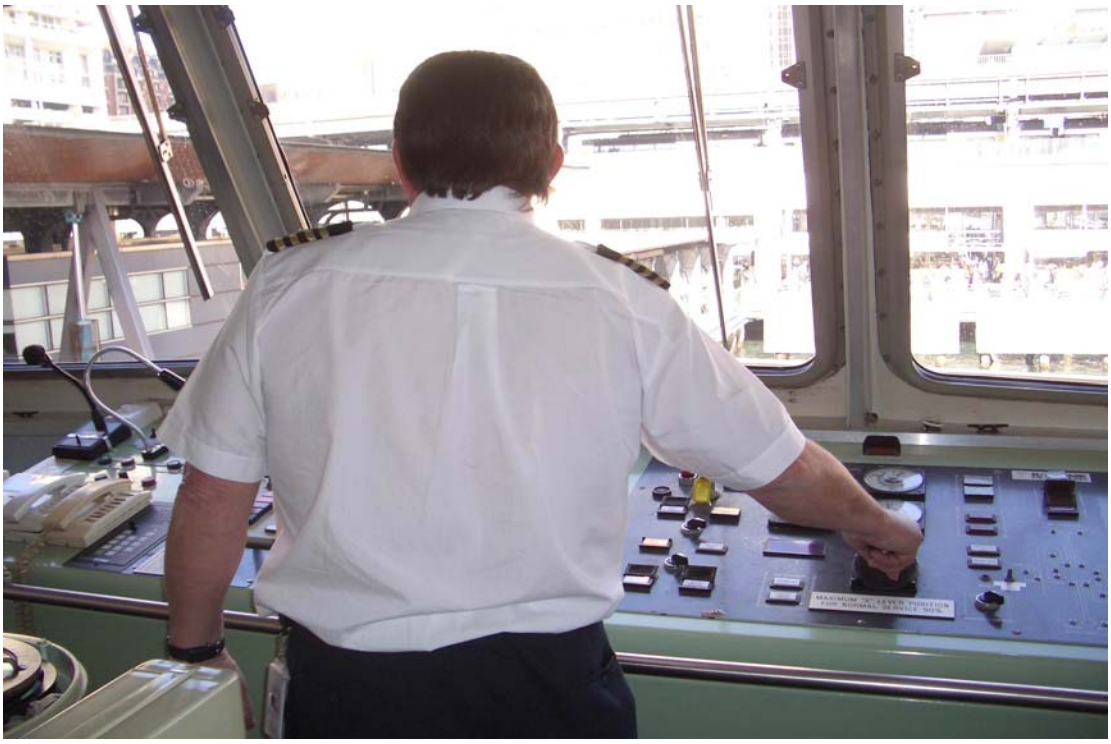

Figure 5 A master at the Centre Control Console

Figure 6 *Collaroy's* Machinery Control Room (MCR) Mimic Panel and Data Logger Console

Crew Information

2.14 Each member of the *Collaroy's* crew was appropriately qualified and held the relevant certificates of competency. As is the usual case, the master was the only person on board holding a Uniform Shipping Laws Code (USL) Master Class Four qualification, entitling him to exercise navigational command of the vessel. As required under the *Ports Corporatisation and Waterways Management Act 1995* for masters of large vessels, *Collaroy's* Master held a valid local knowledge certificate.

2.15 Collaroy's Engineer held an AMSA (Australian Maritime Safety Authority) qualification as a Marine Engineer Class 1 which exceeds the minimum requirement for an Engineer certificate of competency of USL Class Two or higher.

2.16 GPHs or 'deckhands' do not require a marine certificate of competency, but must qualify for a Pre-Sea Safety Certificate in order to obtain an endorsement issued by the NSW Maritime Authority. *Collaroy's* deckhands had been appropriately endorsed.

Medical and Toxicology Information

2.17 NSW Water Police breath-tested all crew members and all returned negative results. However, there was a delay, addressed in Part 3 of this report, in the conduct of those tests prescribed by Sydney Ferries' Drug and Alcohol Policy.

PART 3 ANALYSIS

Propulsion Control System

3.1 There are two propulsion modes on *Freshwater* Class vessels, ***Sailing*** and **Manoeuvring** modes. In **Sailing** mode, which is used in open waters, the vessel is propelled conventionally by way of a stern propeller and steered by a rudder. **Manoeuvring** mode is used to control movement in more confined areas, e.g., when berthing. It involves the use of a joystick-like control lever, known as the X-Y lever, which converts fore, aft and transverse thrust commands into electrical signals, via potentiometers. The additional longitudinal and transverse thrust needed to slow the ferry and move it sideways into position is provided by the propeller and rudder fitted at the bow. This provides for increased manoeuvrability and removes the need to turn such a large passenger ferry around in a confined space after each passage.

3.2 Significantly, forward or astern propulsion in **Manoeuvring** mode is effected via adjustment of the controllable pitch of propeller blades, rather than by the more traditional means which change the direction of rotation of the propeller shafts via a gearbox and altering engine RPM. This configuration also allows the vessel's engines to run at a constant speed which reduces the wear and tear on engines and transmission gear.

3.3 *Collaroy*'s *Kamome* propulsion system relies on complex electronic control circuitry to operate the vessel's main engines and steering rudders. Electrical signals, appropriate to the desired propulsion settings ordered by the Master, are interpreted by electronic logic units known as Programmable Logic Controllers (ProCons) and are transmitted by more than 600 electro-mechanical relay units to the hydraulic and mechanical systems controlling engine speed, propeller pitch setting and rudder angles.

3.4 Masters activate the propulsion control system by operating a switch, not unlike a car's ignition switch, on the centre console. Once the vessel's master makes this switch, or **Keys In**, control of the vessel's propulsion and steering is set at that location.

3.5 Masters usually remain at the centre console until they have stopped the vessel just short of its final position, then relocate to the bridge wing on the side closest to the wharf to complete the berthing procedure. Although the Master has radar and instrumentation that indicates each of the vessel's rudder and propeller pitch settings, as indicated in *Figure 7*, there is no speedometer and the master visually estimates his/her vessel's closing rate towards the berth.

Figure 7 Pitch Setting Indicating Gauges, at right

What Went Wrong?

3.6 Following the accident, experts from, or on behalf of, the manufacturers of the *Collaroy*'s data logger, engines' governors and propeller pitch control systems, together with independent specialists in propulsion control systems, joined technical staff from Sydney Ferries to

determine whether there actually had been a loss of control and, if so, those factors that may have contributed to it. Sydney Ferries also engaged the services of a marine surveyor to provide an assessment that was independent of those being proffered by the various manufacturers or their agents. OTSI investigators were involved in the testing and simulations, as were officers from the NSW Maritime Authority, and subsequently accessed the various inspection reports.

3.7 Information downloaded from *Collaroy's* on-board data logger confirmed the Master's account. It showed that he began to transfer from **Sailing** mode to **Manoeuvring** mode after he entered Sydney Cove and as he passed the Opera House. OTSI noted that whilst there was no requirement for the Master to have changed to **Manoeuvring** mode earlier, it is generally the case that they do make such a switch before passing the Opera House. Sydney Ferries has subsequently designated that this switch is to be made when Freshwater class vessels, entering Sydney Cove, pass an imaginary line between Dawes and Bennelong Points. The data downloaded also confirmed that a malfunction had occurred and that it effectively isolated both the primary and back-up bridge propulsion control systems for approximately 35 seconds.

3.8 An examination of electronic components and circuitry in the *Kamome* propulsion control system indicated that an electrical relay failed and that this had the effect of switching off or **Keying Out** of the control system. A high resistance reading was obtained from Relay No 303, a component in the **Key In** circuit, and it was thought that this could have induced such a significant failure. This was confirmed by simulation and when this relay was replaced, the fault did not recur during sea trials. *Figures 8* and *9* show some of the related circuitry, Relay 303 and testing equipment.

Figure 8 Electrical Relays with Relay # 303 indicated

Figure 9 Relay # 303 being tested.

Master's Emergency Actions

3.9 As described in paragraph 2.3, there were a number of indicators of a power failure at the time the Master switched from **Sailing** to **Manoeuvring** mode and the loss of control was the subject of communication between the Master and the Engineer. The Master requested advice from the Engineer, who told him to **Key Out** on his bridge master switch and **Key In** again in the hope that this action would re-set propulsion control. The Master performed this function but the vessel continued to move forward under its own momentum. OTSI noted that even if the propulsion control system had been functional, the advice provided by the Engineer was not appropriate in the confines of Sydney Cove because it disengaged both propulsion transmission clutches initially which would have delayed any recovery.

3.10 The Master's next action was to attempt to revert to the **Back-up** or emergency propulsion control system; a system that uses separate

electrical and hydraulic equipment and which ordinarily would have automatically provided an immediately available means of stopping the vessel. However, there was no indication on the centre control console that the **Back-up** propulsion control system was operational. At this stage, the Master would have been able to regain control by transferring propulsion control to the Engineer, but he was unaware of the procedure for doing so, and the Engineer advised that he had never practised this procedure.

3.11 Confronted by the prospect of a now imminent collision with Circular Quay and unaware of a means to overcome a complete loss of bridge propulsion control, *Collaroy's* Master decided to let go an anchor. He attempted, unsuccessfully, to summon the GPHs to the cable deck using a recently installed anchor alarm. The Master could not hear any audible alarm when he activated the alarm and interpreted this as another malfunction. In fact, the alarm's volume increases over a period of seven seconds before it becomes audible in the bridge. The alarm is cancelled if the actuating button is pressed again, as appears to have happened in this case. The Master advised OTSI that he had neither used, nor been instructed in the operation of the anchor alarm. At this stage, the GPHs were below deck in the mess room and oblivious to the Master's predicament. He should have been able to communicate with them via a PA system or a hand-held radio. However, the wiring to the PA speakers in the mess room had been disconnected and the hand-held radio not been brought aboard the vessel at the commencement of the shift.

3.12 The Helmsman left the bridge and went to the mess room to summon the GPHs. Thereafter, he assisted the other GPHs in their attempt to deploy the anchor. When the Master left to supervise the deployment of the anchor, the bridge was unattended. The subsequent deployment of the anchor was not without its problems because the GPHs had not recently practised the related drills. After some delay, the port anchor was let go but it had little effect as the anchor trailed rather than held.

OTSI was not able to determine whether this was a consequence of insufficient cable being deployed or an excessive speed for the anchor to take hold. *Collaroy* subsequently ran into the Northern end of the pontoon at No.2 Circular Quay. OTSI has noted that Sydney Ferries subsequently issued a Fleet Marine Circular detailing the procedures to be followed in the event that an anchor has to be deployed under emergency circumstances.

3.13 Under emergency procedures detailed in the *Freshwater* Class VOM, the Master was required to activate a pre-recorded audio emergency message over the PA system, but did not do so. OTSI has noted in a number of its investigations over the last 12 months that Masters have failed to activate this alarm and it is apparent that they have little regard for this facility, believing the message to be too lengthy and not sufficiently compelling. However, the Master sounded a prolonged warning blast on *Collaroy's* whistle before leaving the bridge. He also contacted Sydney Ferries' operations room advising them of the need to notify the emergency to the crew and passengers of another Sydney Ferries' vessel, the *Golden Grove,* which was embarking passengers at No 2 West Wharf.

Organisational Issues – Training and Crew Resource Management

3.14 If the Master and the Engineer had possessed the knowledge and confidence to change to MCR control, this collision would probably have been averted. OTSI considers the system which allowed the Master and Engineer to operate a vessel in the absence of such knowledge to have failed. In addition to not having been trained in the procedure, OTSI noted that there was no reference to the related procedure in the Class VOM, the FERP, or any of the other references used by Sydney Ferries.

3.15 OTSI examined the training records of the crew. It noted that the Engineer had not undergone any emergency training onboard *Freshwater* Class vessels and that while crew are required to participate in such training on a monthly basis, one of the GPHs had not undergone any emergency training since February 2005.

3.16 The inadequacy of the communications between the Master, Engineer and GPHs, and their actions before and during the accident, was indicative of poor equipment maintenance and utilisation, as well as uncoordinated CRM. In addition, earlier on the morning of 19 September, an extra training engineer and two trainee engineers embarked on *Collaroy* without the Master having been fully briefed about their presence and purpose. They conducted a series of machinery training evolutions that did not interfere with the ferry's scheduled services. At the time the *Collaroy* lost propulsion control, the Master was not aware which engineer was actually in charge of operations in the MCR. OTSI has noted that this is not the first such instance of training occurring onboard vessels without the full knowledge of masters.

3.17 The sequence of events makes it plain that there was no-one on the bridge during the final moments before *Collaroy* collided with No.2 Wharf. The Master and Helmsman are uncertain whether the Master directed the Helmsman to go to the cable deck to prepare the anchor for letting-go, or whether he went on his own initiative. The Master's decision to leave the bridge was prompted by his concern about the length of time being taken to let the anchor go; concerns which were magnified by his inability to communicate with the GPH cable party. OTSI has noted that while Sydney Ferries has a reasonable expectation that the master and helmsman will be on the bridge of *Freshwater* Class vessels at all times during operations, this had not actually been specified as a requirement in policy documents and in particular, the VOM.

3.18 The limitations of actions taken in emergencies, and CRM more generally within Sydney Ferries, has been the subject of comment in previous OTSI reports. OTSI is aware that there is a degree of Union dissatisfaction with the programming of emergency response training and that masters and engineers in particular do not have confidence in the design, delivery and evaluation of the refresher training that is intended to ensure they can respond to emergency situations. Sydney Ferries has acknowledged the limitations of its training regime in dialogue with OTSI and recently engaged the services of the Australian Maritime College and the Australian Maritime Safety Authority to review its training. A new round of refresher training commenced in December 2005 and has been enthusiastically embraced by those *Freshwater* Class masters and engineers who have participated in it. However, the training has yet to include GPHs and has not been extended to those crewing other classes of vessels. It is also apparent to OTSI that there are some fundamental organisational, industrial and cultural issues which will continue to impact on both training and crew resource management and which are unlikely to be resolved in the near term. OTSI intends to examine these matters in detail in the context of a systemic investigation, currently underway, into a series of collisions across the *Freshwater* Class of vessels.

Organisational Issues – Fatigue and Impairment

3.19 Having examined rosters and work sheets, there was nothing to suggest that fatigue was an issue. All crew returned negative results when breath tested for the presence of alcohol by Sydney Water Police. However, there were delays in the testing required under Sydney Ferries Drug and Alcohol Policy which resulted in the master and two GPHs not being tested within the specified timeframe (this compliance failure has already been dealt with by Sydney Ferries). The tests detected that one of the GPHs had used cannabis.

Organisational Issues - Risk Management

3.20 In its report into a collision involving *Collaroy* on 4 March 2005, OTSI observed that the risks associated with the vessel's unique *Kamome* propulsion control system had not been properly anticipated by Sydney Ferries. OTSI noted that there was an absence of specific reference in the *Freshwater* Class VOM to those matters that made *Collaroy* unique in its Class and that some material in the VOM was either erroneous or irrelevant when applied to the *Collaroy.* In response, Sydney Ferries advised that they had initiated a "Big Boat Project" intended to:

i. assess the risks associated with the operation of *Freshwater* class vessels;

ii. review crewing arrangements and qualifications in the light of assessed risks;

iii. review the roles and responsibilities of all crew members, including the processes for selection and appointment for the roles, and the opportunities for career pathways and skills enhancement;

iv. review the engineering history across the class and the related maintenance and audit processes;

v. include broader areas such as security, CRM and contingency planning, including the use of other classes on services to and from Manly, and

vi. introduce, on a trial basis and in consultation with Unions, a Mate IV or Master Class V onboard Freshwater Class vessels.

3.21 Following the collision on 19 September 2005, *Collaroy* was taken out of service and has remained so. Sydney Ferries has recently advised OTSI that there has been little implementation progress of the various elements of the "Big Boat Project" during the period between the two *Collaroy* collision incidents, but that progress has been made

subsequently in the area of identification of operational risks and training/competency issues. It has also advised that it is planned to bring *Collaroy* back into service towards the end of April 2006 after a number of the components in, or impacting on, the vessel's propulsion control system have been upgraded. Sydney Ferries has further advised that it has engaged the services of Lloyds to determine whether the *Kamome* propulsion control system should, in the longer term, be upgraded or replaced and that the Lloyd's report should be available in late March or early April 2006. In the interim, a draft Technical Maintenance Plan has been developed for the *Freshwater* Class and it is expected the Plan will be formally accepted in April 2006.

3.22 In reviewing the circumstances of the incident on 19 September 2005 and specific aspects of the crew's actions in response to the emergency, OTSI notes in particular the absence of Master and Helmsman from the bridge in the final stages of an uncontrolled approach to the wharves at Circular Quay. In addition, it is of significant concern how a matter as fundamentally important as the ability to communicate could have been allowed to reach a point onboard *Collaroy* where the Master was unable to communicate with the GPHs. It is understood by OTSI that the PA system in the mess room had not been functioning for some time. It was suggested to OTSI that the system had been disconnected because it was considered to be a source of annoyance to the GPHs who frequent the room whilst the vessel is in transit, although OTSI was unable to establish the veracity of this suggestion. The fact that the absence of the hand-held radio used by GPHs was not discovered until there was an emergency is also of concern. Such a matter would not have gone unnoticed had a proper communications check been conducted during vessel start-up procedures.

Emergency Response

3.23 In the absence of injuries, environmental damage and significant damage to *Collaroy*, the management of the emergency response was relatively uncomplicated and effectively executed. The delay in advising OTSI of this matter was the consequence of an oversight by a manager who was directly involved in the emergency management and who was, at the time, also carrying additional responsibilities in the absence of a General Manager Operations.

Other Matters that Might Enhance the Safety of Ferry Operations

3.24 OTSI has commented, in previous investigation reports, on the limitations of buffering arrangements at No.6 Wharf at Circular Quay and at the Southern end of Manly Wharf; the inadequacies of CCTV coverage at Circular Quay, and has highlighted that not all Sydney Ferries vessels are equipped with data loggers. OTSI notes that the NSW Maritime Authority has advised that improvements will be made to No. 6 Wharf at Circular Quay during financial year 2006/2007; that Manly Wharf is due to be upgraded in the near term and that the upgrading of CCTV at a number of locations, including Circular Quay, is in prospect. It also notes that Sydney Ferries is currently evaluating tenders for the provision of data loggers.

PART 4 FINDINGS

4.1 In relation to those matters prescribed by the Terms of Reference as the principal lines of inquiry, OTSI finds as follows:

4.1.1 *Causation*.

a. The collision occurred when *Collaroy* failed to respond to the Master's initial propulsion control instructions and a number of back-up and recovery measures either failed or were ineffective.

b. The collision was initiated when an electronic component in the vessel's propulsion control system malfunctioned, for a period of about 35 seconds, rendering both the primary and back-up propulsion control systems inoperable from *Collaroy's* bridge. Approximately three minutes elapsed between the onset of the failure and the collision, during which time the Master was unable to regain propulsion control.

c. The Master's actions to regain control were limited by his mis-interpretation of the nature of the malfunction and his lack of familiarity with an important procedure that would have allowed him to revert to another form of control that was not affected by the malfunction.

4.1.2 *Effectiveness of the Emergency Response.*

a. When confronted with the loss of propulsion control, the Master had limited options available to him in the confines of Sydney Cove and recognising the imperative to stop, the Master decided to let go an anchor. However, the process of deploying the anchor was delayed by the combined effects of two factors:

- the requirement to physically muster the GPHs since one of the electronic means of communication normally used

for such purposes did not function and the other had been left ashore, and

- the GPHs' lack of familiarity with the required procedures. Once deployed, the anchor proved to be ineffective in halting the *Collaroy's* forward momentum.

b. The Master could have arrested *Collaroy*'s momentum by directing the Engineer to assume control of propulsion from within Machinery Control Room (MCR), but did not do so because he was unfamiliar with the related procedures, as was the Engineer.

c. The difficulties in communication, which arose from defective and missing equipment, and the lack of familiarity with the procedures required to revert to MCR control and to deploy the anchor, were reflective of ineffective defect reporting and management; incomplete equipment checks; inadequate training and uncoordinated Crew Resource Management.

d. Both the Master and the Helmsman left the bridge and became involved in the actions to deploy the anchor, which meant that the bridge was unattended immediately prior to, and at the moment of, the collision.

e. The Master initiated a prolonged sounding of *Collaroy*'s whistle to alert others of his predicament, but did not activate a pre-recorded warning message as was required by standard operating procedures.

f. Duty personnel at Circular Quay from both Sydney Harbour Control and Sydney Ferries acted quickly and efficiently to evacuate passengers from another ferry that was berthed at an adjacent wharf as soon as the alarm was raised. They also assisted *Collaroy*'s crew to secure the vessel and cordon the area to minimise the possibility of environmental damage. They alerted other response agencies, including the NSW Maritime Authority, which responded quickly and efficiently.

g. While the crew were promptly breath tested by the NSW Water Police for the presence of alcohol, the conduct of drug and alcohol testing by Sydney Ferries did not occur within the timeframe specified in their Drug and Alcohol Policy.

4.1.3 Effectiveness of Sydney Ferries' Risk Management Strategies.

a. *Collaroy's* propulsion control system is unique within Sydney Ferries and the risks associated with the operation of the vessel had not been fully anticipated by Sydney Ferries.

b. Not all of *Collaroy's* crew had undergone recent emergency training and the particular contingency that occurred had not been the subject of recent training.

c. Sydney Ferries' has an expectation that the Master and Helmsman be present on the bridge at all times when a vessel is underway, but this was not formally articulated until after the incident.

4.1.4 Other Safety Matters.

a. A number of matters identified in previous OTSI reports, viz., the fitment of data loggers to all Sydney Ferries' vessels; the upgrading of safety backboards at Circular Quay and Manly Wharves and the upgrading of CCTV capabilities, remain unresolved but are the subject of approved planned works.

PART 5 RECOMMENDATIONS

5.1 In order to prevent a recurrence of this type of accident, the following remedial safety actions are recommended for implementation by the organisations specified below:

5.1.1 Sydney Ferries Corporation

a. Undertake a thorough risk assessment in order to determine whether it should continue to operate the *Collaroy* in its current configuration.

b. As long as the *Collaroy* continues to remain unique in its class, take action to ensure its uniqueness is fully understood by all personnel required to either operate or maintain the vessel.

c. Ensure that recently introduced instructions for amended propulsion mode changeover procedures are reflected in VOMs and are being adhered to by crew.

d. Ensure that all changes to operating instructions are underpinned by proper risk assessments; are formally advised to those who are required to implement the instructions and are the subject of appropriate training.

e. Ensure that planned maintenance inspections of safety-critical equipment, such as propulsion control electrical relays and bridge VHF and UHF communications radios, are being completed and that any reported defects are rectified in a timely manner.

f. Review the content and delivery of emergency training, ensuring that crews are well versed in the actions required to overcome control failures.

g. Act to reinforce Crew Resource Management throughout its organisation.

h. Issue a formal policy requiring an appropriately qualified master and GPH to be present at all times on the bridge of *Freshwater* class vessels during their operation.

i. Review the utility of its extant pre-recorded emergency broadcast messages.

5.1.2 NSW Maritime Authority

a. Review the risk assessments that underpin any plan/s that Sydney Ferries might develop to return *Collaroy* to service.

b. Monitor the actions being taken within Sydney Ferries to improve training and Crew Resource Management