Office of Transport Safety Investigations

FERRY SAFETY INVESTIGATION REPORT

COLLISION INVOLVING SYDNEY FERRIES VESSEL *MARJORIE JACKSON*

BALMAIN SHIPYARD

2 AUGUST 2010

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THE OFFICE OF TRANSPORT SAFETY INVESTIGATIONS

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. OTSI investigations are independent of regulatory, operator or other external entities.

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Once OTSI has completed an investigation, its report is provided to the NSW Minister for Transport for tabling in Parliament. The Minister is required to table the report in both Houses of the NSW Parliament within seven days of receiving it. Following tabling, the report is published on OTSI's website at www.otsi.nsw.gov.au.

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ACRONYMS AND ABBREVIATIONS

CAN BUS	Controller Area Network Bus. A digital pathway that connects devices.
FLIR	Forward Looking Infrared. An imaging technology that senses infrared radiation. The heat source is used to create a picture assembled for video output. It assists Masters in navigating their vessels at night, and in fog, or detects warm objects against a cold background when it is completely dark.
GPH	General Purpose Hand, also referred to as a deckhand.
MED III	Certificate of Competency as a Marine Engine Driver Grade 3.
PLC	Programmable Logic Controller.
SRP	Steerable Rudder Propeller.
VDRS	Voyage Data Recording System.
VOM	Vessel Operations Manual. The prime reference, issued by Sydney Ferries, containing technical information and operating instructions for each class of ferry.

EXECUTIVE SUMMARY

At approximately 6.38am on 2 August 2010, the Master of the Sydney Ferries' RiverCat Class ferry, the *Marjorie Jackson*, was moving the vessel from the Eastern to the Western side of Number 3 Wharf at the Balmain Shipyard to pick up his cashier prior to commencing services. As he completed the 180° turn, the Master heard the sound of a steering failure alarm and, in the seconds that followed, he attempted to arrest the vessel's movement by going astern on both engines. However, the starboard steering control, a Schottel steerable rudder propeller, failed in the ahead position, driving the vessel forward from the starboard unit despite the position of the steering controllers.

The port bow of the *Marjorie Jackson* collided with the Wharf twice as the vessel kept moving forward, finally hitting the stern of the *Betty Cuthbert* which was then forced into the stern of the *Evonne Goolagong* tied up ahead of it. The wharf piles sustained minor damage which did not affect the structural integrity of the Wharf. The damage to the *Betty Cuthbert* and the *Marjorie Jackson* was confined to structural damage above the waterline. The General Purpose Hand sustained a minor injury to her arm while attempting to tie up the vessel.

The collision was determined to be the result of a steering failure. Notwithstanding the absence of data from the vessel's voyage data recording system, which was not operational at the time, it is concluded that the steering failure was due to the failure of a potentiometer, a vital component within the vessel's electronic control system.

There was no system in place to monitor the service usage of potentiometers and so be able to identify when they were approaching the end of the manufacturer's specified life expectancy. Since existing potentiometers have been replaced and a range of initiatives implemented to guard against future problems with the RiverCat control systems, there have been no further steering control failures on Sydney Ferries' electronically controlled RiverCats.

Masters were not equipped with sufficient knowledge to deal effectively with the demands of managing the full range of potential control irregularities on electronically controlled RiverCats because of deficiencies in their training and in the contents of the RiverCat operations manual. The training has since been revised and the vessel operations manual upgraded to clearly identify and deal with mechanically and electronically controlled RiverCats as separate variants.

Given the appropriate remedial action already undertaken by Sydney Ferries, no recommendations in relation to the key issues of monitoring potentiometers and training of Masters are deemed to be necessary. However, four recommendations are made in relation to ancillary findings which have the potential to further enhance the efficiency and safety of RiverCat operations.

PART 1 - CIRCUMSTANCES OF THE INCIDENT

The Collision

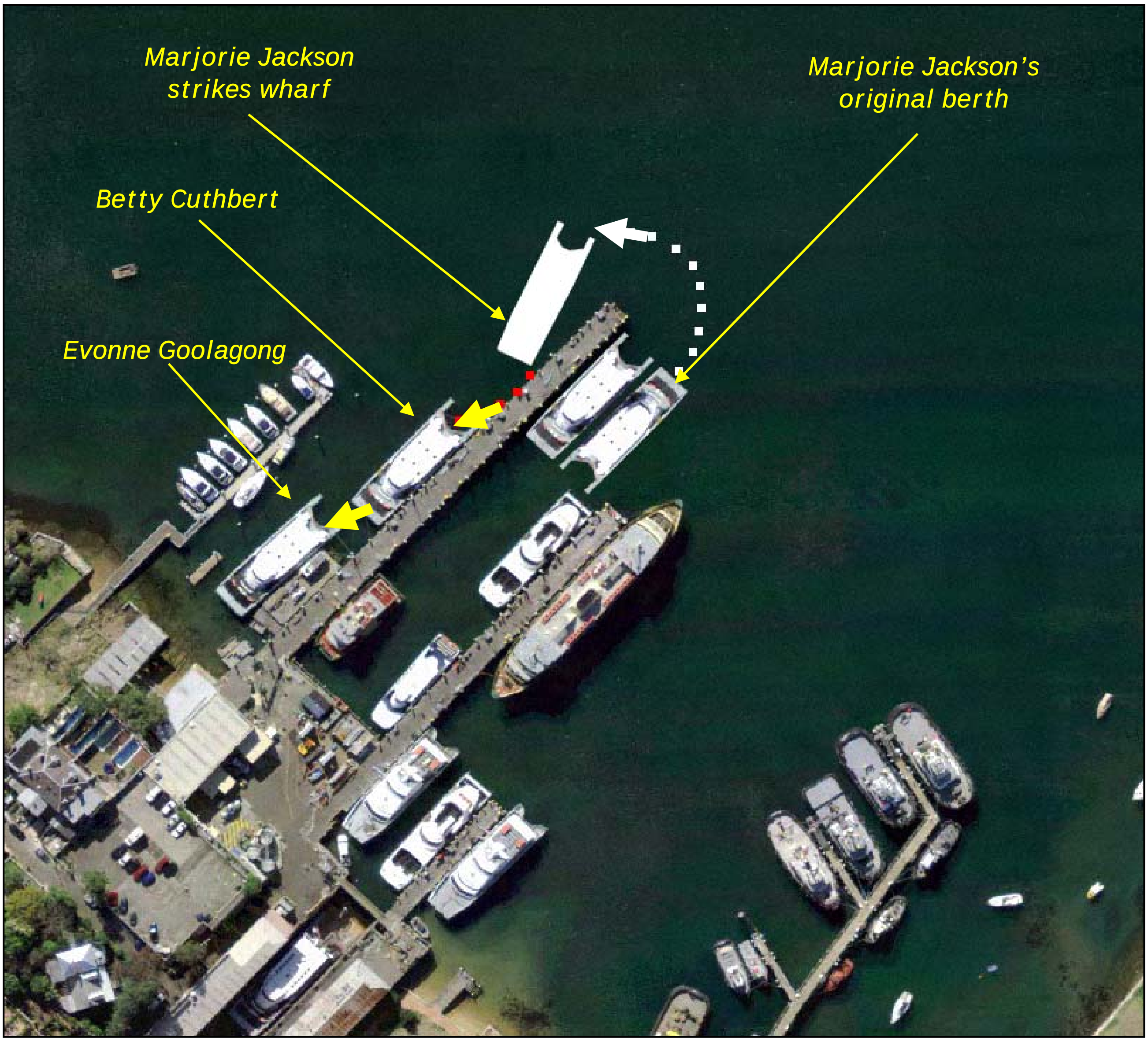
1.1 At approximately 6.38am on 2 August 2010, the Master of the *Marjorie Jackson*, a Sydney Ferries' RiverCat Class ferry, after completing all pre-departure checks, began manoeuvring his vessel from a position facing North on the Eastern side of Number 3 Wharf to a position facing South on the Western side of Number 3 Wharf at the Balmain Shipyard (see *Photograph 1*). His intention was to turn the vessel 180° to port as it rounded the end of the wharf so that a cashier could be collected after the vessel had come alongside the wharf. The Master recalled a Westerly wind blowing at the time, creating too large a gap between the wharf and a HarbourCat he was tied up alongside for his cashier to cross safely, hence the decision to reposition the vessel to the Western side.

1.2 The Master commenced to move the RiverCat forward but observed another ferry crossing his bow from the starboard side. He stopped his ferry by going astern on both controls and, when the crossing ferry was clear, continued his journey to the Western side of the wharf.

1.3 After he had turned to Port around the end of the wharf, the Master heard what he described as a steering failure alarm and then noticed that the vessel was continuing on its port turn towards the wharf. He attempted to go astern by turning both controllers and increasing the throttle, but this action did not arrest the vessel's movement and it continued forward. He did not immediately realise that the starboard Schottel steerable rudder propeller (SRP) was still in the ahead position, with any power commands effectively driving the vessel forward from the starboard unit despite any alteration to the position of the controllers.

1.4 The Master was able to alert the General Purpose Hand (GPH) of a steering failure and an attempt was made to throw a line from the vessel to a wharf pile. However, this was unsuccessful due to the speed of the vessel. The port bow of the vessel collided with the wharf twice at a speed of 2.8 knots as it kept moving ahead. It then accelerated reaching a maximum speed of 6 knots before colliding with the stern of the *Betty Cuthbert* at a speed of 5.8

knots. The force of the impact pushed the *Betty Cuthbert* into the *Evonne Goolagong* which was tied up ahead of it.



Photograph 1: Aerial view of Balmain Shipyard showing vessel path

1.5 The Master did not shut down both engines but declutched on impact with the *Betty Cuthbert,* leaving both motors running. When the vessel was stationary, he went to the master (central) control station where the starboard backup light was flashing, indicating a steering failure, and accepted backup to stop the audible alarm. Shipyard staff attended immediately after the collision and observed both engines were still running and the starboard Schottel backup light was fixed, indicating backup had been accepted.

Damage

1.6 The wharf piles sustained only minor damage during the collision and the structural integrity of the wharf was not affected.

1.7 The damage to the *Betty Cuthbert* and the *Marjorie Jackson* was the most significant, yet was confined to structural damage above the waterline. The *Marjorie Jackson* had to be dry-docked for repair to impact damage from penetration of the aluminium skin of the starboard pontoon (see *Photograph 2*). The stern railings and other fittings on the *Betty Cuthbert* were repaired at the Balmain Shipyard.

Photograph 2: Damage to the *Marjorie Jackson*'s starboard pontoon

Injuries

1.8 The GPH sustained a minor strain injury to her arm while attempting to tie up the vessel. There were no injuries to those on board the other vessels.

Vessel Characteristics

1.9 Sydney Ferries' RiverCat Class vessels are catamarans of aluminium construction, 34.99 metres in length, with a normal operating speed of 22 knots. The vessels are in survey with the NSW Maritime Authority in Classes 1D and 1E to carry up to a maximum of 230 passengers. A Class 1D RiverCat carrying up to 150 passengers requires a minimum crew of two, a Master 4 who also holds a MED III and a GPH. A Class 1D RiverCat carrying more than 150 passengers requires an additional GPH.

1.10 Propulsion is by way of twin 372.8 kW engines driving Schottel steerable rudder propellers (SRP) (see *Photograph 3*). The engines and auxiliary generators are situated with the SRPs at the rear of both hulls. The SRP is similar to an outboard motor leg but it operates in reverse. The propeller sits in front of the leg in the direction of travel, effectively pulling the leg through the water, whereas the propeller on outboard motors is at the rear of the leg and pushing the leg forward.

Photograph 3: Bottom-up view of SRPs on the *Marjorie Jackson*

1.11 The two legs can be independently steered through 360° providing exceptional manoeuvrability. *Figure 1* illustrates how the thrust vectors of each SRP influence vessel movement.

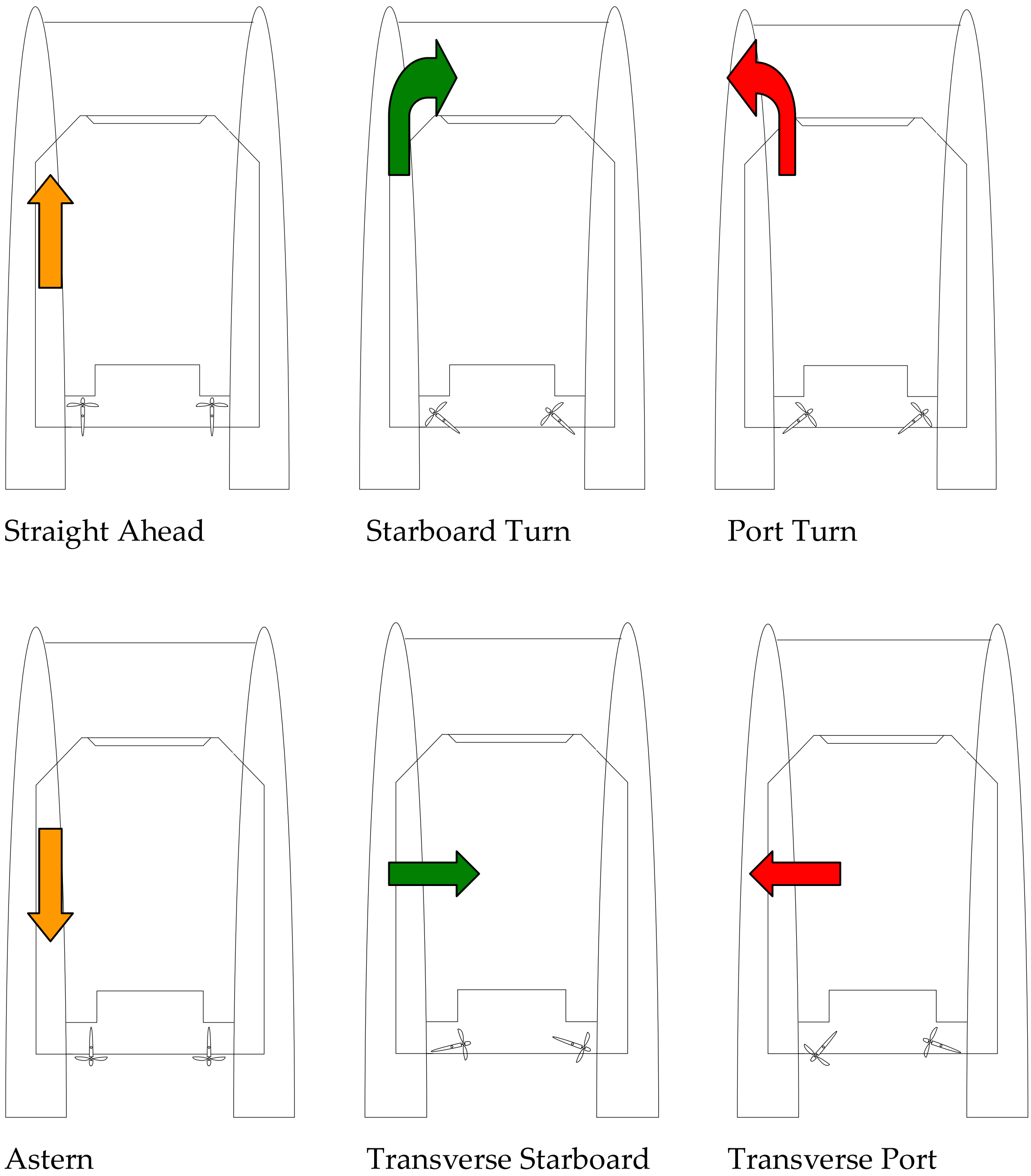


Figure 1: Thrust vectors and vessel responses

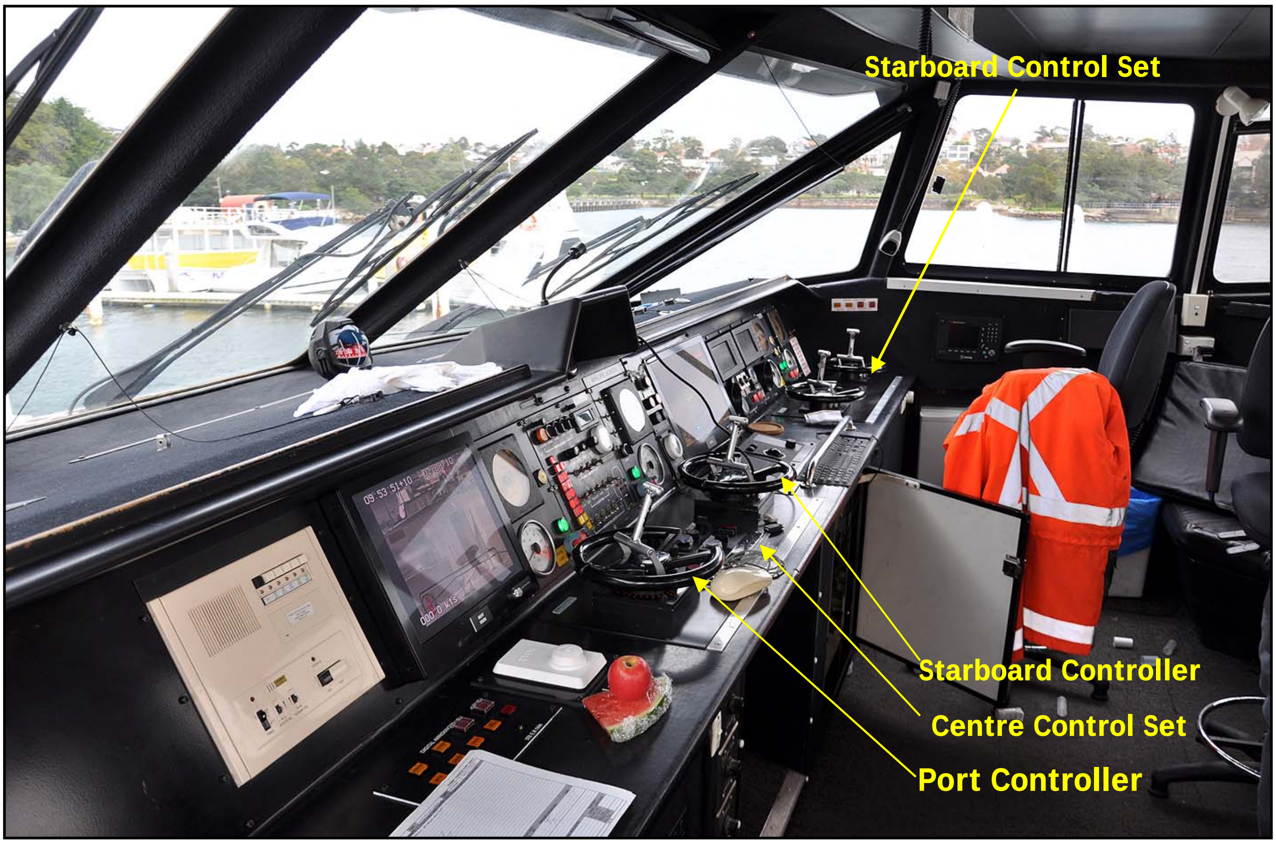
1.12 Propulsion is transferred through a two-to-one reduction gearbox at the rear of the engine by way of a horizontal drive shaft to the top of the SRP. From there, it is transferred vertically to the final drive at the bottom of the leg. Propulsion is engaged in and out through a hydraulically operated clutch unit

at the engine end of the drive shaft. There is only a forward gear and no reverse gear; turning the SRP 180° in either direction allows the vessel to go astern.

1.13 Having fixed pitch propellers, vessel speed is increased or decreased according to engine speed. Both engine throttles can be independently controlled to further increase manoeuvrability. The propellers are not counter rotating so transverse thrust cants the bows to starboard when the vessel is going ahead. Therefore, it requires constant steering adjustments to port for straight line navigation.

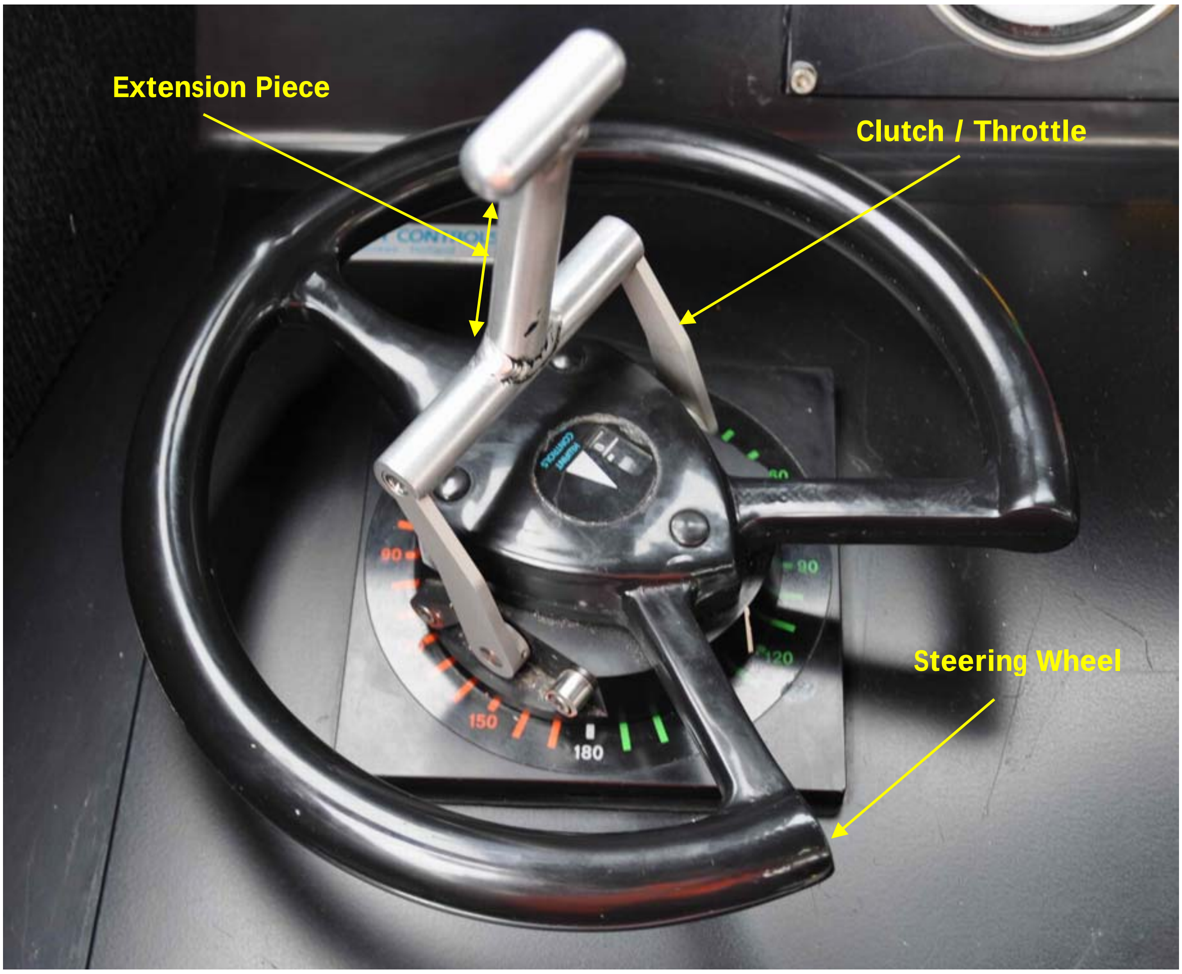
Controls

1.14 There are three groups of controls in the wheelhouse of the RiverCats. The centre control station is the master control station consisting of a port and a starboard controller. These controllers are duplicated on the port and starboard sides (wings) of the control console thus enabling the Master to move to either position to gain a clearer view of a wharf on approach during docking (see *Photograph 4)*. The controllers are designed and manufactured by the Dutch company, Kwant Controls.



Photograph 4: Controller layout

1.15 Controllers rotate through 360° and have a throttle / clutch lever in the centre (see *Photograph 5*). As the control lever is moved forward, a micro-switch inside the control head engages the clutch and further movement forward of the lever provides a signal to the engine management unit to increase engine speed.



Photograph 5: Kwant control wheel

1.16 Although each controller in the three pairs can be turned independently, there is provision at the centre or master position for either of the two controllers to take command of both the port and starboard controls. The synchronisation of two controllers in tandem allow steering and throttle operation from the one controller, an arrangement often used by Masters on longer runs. However, in this configuration, control can still be transferred to a wing position without changing the master control setting, but the wing controls will operate independently in the standard manner and not in tandem. When transfer is

then made back to the master position from the wing, the master controls will operate in tandem unless the tandem setting is deactivated. , There is a risk, therefore, that a Master operating with tandem control who transfers to the wing to dock, might move back to the centre controls on departure and not realise these controls are still set in tandem.

1.17 There are seven RiverCats in the Sydney Ferries' fleet. All vessels were originally equipped with mechanical connections which joined the six controllers together to provide a positive connection between corresponding controllers. The connections were constructed of a series of shafts, universal joints and gearboxes. Commencing in 2006, three vessels underwent a control refit in which the mechanical linkages were replaced with Kwant 'Electric Shaft System' controllers. This effectively replaced the mechanical linkages with an electronically controlled method of synchronisation between controllers.[1] *Figure 2* shows the basic schematic of the data flow in the Kwant electronically controlled vessels, with the Kwant system programmable logic controller (PLC) providing positional data amongst the network of controllers.

1.18 When three of the RiverCats needed new engines, there was significant benefit to be gained from installing the same type of engine as was being installed in the nine vessels of the First Fleet Class. The electronic Kwant controls were identified as the most suitable for the new RiverCat engines connected to Schottel SRPs. An added benefit of the change from mechanical to electronic linkages was a potential reduction of workplace injuries as Masters had been complaining of repetitive strain injuries. The electronic system was seen as a better alternative (noting that the old controls would not work with the new engines) as the controls were lighter to operate than the mechanical ones, while theoretically still providing a similar level of redundancy.

1.19 The three vessels of the RiverCat Class fitted with the Kwant controls were the *Betty Cuthbert*, *Marjorie Jackson* and *Dawn Fraser*, and the conversion was carried out in that order between May 2006 and January 2008. Since this refit, the number of reported control system problems on each of these

1 For clarity in this report, vessels will be identified as either "mechanically controlled" or "electronically controlled".

three vessels has been 24, 20 and 18 respectively.[2] There were no reported failures of the connections between controllers of the remaining mechanically controlled vessels in the Class over the same period.

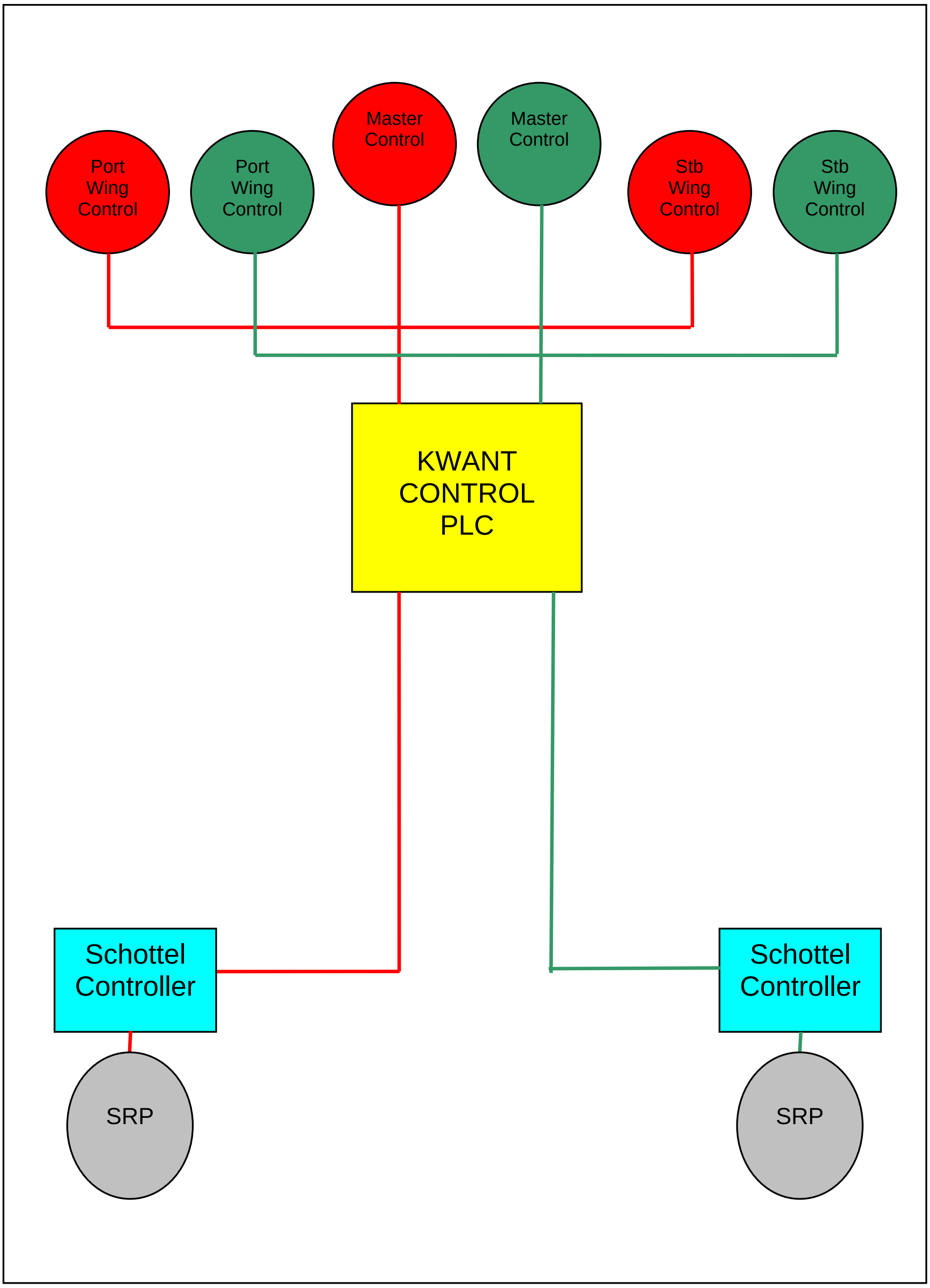


Figure 2: Data flow between components

2 Such high rates may be explained to some degree by the fact that Shipyard engineers did not consider faults to be control failures whereas Masters considered faults and failures to be the same which resulted in them recording all faults as failures.

1.20 In order for the electronically controlled vessels to emulate the operation of the mechanically linked controllers, a complex series of potentiometers and servomotors are incorporated in the Kwant control heads. These potentiometers are manufactured by Feteris Components, an industrial electronics company based in the Netherlands (see *Photograph 6*).

Photograph 6: Potentiometer removed from head unit

1.21 There are a total of twenty-six potentiometers used in the control system, four in each of the six control heads and one located on top of each Schottel unit. Only the two on top of the Schottel units and one in each Kwant control head are engaged with steering. The other potentiometers are for feedback and voyage data recording system (VDRS) signals.

1.22 A set of potentiometers measures the movement on the master controller then servomotors move the controls on the slave controller in concert, and vice versa. The signals between the controllers are carried over a controller area network bus (CAN BUS) which is similar in design to a computer

network, with each controller becoming a node on the network and able to communicate directly to other nodes. This allows synchronisation of controls through a two way data flow between controllers. The potentiometers measure control positions and send that signal to the other controllers and the Kwant control unit, which translates the data into a signal which is sent to the Schottel controller assigned to each SRP. The Schottel controller interprets the signal and uses it to control a hydraulic solenoid valve to effect steering.

Redundancy

1.23 The RiverCats have an independent backup steering circuit consisting of a pair of toggle switches which can be used to control rudder angle. They operate on a separate direct line to the Schottel unit and act directly on the hydraulic control valves, bypassing the PLC normally involved in controlling the vessel.

1.24 There are also clutch / throttle controls that are independent of the primary control unit, allowing the Master to command clutch in and engine speed with a push button control.

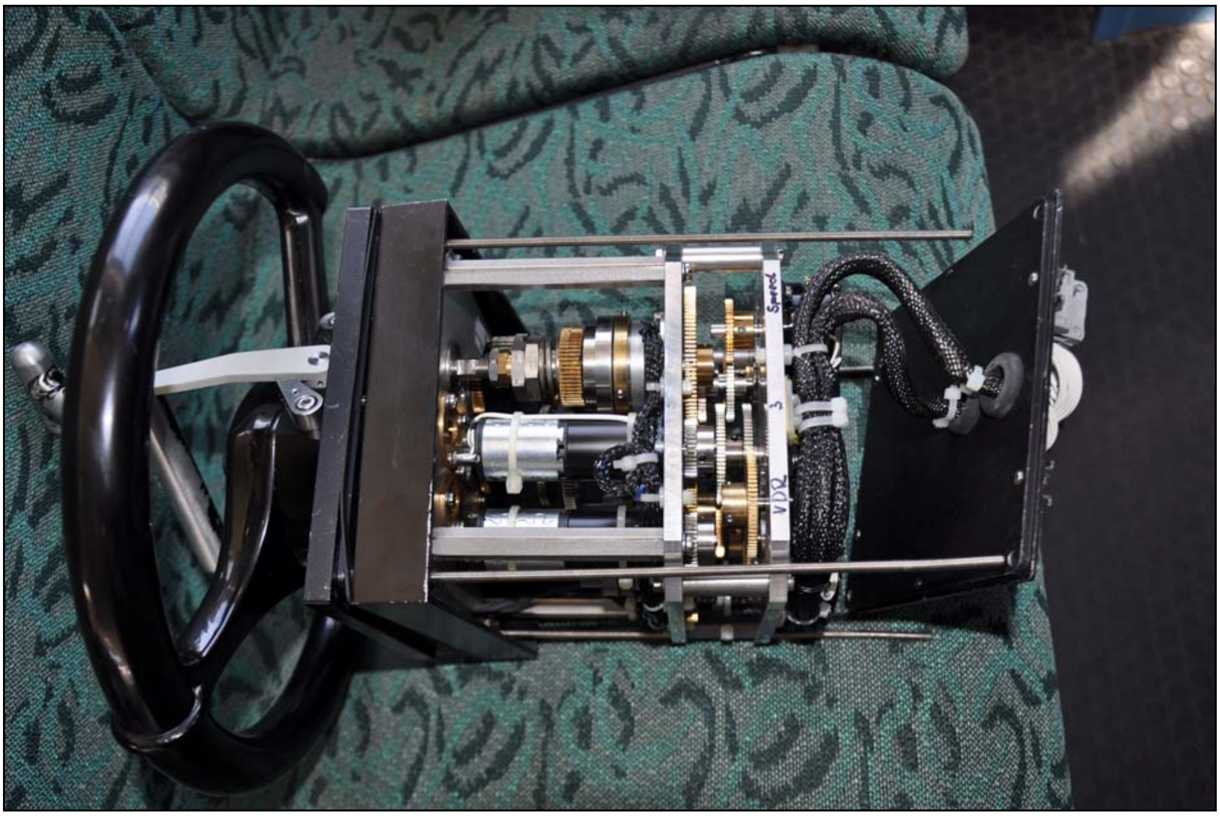
1.25 Backup control can be activated at any time but it does not automatically switch in when there is a steering failure or Kwant fault. On being alerted through a failure alarm or other control irregularities, the Master must switch over to backup mode manually by pressing the backup accept button. This can only be achieved at the master control panel as there is no provision to engage back from either of the wing positions. However, both clutch and throttle can be operated at all times from any position.

Faults

1.26 For there to be a loss of steering, there must be a failure of a steering potentiometer, of the link (wiring) between a potentiometer and a Schottel interface, or at the Schottel interface itself. *Photograph 7* shows a control unit with its complexity of gears, motors, clutches and potentiometers required to mimic its paired control.

1.27 Other faults that do not affect the steering of the vessel can include the synchronisation of controllers, the most common of which is a misalignment

fault, where the link between master and slave controllers is interrupted or one component of either controller becomes out of calibration. This triggers a misalignment alarm and it can present as one controller moving backwards and forwards in an attempt to synchronise with its master controller, a condition referred to as 'ratchetting'. Steering remains unaffected as the potentiometer for steering is separate from the other communicating potentiometers.



Photograph 7: Kwant control head removed for service

1.28 The Kwant system has a self-diagnostic feature which provides a coded display when any system irregularities are detected. This allows for more streamlined troubleshooting, but it is limited only to the Kwant control system and is unable to diagnose faults occurring at the Schottel interface. For Masters to be able to read-off the fault code for maintenance support, they had to access the underside of the wheelhouse console where the digital display panel was located at the time of the incident. The location of this panel under the wheelhouse console was a contributing factor to less than satisfactory information being provided to the relevant Master and

Engineering Superintendent to assist with investigating faults. A characteristic low output beeping alarm tone accompanies a Kwant system failure.

1.29 A steering failure alarm is characterised by a high output beeping and a flashing red backup light on the main console, and requires a transfer to backup mode. Once backup mode has been accepted, a return to normal steering could only be achieved through engine shutdown and restart. Acceptance of backup immediately cancels the audible failure alarm.

1.30 RiverCats are fitted with a voyage data recording system (VDRS) which captures a wide range of inputs - date and time, ship's position, speed, heading, rudder order and response, engine order and response, clutch position, backup control mode, engine speed, shaft speed, hydraulic pressure to steering, source of steering hydraulic pressure (main/backup) and power to control system (main/backup). As it happened, at the time of the incident, the VDRS on the *Marjorie Jackson* was found to be non-operational by the suppliers of the equipment who were engaged by Sydney Ferries to extract data from it.

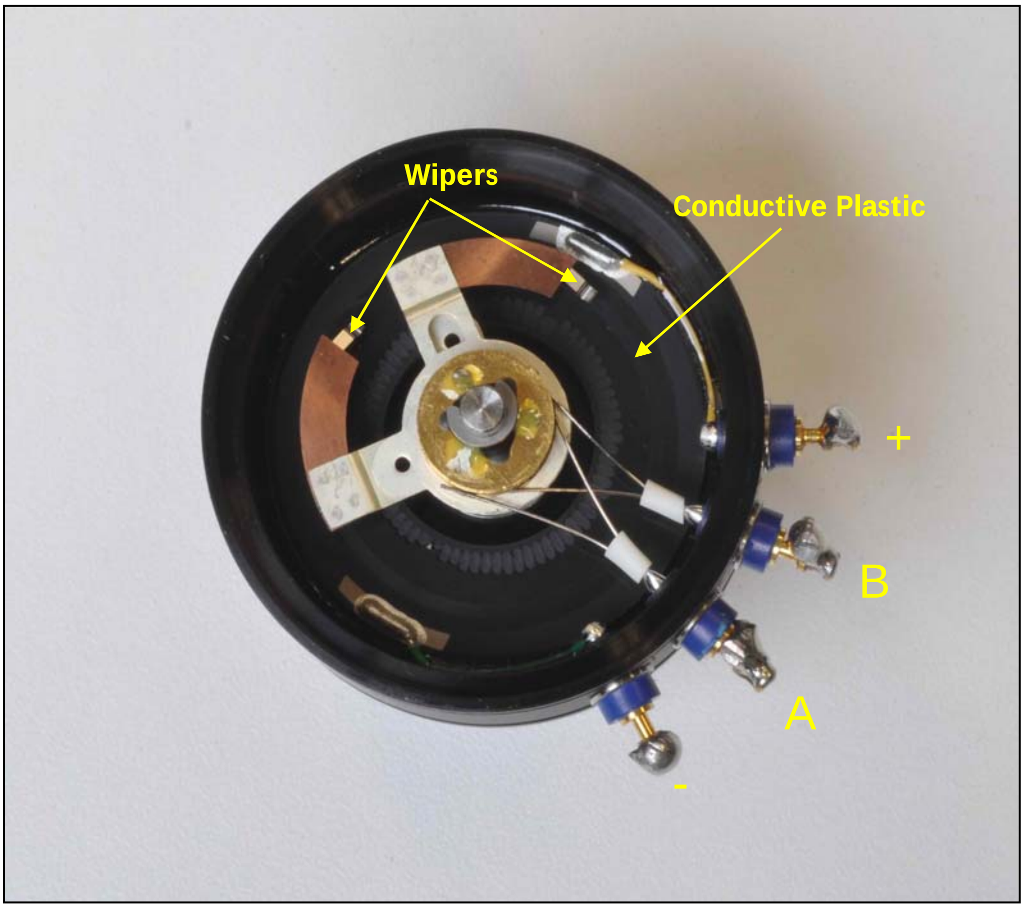
1.31 The vessel was fitted with a forward looking infra-red camera (FLIR) which recorded to solid state media. The FLIR footage corroborated the Master's version of events. The Master recalled that, as he applied thrust to go astern, he noticed an increase in the forward speed of the vessel. The reason for this was that the starboard Schottel unit was locked in the forward thrust vector and so did not respond to the Master turning the wheel to go astern.

1.32 A CCTV camera positioned at the shipyard administration building captured the incident and validated the FLIR evidence. There is also a CCTV security camera on the afterdeck of the vessel but it has no recording capability.

Fault Finding

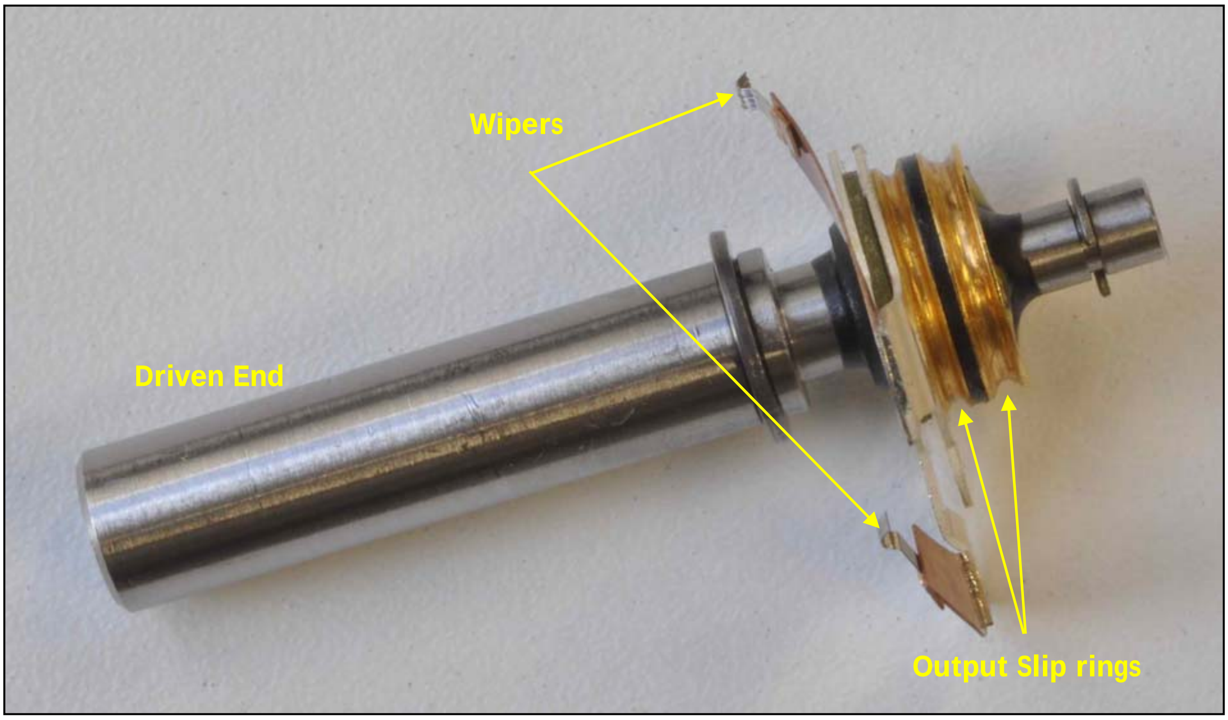
1.33 The Master stated that he followed all pre-departure checks and testing of backup control by switching off and restarting both engines and then resetting the controls before moving the vessel from its original location. In the absence of any VDRS information to verify events, trials were conducted with the vessel in an attempt to replicate the problem, but it did not recur during

the trials. Sydney Ferries technical staff then turned their attention to examining the steering potentiometers in the Kwant controls of the three electronically controlled vessels.



Photograph 8: Partially disassembled steering potentiometer

1.34 Within the potentiometer is a disc-shaped conductive plastic resistance component (see *Photograph 8*). A pair of contact wipers offset at 90° travel around the surface of the disc, and the distance of the wiper away from the conductor tap varies the amount of output voltage at the wiper terminal. For example, if five volts is the input voltage when the wiper is closest to the input tap on the resistance disc, the output voltage will be close to five volts. However, as the wiper travels around the disc away from the input, the output voltage lowers linearly. The reason for the second wiper offset is to provide a differential voltage which enables the Schottel controller to determine steering direction, left or right. *Photograph 9* shows the shaft and wiper assembly removed from the potentiometer housing.

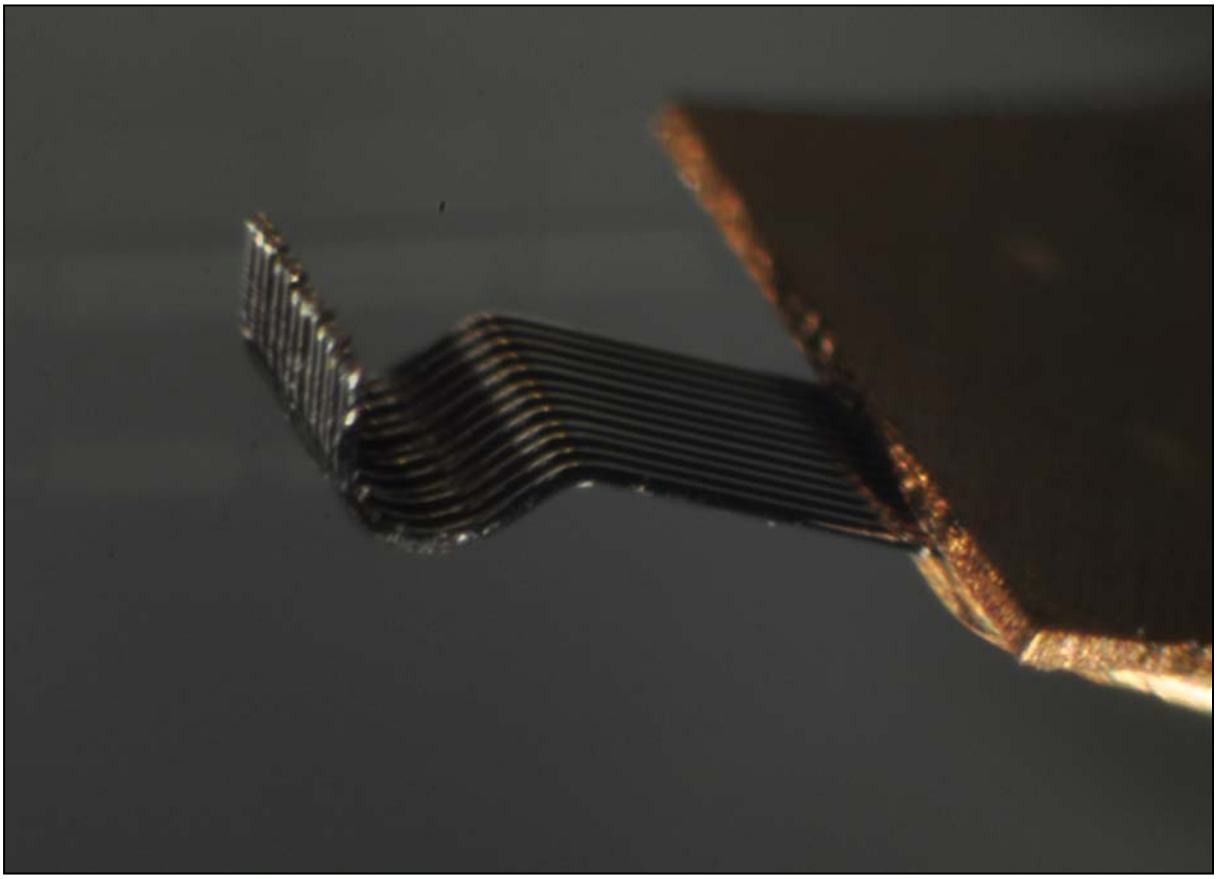


Photograph 9: Potentiometer shaft and wipers

1.35 No clear evidence of degradation of the conductive plastic surfaces was found which would suggest that the potentiometers were worn out. However, one theory held by Sydney Ferries' staff was that a build-up of resistance element material worn off through movement was causing the wipers to momentarily lift from the track during rotation, returning an open circuit signal to the Schottel control unit.

1.36 An examination of a potentiometer under a stereo microscope found that the wipers are made up of a group of individual wire wipers fixed to the wiper arm. *Photograph 10* is a photomicrograph of one of the wipers.

1.37 For an open circuit to occur, essentially all twelve of the wiper wires must lose contact with the resistive element. Furthermore, if the loss of contact is due to the wiper riding over a build-up of material worn from the resistive element, only an irregular voltage output should be returned because the material would be conductive to the same degree as its parent material.



Photograph 10: Photomicrograph of wiper contacts

1.38 Sydney Ferries' engineering staff were also of the opinion that, because older potentiometers were not as smooth to turn as new units when the potentiometer shaft was rotated, it was an indication of wear along the resistive element track. OTSI noted that the front shaft bearing of the potentiometer was not sealed on either side. As the potentiometers are fitted with the shaft in a vertical position and the steering potentiometers are fitted shaft end in to the assembly, small foreign particles may enter the bearing through the gap between the shaft and the housing, causing a noticeable reduction in smoothness.

1.39 The testing of potentiometers through the use of a digital multimeter and rotation of the shaft by hand is an unreliable means of testing. The only definitive test for whether or not a potentiometer is operating within the design parameters would be to run the potentiometer on a jig fitted with an event logger. Such a rig would need to spin the potentiometer through varying speeds and directions of rotation, while at the same time recording output

linearity and tracking any open circuit events. *Figure 3* shows how such an open circuit should display when plotted graphically.

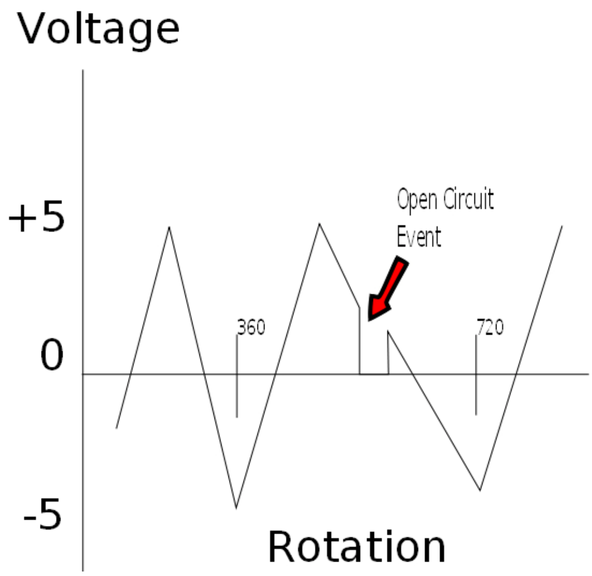


Figure 3: Graphical representation of how an open circuit would appear

1.40 The data sheets for the potentiometers used on the Kwant control heads claim a linearity of 0.25%, which means that when rotated, the voltage output should be within +/- 0.25% of a straight line when plotted on a graph. They also have an infinite resolution, meaning that there are no identifiable steps in resistance throughout the rotation of the potentiometer. Furthermore, they have manufacturer-specified rotational life expectancy of 50,000,000 shaft revolutions before measurable output discrepancies should occur. Assuming the environmental conditions of the potentiometers are not being exceeded, it would mean that they are either failing prematurely or because the equivalent of 50,000,000 shaft revolutions (1.8 x$10^{9\circ}$) is being exceeded.

1.41 OTSI was supplied with the raw data from 48 hours of VDRS information from an electronically controlled RiverCat in an attempt to derive an estimate of how long it might take to reach the life expectancy of potentiometers based on shaft revolutions. However, it was not possible to identify potentiometer absolute movement in degrees from this data.

1.42 The RiverCats operate on regular passenger services for periods of between nine and twelve hours a day every day of the week. This involves manoeuvring to dock and undock at approximately 200 wharves which

requires continual steering movements on both control units from various wheel house positions. The combined effect of docking manoeuvres, the constant steering adjustments required to maintain straight line travel and normal en route changes of direction accumulates a significant number of potentiometer shaft revolutions each day.

1.43 Potentiometers on the electronically controlled RiverCats had been swapped between control heads and vessels without a record being kept of the length of their operational service. Therefore, it is likely that at least some of the potentiometers on the electronically controlled RiverCats exceeded their effective design life-expectancy in the process.

1.44 Sydney Ferries removed the steering potentiometers from the electronically operated RiverCats and tested them on an oscilloscope. Three of the nine tested showed there were inconsistencies in their performance which was outside manufacturer's specifications, although the reasons could not be identified.

Failure Management

1.45 Each vessel class within Sydney Ferries is operated in accordance with a Vessel Operations Manual (VOM). The manual contains everything from vessel specifications through to control, monitoring and emergency management. The VOM for the RiverCat Class was based on the original mechanically controlled vessel. Differences between the electronically and the mechanically controlled vessels were subsequently notated in the VOM but not accompanied by sufficient performance and functionality detail necessary for Masters to fully understand the electronically controlled operation.

1.46 With the mechanically controlled vessels, the same control is exercised at all stations. In contrast, the electronically controlled vessels require a changeover and acceptance of controls when moving between the master control station and the wings, and this was not adequately covered in the VOM. The significant difference in operation between the two creates, in effect, two distinct classes of vessel and justifies separate VOMs.

1.47 Sydney Ferries also identified a discrepancy in the manner in which Masters were trained to operate RiverCats. The training was based around the mechanical control system and related procedures, with insufficient attention being paid to the distinct differences between electronic and mechanical control. Hence, Masters rostered for the electronically controlled RiverCats were not fully conversant with the most appropriate procedure to deal with failures or faults and treated both as failures.

1.48 Masters didn’t fully comprehend that, when a steering problem was encountered while operating from the wings, control could only be exercised from the master control position by accepting backup.

1.49 Masters were trained to immediately activate the backup mode in response to all alarms. However, on regaining control and reaching a safe location they would shut down and then restart the engines. This action reset the Kwant control system and erased the error identification display resulting in the loss of valuable information necessary for the Engineering Superintendent to be able to accurately identify the cause of the alarm and take appropriate remedial action.

1.50 Additionally, Masters believed they had suffered a control failure if transfer of control from a wing to the master position or vice versa was not immediately achieved, or if they observed ratchetting of a control head at another station. On these occasions they would respond in the same manner of shutting down and then restarting the engines.

1.51 Initially, after conversion to the electronic controls, most problems occurred in non-acceptance of transfer of control to a wing position from the master position. These were treated (and reported) as failures to which Masters responded by shutting down and re-starting engines with consequent loss of fault data. The transfer acceptance button on the wing had to be held down for two seconds. Because this action was not always successful in achieving transfer, ostensibly because the button was not being held down long enough, instructions were changed, requiring Masters to push the transfer acceptance button twice to affect transfer.

1.52 There was also a lamp test button immediately below the transfer accept button on the wing positions. This looked and felt the same as the transfer accept button. A Master looking ahead and concentrating on the distance to an upcoming docking location could mistake one for the other.

1.53 Realising that problems existed with the transfer acceptance process, in 2008 Sydney Ferries replaced the transfer accept button with a two part relay requiring only one push and also relocated the lamp test button to a position further away and changed the colour of the light.

1.54 The Sydney Ferries' Engineering Superintendent was on the scene immediately after the collision. He observed that the light indicator for backup mode for the starboard control was fixed at the master control position, indicating that the backup mode had been accepted as described by the Master.

1.55 When the alarm sounded, the display on the Schottel position indicator would have shown the starboard steering control still in the ahead position and not following movements of the control when the steering was rotated to go astern. To regain control in this situation, the Master needed to return to the master control and accept backup control as this cannot be done from a wing position. Alternatively, the Master could have immediately declutched which would have slowed the vessel and reduced the effect of subsequent impacts.

1.56 However, as evidenced by the CCTV and FLIR recordings, the Master had very little time in which to diagnose the problem, move to the master control and activate the backup system because of his immediate proximity to the wharf and other vessels.

Remedial Action

Training

1.57 During October and November 2010, Sydney Ferries engineering, management and crew representatives collaborated in discussions on the causes and remedies surrounding faults encountered on electronically controlled vessels. Realising that there had been a cluster of faults,

engineering and operations personnel met on 17 November 2010 to undertake a risk analysis workshop with the following planned outcomes:

- to establish what common faults and failures are occurring;
- to determine the method by which these can be identified by a Master; and
- to determine the actions a Master should take to best manage faults and failures and ensure the safety of crew, passengers and vessels.

1.58 What followed was the development of an enhanced training package for Masters of the electronically controlled RiverCats reflective of technical engineering information previously not provided which covers the clearer identification of types of faults, what they mean to vessel control and how to best manage them. Only Masters who have completed this revised training are authorised to drive the electronically controlled vessels. In conjunction with this, Sydney Ferries has upgraded the VOM such that mechanically and electronically controlled RiverCats are clearly identified and dealt with as separate variants.

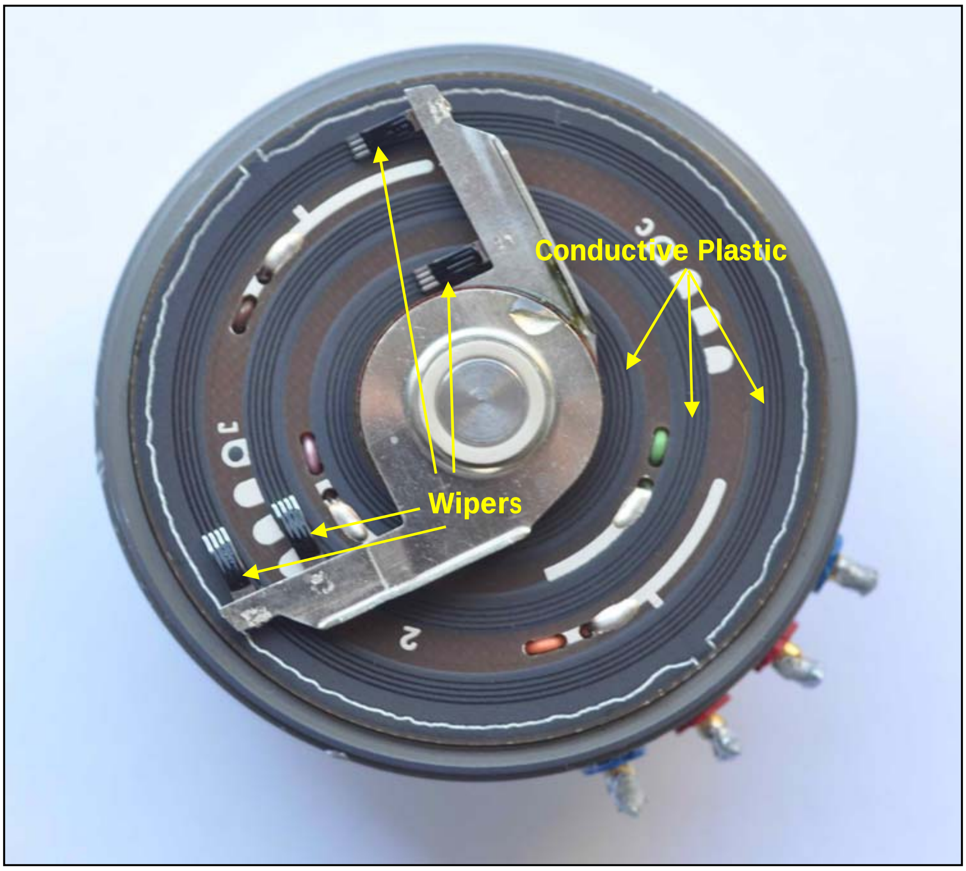
Control system maintenance

1.59 Sydney Ferries has undertaken a number of initiatives to guard against future problems with the RiverCat control systems, including the following:

- instituted a program of tracking individual potentiometers by numbering each unit and automatically replacing them after 12 months of use;
- replaced the potentiometer on the Schottel unit with a larger and more robust unit having a double conductive plastic surface allowing a constant connection (see *Photograph 11*);
- instigated a maintenance plan to replace the control board every four years;
- replaced the wiring connection for the control units with a pin connection in place of the screw terminal to ensure better connection and prevention of damage to wires during inspections;

- replaced the red light displayed by the starboard backup accept button with a green light so as to clearly differentiate between the starboard and port buttons (both were previously red); and
- installed a relay to reset the controls after a failure which eliminates the requirement to stop the engines and restart them with the consequent loss of data pertaining to the failure or fault.

1.60 The Kwant coded error display panels have been moved from a previous position under the main console to a position on the front of the console readily visible to the Master. However, in this position, the display can be bumped which can easily result in the settings being changed. A protective see-through guard or similar protection should be fitted to these units.



Photograph 11: Replacement SRP steering potentiometer

Data loggers

1.61 At start-up for the day on all vessels including RiverCats, Sydney Ferries' Masters are now required to check that data loggers are working, note the

result in their vessel logs, and inform the Operations Centre accordingly. If a data logger is found not to be working the Engineering Superintendent is to be notified immediately.

Other Observations

1.62 **Emergency stops.** During the investigation, several Masters brought the issue of the emergency or “crash” stop while under way procedure to the attention of OTSI Investigators. Sydney Ferries’ recommended procedure was to declutch, rotate the steering controls through 180° to the reverse position, then clutch in and apply increased throttle. In response, the vessel still continues to proceed forward under its residual momentum for four seconds before the clutch engages and throttle is allowed to be applied. Demonstrations showed that a more effective stop can be achieved by not declutching but reducing the throttle, rotating the steering controls 180° and immediately applying throttle. This eliminates the time delay of the disengaging and re-engaging of the clutch and results in a shorter stopping distance.

1.63 **In-line control fault alert.** Another observation during vessel trials was that when a fault occurred in the in-line control between a wing position and the central master control, there was no audible or visual alarm at the wing position to alert the Master to the problem.

1.64 **Crewing.** The crewing arrangement of the RiverCat and HarbourCat ferries differs from the remainder of the other five classes of vessels in operation by Sydney Ferries. These two classes operate with a dual certified Master holding a MED III Certificate of Competency while all the other classes operate with a dedicated Engineer. One of the tasks of this dedicated Engineer is to be on standby to initiate the backup procedure if a control failure occurs, whereas the backup procedure can only be undertaken by the Master on the RiverCat and HarbourCat ferries.

1.65 The following table provides a comparison of the crewing for three vessels of similar speed, type of service within the SF fleet.

Class	Length	Operating Speed	Pax	Survey Class	Crew
RiverCat	34.98m	22 knots	230	1D/1E	Master / MEDIII, 2xGPH
SuperCat	34.20m	24 knots	326	1D/1E	Master, Engineer, 2xGPH[3]
First Fleet	24.85m	12 knots	396	1D/1E	Master, Engineer, GPH

Table 1: Crew comparisons

The SuperCat Class of ferries is similar in operating speed, length and passenger capacity to the RiverCats but Sydney Ferries provides a crew inclusive of a dedicated Engineer. The First Fleet Class of ferries also carries a dedicated Engineer but the vessels are much smaller in length and operate at half the speed of the other two classes.

3 An additional GPH is required at night when more than 250 passengers are being carried.

PART 2 - FINDINGS

Causation

2.1 The collision between the Sydney Ferries' RiverCat *Marjorie Jackson* and Number 3 Wharf, then subsequently with the *Betty Cuthbert* was the result of a steering failure. Notwithstanding the absence of data from the vessel's voyage data recording system, which was not operational at the time, it is concluded that the steering failure was due to the failure of a potentiometer, a vital component within the vessel's electronic control system.

Contributing Factors

2.2 There was no system in place to monitor the service usage of potentiometers and so be able to identify when they were approaching the end of the manufacturer's specified life expectancy. Since existing potentiometers have been replaced and a number of initiatives implemented to guard against future problems with the RiverCat control systems, there have been no steering control failures on Sydney Ferries' electronically controlled RiverCats.

2.3 Due to inadequacies identified in both the training of RiverCat Masters and the contents of the vessel operations manual, with its emphasis on mechanically controlled vessels at the expense of electronically controlled vessels, RiverCat Masters were not equipped with sufficient knowledge to be effective in dealing with the complexities of managing the full range of control irregularities on electronically controlled RiverCats. The training has since been revised and the VOM upgraded such that mechanically and electronically controlled RiverCats are clearly identified and dealt with as separate variants.

Other Matters

2.4 Though the Kwant coded error display panel has been moved to a more readily visible position, it can be easily accidentally bumped which can result in settings being changed.

2.5 The time delay in a vessel stopping in response to an emergency ("crash") stop procedure can be decreased by using a modified version of the procedure currently recommended by Sydney Ferries.

2.6 There is no audible or visual alarm at the wing positions to alert Masters to an in-line control fault.

2.7 Crewing RiverCats with a dual ticketed Master/Engineer does not allow for the same redundancy as other similar vessels within the fleet which have a dedicated Engineer onboard to assist in an emergency should a control failure occur in close proximity to a wharf or other vessel.

PART 3 - RECOMMENDATIONS

3.1 As Sydney Ferries has taken positive remedial action in relation to control system maintenance and the training of Masters operating electronically controlled RiverCats, no recommendations in relation to these issues are deemed necessary.

3.2 In relation to other matters identified in the course of the investigation, it is recommended Sydney Ferries consider:

a. providing a protective cover over the Kwant indicator panel to prevent accidental resetting of codes;

b. evaluating alternatives that might improve the responsiveness of vessels to emergency stop procedures;

c. examining the feasibility of installing alarms on both wing positions to alert Masters to control faults originating between the master and wing position;[4] and

d. reviewing the crewing arrangements of RiverCats.

[4] This recommendation has been considered by Sydney Ferries' Engineering Division at Balmain Shipyard and deemed that the level of risk associated with the current arrangement is as low as reasonably practicable (ALARP) and that the modifications suggested would be excessively expensive.

PART 4 - APPENDIX

Appendix 1: Sources, Submissions and Acknowledgements

Sources of Information

- Sydney Ferries
- Kwant Controls-Sneek Holland-Integrated Potentiometers
- Novamarine Instruments Pty Ltd

Submissions

The Chief Investigator forwarded a copy of the Draft Report to the Directly Involved Parties (DIPs) to provide them with the opportunity to contribute to the compilation of the Final Report by verifying the factual information, scrutinising the analysis, findings and recommendations, and to submit recommendations for amendments to the Draft Report that they believed would enhance the accuracy, logic, integrity and resilience of the Investigation Report. The following DIPs were invited to make submissions on the Draft Report:

- Independent Transport Safety Regulator
- NSW Maritime Authority
- Sydney Ferries
- The Master of *Marjorie Jackson* at the time of the incident.

Written responses were received from all DIPs except the Master who gave a verbal indication of concurrence with the Report. The Chief Investigator considered all representations made by DIPs and responded to the author of each of the submissions advising which of their recommended amendments would be incorporated in the Final Report, and those that would not. Where any recommended amendment was excluded, the reasons for doing so were explained.

Acknowledgements

Sydney Ferries cooperated fully with the OTSI Investigators during the investigation providing Engineers, Masters and RiverCats on numerous occasions for consultation and vessel trials and demonstrations.

Photograph 1 was sourced from *Google Earth*.