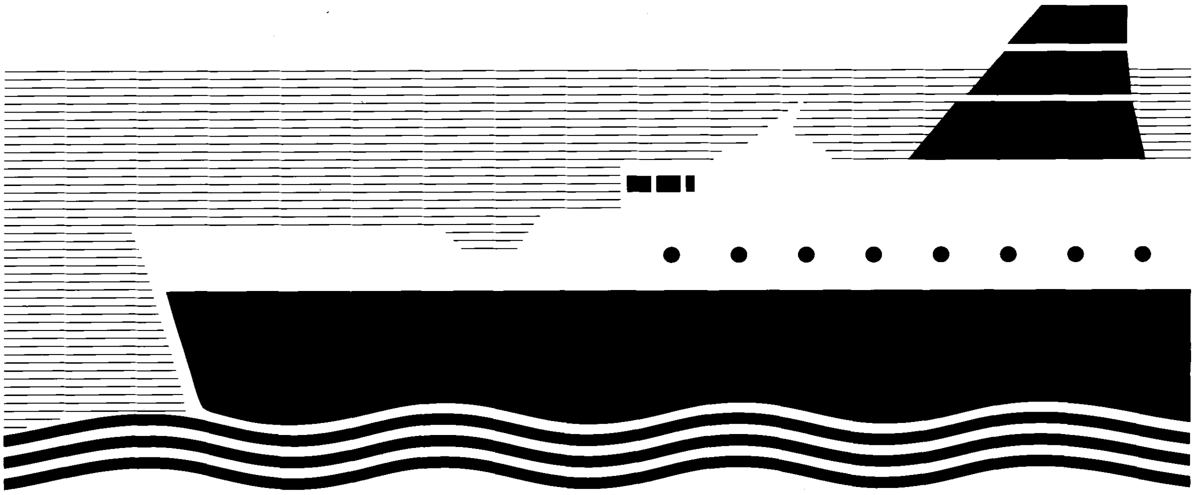
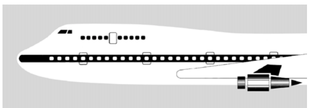
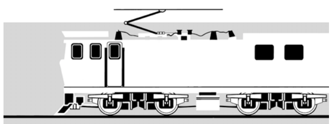
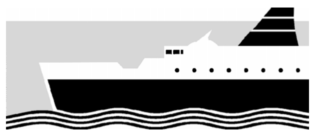


MARINE OCCURRENCE REPORT

05-202 and 05-204 **passenger freight ferry *Aratere*, steering malfunctions, Wellington Harbour and Queen Charlotte Sound,** **9 February and 20 February 2005**

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
TE KOMIHANA TIROTIRO AITUA WAKA

Reports 05-202 and 05-204

passenger freight ferry *Aratere*

steering malfunctions

Wellington Harbour and Queen Charlotte Sound

9 February and 20 February 2005

Abstract

On Wednesday 9 February 2005 and Sunday 20 February 2005, incidents involving steering malfunctions occurred on board the passenger freight ferry *Aratere* while the vessel was on passage between Picton and Wellington. In both incidents, the steering gear operating the port rudder failed to respond to command signals from the navigating bridge. However, in both incidents the navigation of the vessel was continued safely using the starboard steering gear and rudder.

Because of the similarities arising from each incident, both incidents have been combined into one report.

There were no injuries to passengers or crew during either of the incidents.

Because the *Aratere* was capable of being navigated and manoeuvred safely on either of the 2 independent steering systems fitted, and the crews exercised good Bridge Resource Management during the incidents, bringing each to a safe conclusion, no specific safety issues were identified.

Because of the safety actions taken by Toll NZ Consolidated Limited, no safety recommendations have been made.

The *Aratere* under way in the Marlborough Sounds

Contents

Figures

Abbreviations

°	degree(s)
AC	alternating current
ARPA	automatic radar plotting aid
BRM	Bridge Resource Management
ECDIS	electronic chart display and information system
kt	knot(s)
kW	kilowatt(s)
LED	light emitting diode
m	metre(s)
PCB	printed circuit board
ro-ro	roll on – roll off
T	true
UTC	co-ordinated universal time
VDC	direct current voltage
VDR	voyage data recorder
VHF	very high frequency

Glossary

athwartships	transversely across a ship, from one side to the other
bollard pull	a measure of the static pull a vessel can exert
bow thruster	a small athwartships propeller mounted in a tunnel at the forward part of a ship, used to manoeuvre a ship at low speeds
con (conduct)	direct the course and speed of a ship
gross tonnage	a measure of the internal capacity of a ship; enclosed spaces are measured in cubic metres and the tonnage derived by formula
helm	the amount of angle that a rudder is turned to port or starboard to steer the ship
knot	one nautical mile per hour
neap tide	tidal undulation that has the highest low water, and lowest high water, in a series
perigee	the point in a body's orbit at which it is nearest Earth
port	left-hand side of a ship when looking forward
rudderstock	vertical member of the rudder, to which the rudder blade is attached
solenoid	a mechanical device that converts energy into linear motion. Solenoids can be constructed to use electricity, compressed air (pneumatic solenoids), or pressurized fluids (hydraulic solenoids)
spring tide	tidal undulation that has the lowest low water, and highest high water, in a series
starboard	right-hand side of a ship when looking forward
steering gear	all connections and mechanisms between the steering wheel and the rudder, by the working of which the vessel is steered. More particularly the equipment mounted aft above the rudderstock and rudder

Data Summary

Vessel particulars:

Name:	*Aratere*
Type:	passenger freight ferry
Class:	✠ 1A1 car and train ferry A, general cargo carrier RO/RO DG-P
Classification:	Det Norske Veritas
Length:	150.00 m
Breadth:	20.25 m
Gross tonnage:	12 596
Built:	1998, Hijos de J. Barreras S.A. in Vigo, Spain
Propulsion:	four 3680 kW diesel generators driving four 2600 kW electric motors coupled in pairs through a reduction gearbox to two 4-bladed fixed-pitch propellers
Service speed:	19.5 kt
Owner:	Toll NZ Consolidated Limited[1]
Operator:	Interislander
Port of registry:	Wellington
Minimum crewing requirement:	12

Date and time:		9 February 2005 at about 2120[2]	20 February 2005 at about 0140[2]
Location:		Wellington Harbour	Queen Charlotte Sound
Persons on board:	crew:	30	24
	passengers:	155	2
Injuries:	crew:	nil	nil
	passengers:	nil	nil
Damage:		nil	nil
Investigator-in-charge:		Captain Iain Hill	

[1] New Zealand Railways underwent several changes of standing as a company after 1987, as did the rail ferry division. The current names, Toll NZ Consolidated Limited for the company and Interislander for the rail ferry division have been used throughout this report for consistency.
[2] Times in this report are New Zealand Daylight Time (UTC + 13 hours) and are expressed in the 24-hour mode.

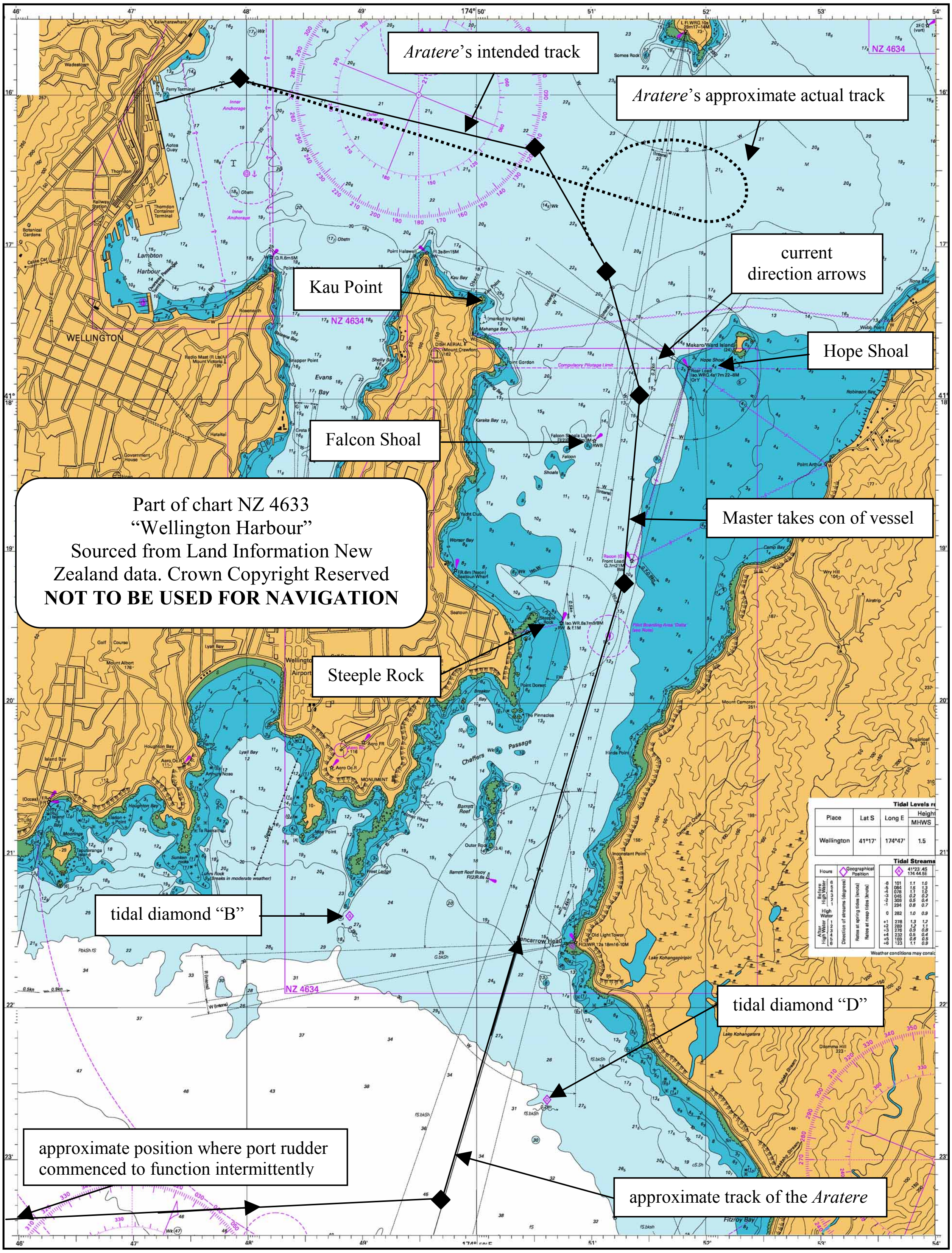


Figure 1
General area of the incident 05-202

1 Factual Information

1.1 History of the voyage

05-202 Wellington Harbour

1.1.1 On Wednesday 9 February 2005 at about 1800, the passenger and freight ferry *Aratere* departed from Picton ferry terminal with 155 passengers and 30 crew on board. The journey through the Marlborough Sounds and across Cook Strait was uneventful. The weather was calm and clear.

1.1.2 The Third Officer, who was on watch for most of the passage and had the con of the vessel, handed the watch and con of the vessel over to the Second Officer about the time the *Aratere* passed Karori Rock.

1.1.3 As the *Aratere* approached the entrance to Wellington Harbour, the Second Officer completed the pre-arrival tasks, which included summoning a helmsman and calling the Master to the navigating bridge.

1.1.4 When the helmsman arrived on the bridge, the Second Officer put him on the helm. The helmsman steered the ship according to the courses and helm orders given to him by the Second Officer.

1.1.5 The Second Officer conned the vessel into the entrance to Wellington Harbour and lined the *Aratere* on the entrance leading lights on a course of 016°T (see Figure 1). The helmsman experienced no difficulty in maintaining the course.

1.1.6 By this time the Master had arrived on the bridge. The Master did not take over the con from the Second Officer and allowed him to con the vessel through the channel under the Master's guidance.

1.1.7 Once the Second Officer had brought the *Aratere* onto a course of 005°T shortly after passing Steeple Rock the Master assumed the con of the vessel. The helmsman still experienced no difficulty in maintaining the course. As the *Aratere* approached Hope Shoal, the Third Officer relieved the Second Officer so that the Second Officer could ready himself for the berthing manoeuvre.

1.1.8 As the *Aratere* approached Hope Shoal, the Master could see that there was no other traffic likely to cause concern, so he ordered the helmsman to steer a course of 345°T. Shortly afterwards, when the vessel was abeam of Kau Point, the Master ordered the helmsman to steer a course of 330°T.

1.1.9 At about 2120, as the helmsman steadied the *Aratere* on 330°T, he informed the Master that he was having difficulty maintaining the course. The Master looked at the rudder indicators on his steering console and noticed that the indicator for the port rudder showed a steady 5° to 6° to starboard. The Master thought that the port rudder had stuck in that position because the starboard rudder continued to follow the helm commands.

1.1.10 The Master initially took control of the helm from the helmsman and tried to free the port rudder by using that rudder independently from the starboard rudder. He was unable to regain control of the port rudder by this action. The Master then decided to stop the vessel to investigate the fault further before proceeding with the berthing.

1.1.11 The Master told the Third Officer to inform the engine room and to then stop the propulsion motors. He contacted the high-speed ferry that was entering the harbour astern of him and Wellington Harbour Radio by very high frequency (VHF) radio and informed them of his intentions. He also contacted the Day Master on board and the Interislander duty manager and informed them of the problem.

1.1.12 The ship's Electrician, who had been in the wheelhouse, went and told the chief and first engineers about the problem and returned with them to the bridge.

1.1.13 The Master, having determined that there were no small boats in the vicinity, conned the ship to starboard out of the main shipping lane towards Somes Island. When the propulsion motors had stopped the Master ordered astern power to bring the *Aratere* to a stop in the water.

1.1.14 The engineers and the Electrician were unable to discover what was wrong with the port steering gear from the bridge. They then went to the port steering gear room, electrically isolated the steering gear from the navigating bridge and, using the local controls, brought the rudder back to amidships and shut the system down.

1.1.15 The Master, using both engines, bow thruster and the starboard rudder only conned the *Aratere* in a turn to starboard, returning the ship to its planned track across Wellington Harbour, falling in behind the high-speed ferry, and berthed the vessel at the ferry terminal without further incident.

1.1.16 After arrival at the ferry terminal the Electrician and engineers carried out extensive tests on the port steering gear but were unable to identify or replicate the fault in the steering gear. They also attached electronic monitoring equipment to the port steering gear to monitor and record the signals received from the steering consoles on the navigating bridge.

1.1.17 The *Aratere* sailed for Picton later that night with both rudders operational, with an engineer in the port steering gear room to assume control of the steering gear should it malfunction. The *Aratere* made the voyage to Picton, using the northern entrance to Queen Charlotte Sound at the Marlborough Harbourmaster's instruction, without incident.

1.1.18 Shore technicians downloaded data from the voyage data recorder after the incident and this was played back for analysis. From this data the port rudder was shown to have ceased working synchronously with the starboard rudder from a point outside the Wellington Harbour entrance channel. From this point on the port rudder was seen to make only intermittent movements to starboard.

05-204 Queen Charlotte Sound

1.1.19 On Sunday 20 February 2005 at about 0132, the *Aratere* departed from Picton ferry terminal with 2 passengers and 24 crew on board. The Master had the con for the departure.

1.1.20 At about 0140, the Master noticed that the port rudder was not following the helm orders as sent from the helmsman's station on the bridge. The port rudder would move to starboard, but not to port.

1.1.21 At about 0144, as the *Aratere* passed Mabel Island, the Chief Engineer, Electrician and other engineers, having been told of the problem by one of the bridge team, went to the port steering gear room to investigate. Because they could not immediately rectify the problem, the Chief Engineer ordered the port steering gear to be put to amidships and locked into position.

1.1.22 At about 0155, the Master ordered the engines to be stopped and the crew to standby ready to let the anchors go if they were required. At about 0200, the Master decided to take the ship to anchor to allow the engineers to determine the cause of the problem.

1.1.23 The Master conned the vessel towards the designated anchorage area in Queen Charlotte Sound (see Figure 2), and at about 0210 he ordered the port anchor to be let go. The Master then informed the Harbourmaster via Picton Harbour Radio, and Interislander of his actions.

1.1.24 After the vessel was at anchor, the Electrician and engineers determined that no electrical signal was being received by the port steering gear from any of the steering positions on the navigating bridge, other than the non-follow-up steering on the main control console.

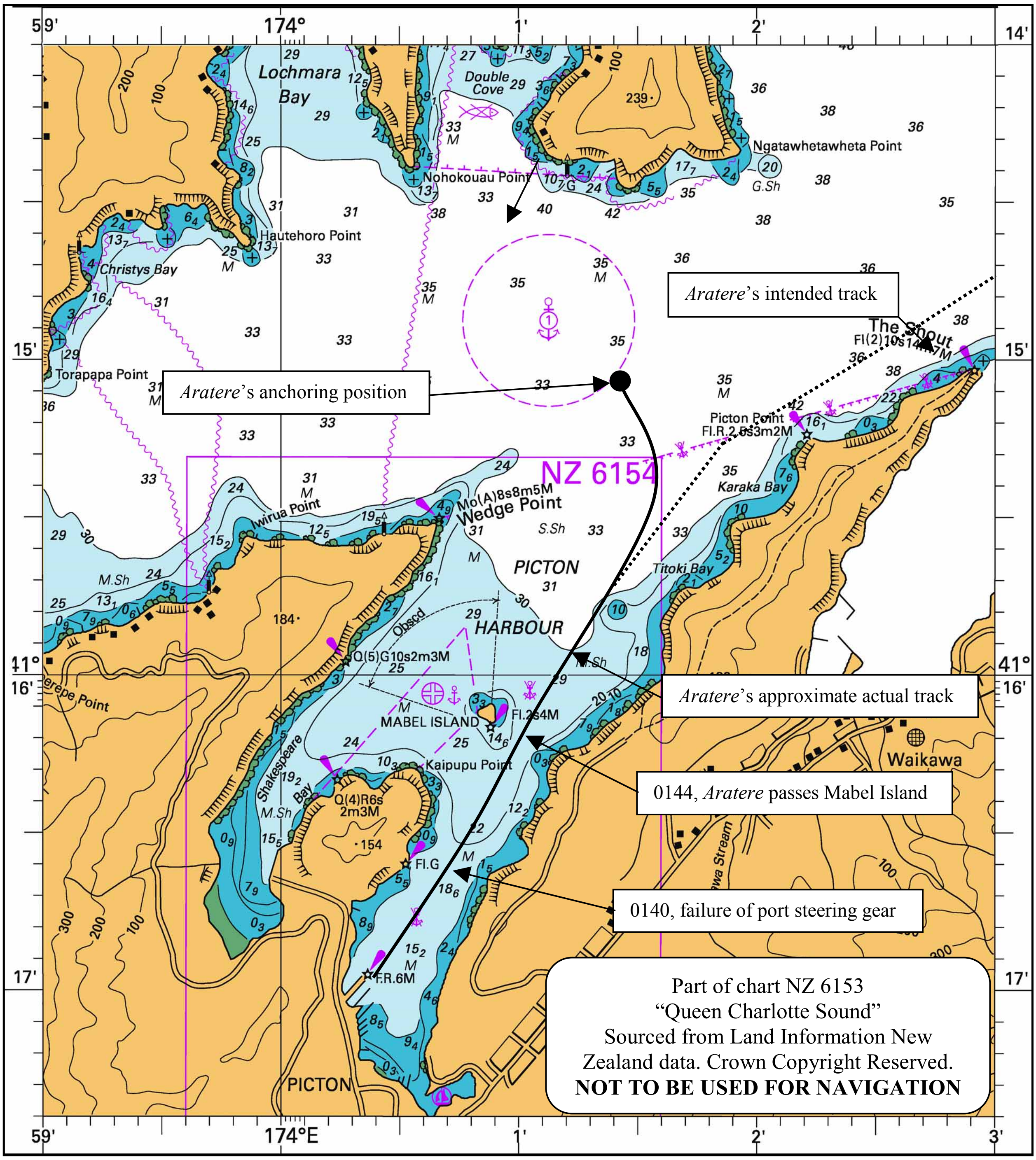


Figure 2
General area of the incident 05-204

1.1.25 The Electrician checked the below-deck equipment located under the navigating bridge. He found that the port amplifier board (see Figure 3) was not receiving an electrical signal for the port rudder to go to port. The Electrician interchanged the port and starboard output circuit boards but the fault remained on the port rudder. He then interchanged the port and starboard amplifier circuit boards, and both the port and starboard systems worked correctly. He then checked and cleaned the edge connectors on the port and starboard amplifier circuit boards. This appeared to remedy the fault, but the Electrician could not prove that dirty contacts were the cause of the fault.

1.1.26 The Master, after receiving permission from the Marlborough District Harbourmaster and the Maritime Safety Authority, weighed anchor and continued on passage to Wellington via the northern entrance of Queen Charlotte Sound. Both the starboard and port rudders were operational throughout the passage and no faults were experienced on the passage. On arrival in Wellington, the operator sent the amplifier circuit boards ashore for testing.

Post-incident actions

1.1.27 On 20 February 2005, after the *Aratere* arrived in Wellington, shore-based technicians examined the suspect printed circuit boards (PCBs). Under visual examination no fault could be seen with the boards.

1.1.28 Technicians sailed on the vessel over a period of days to investigate faults in the electrical telemotor system. They discovered:

- that there was an alternating current (AC) ripple on the power supply for the port servo system
- that the light-emitting diode (LED) indicators on the port control PCB were coming partially on, then fully on, showing that both port and starboard commands were occasionally being given simultaneously
- that a leg on the diode bridge network of the power supply system for the port servo system had become detached
- that the starboard rudder had a 1.5° to 2° error to starboard such that when the port rudder was at 10° to port the starboard rudder was at 8° to port when read at the rudder.

The technicians carried out the following remedial actions. They:

- replaced suspect capacitors on both the port and starboard servo system power supplies
- replaced the bridge diode network on the port servo system power supply
- replaced the amplifier integrated circuit on the port amplifier PCB
- carried out a full system alignment following the manufacturer's instructions
- corrected errors and adjusted the helm servos.

1.2 Vessel information

1.2.1 The *Aratere* was a passenger and freight ferry operated by Interislander, a division of Toll NZ Consolidated Limited (the owner). The ship was certified to carry a total of 399 persons and was capable of carrying both rail and vehicular cargo. The *Aratere* was in class with Det Norske Veritas and was built in Spain in 1998. The ship traded on a scheduled service between Wellington and Picton with a service speed of 19.5 kt.

1.2.2 The *Aratere* was powered by up to 4 diesel-driven DC generators that provided electrical power as required, via frequency converters, to 4 AC electric propulsion motors; 2 to each shaft. The 2 electric motors on each shaft drove a fixed-pitch propeller through a reduction gearbox. The maximum power rating of the propelling machinery was 10 400 kW.

1.2.3 Two rudders provided steering, one aft of each propeller. The rudders could be used either linked, where both rudders moved in the same direction to the same degree, or independently, where the operator controlled the direction and the degree of each rudder independently. In both incidents the Master used the rudders linked. In addition, the *Aratere* had 2 bow thrusters, each with a maximum power rating of 1000 kW, equivalent to 13 tonnes bollard pull each.

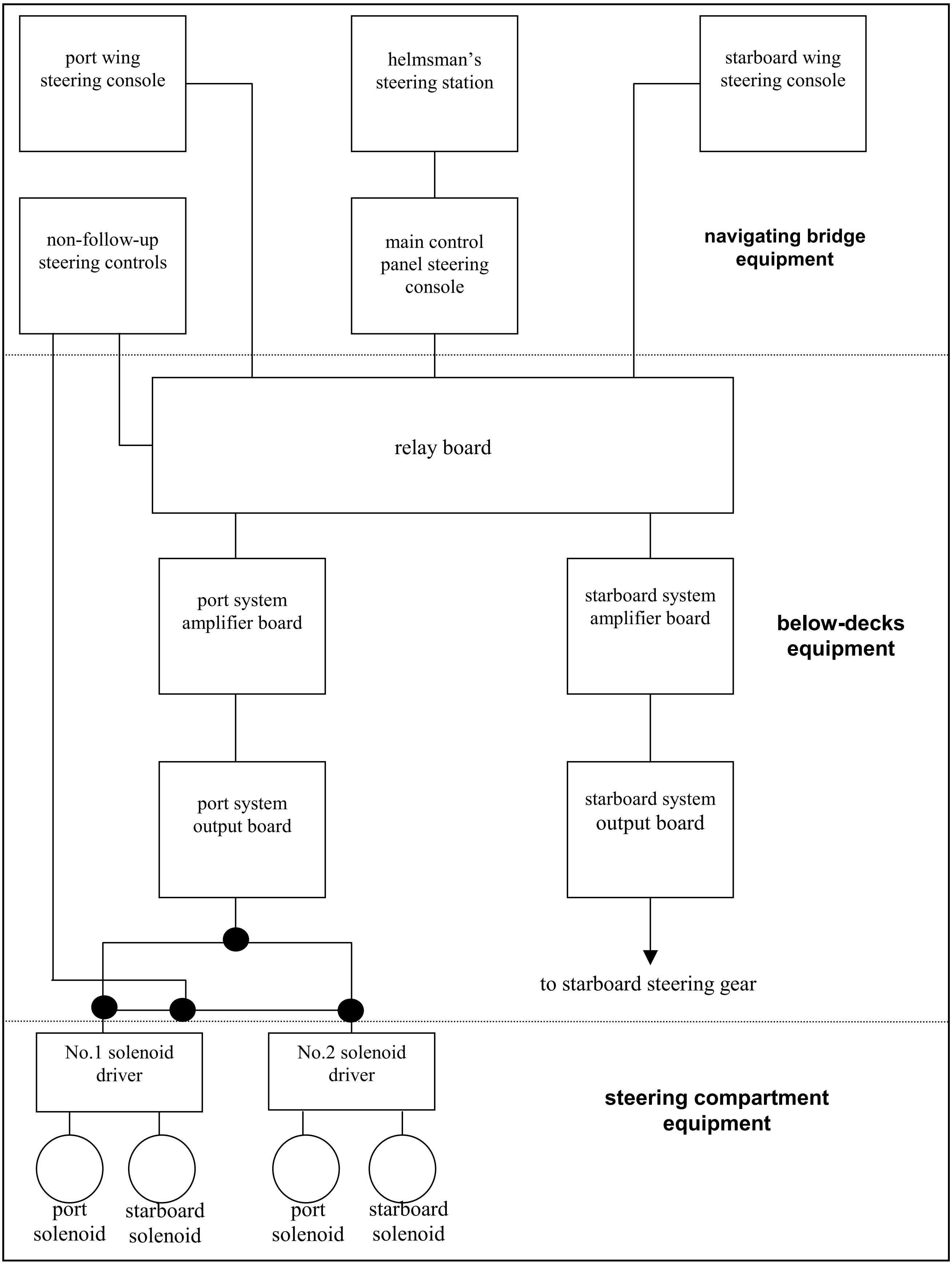


Figure 3
Diagram of the port rudder control circuit on board the *Aratere*

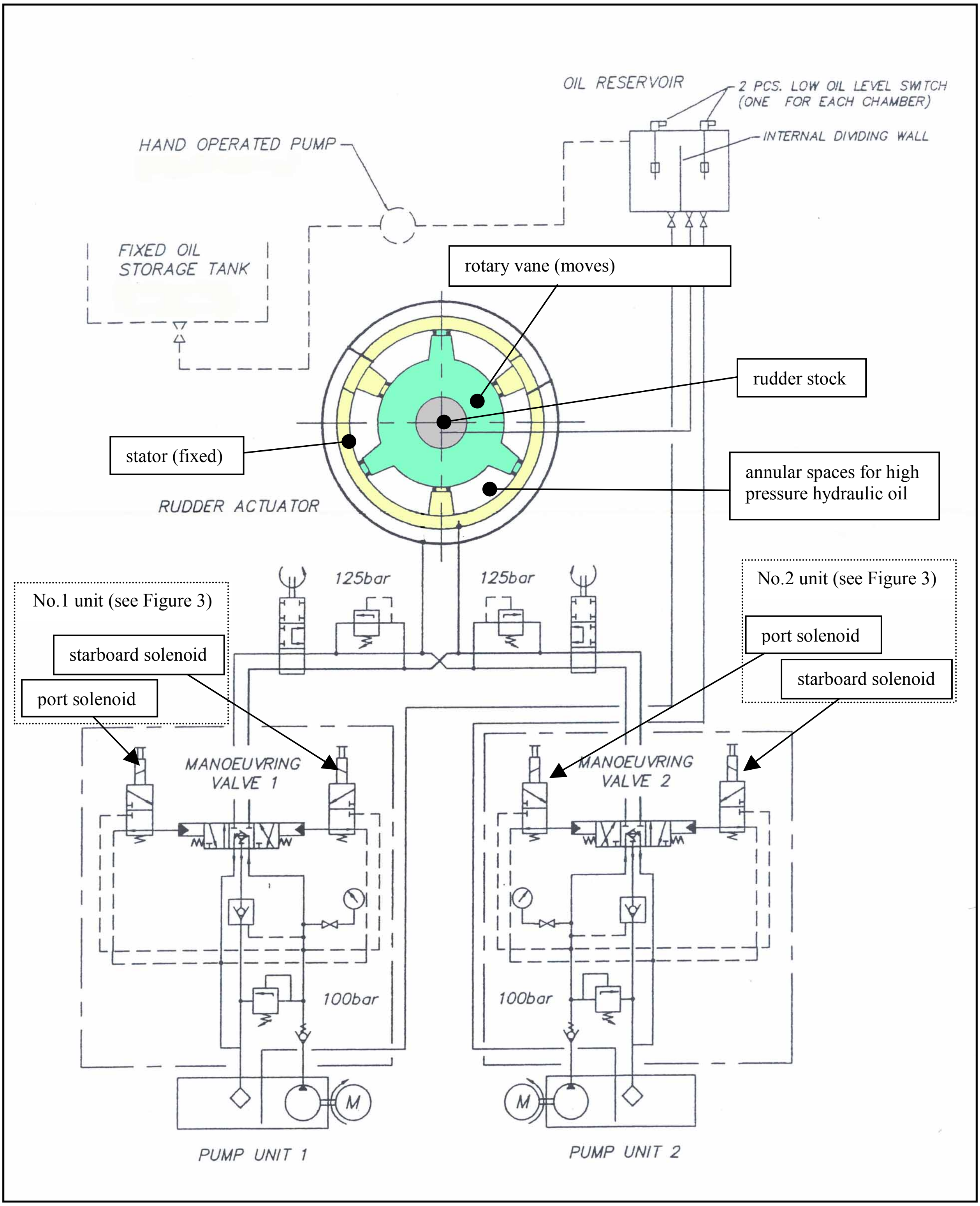


Figure 4
Port steering gear hydraulic circuit diagram

1.2.4 The navigating bridge of the *Aratere* was fitted with 3 manoeuvring consoles, the main console located in the centre of the wheelhouse and one each located at the port and starboard enclosed bridge wings. All the consoles had controls for the bow thrusters, engine, steering, telephone communications, VHF radio communications, searchlights, screen wipers and an electronic chart display and information system (ECDIS). The ship was also fitted with 2 automatic radar plotting aid (ARPA) radars that could be linked into the ECDIS system. Readouts of the wind direction, velocity and the ship's rate of turn were also fitted.

1.2.5 The *Aratere* was fitted with a voyage data recorder (VDR). A VDR is designed to maintain continuously, sequential records of pre-selected data items relating to status and output of the ship's equipment and command and control of the ship. The VDR achieves this by electronically recording signals from many items including: helm position, radar, engine settings, courses steered, speed, depth of water, bridge voice conversations, etc. This data could be downloaded after an incident for analysis ashore.

1.2.6 The helmsman steered the ship, when in pilotage and other congested or difficult waters, under the command of the Master or the officer of the watch. He steered the ship from the helmsman's console located aft of the main console on the bridge. This console was equipped with compass repeater, helm control [wheel] and 2 analogue rudder indicators, one each for the port and starboard rudders (see Figure 5). The illumination on the console could be dimmed so as to prevent glare for the helmsman and other bridge team members.

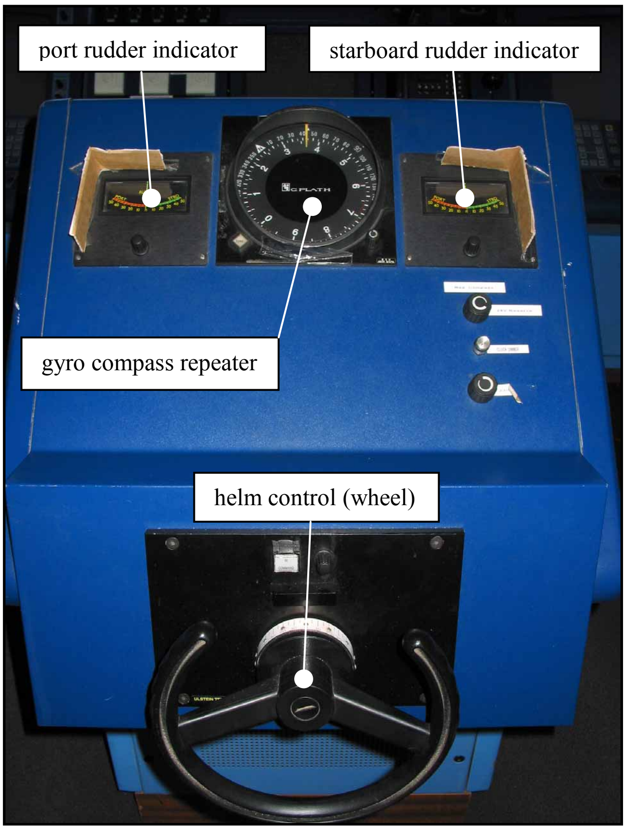


Figure 5
Helmsman's console

1.2.7 At the time of the Wellington Harbour incident the helmsman was steering the *Aratere* using both visual references through the windows at the front of the bridge, and the compass. Out of choice the helmsman tended to use the compass repeater located above the bridge front windows. The lighting on the console had been dimmed so as not to overly distract his attention, with the starboard rudder indicator brighter than the port indicator. The helmsman stated later that he used the starboard indicator for reference, although both were readable, as it was confusing trying to look at both at the same time.

1.3 Steering gear overview and operation

1.3.1 The Commission engaged an independent electronics and electrical specialist to critically review the electrical plans, technicians' and crew reports, and actions taken after the steering malfunctions.

1.3.2 The hydraulic pumps which moved the 2 rudders were controlled from the bridge by an electronic telemotor system. Commands were electrically conveyed to the hydraulic actuators mounted on each rudderstock. Each rudder had its own dedicated hydraulic system that rotated the rudder by either of the dual hydraulic pump systems or both together. The hydraulic pump systems rotated the common rudder actuator vane motor through their respective rudder manoeuvring valves.

1.3.3 Control inputs came from the various bridge stations such as the helm, main steering stand, autopilot and wing stations. The input signal was compared with the actual rudder position signal and the difference (error) amplified and applied to the hydraulic actuators to drive the rudder in a direction that reduced the error signal towards zero. When the error signal reached zero, the rudders were in the desired position and they remained there until another control input change was made. A separate rudder position and feedback unit was located on the starboard rudder. This appeared to provide a synchronising signal to ensure that the 2 rudders tracked together.

1.3.4 The system had built-in redundancy and manual back-up features, so that if various items within the control loop failed, the ship's steering system could be kept operational. For example, the input signal source could be selected from a variety of steering systems for automatic servo control, but could also be manually bypassed, non-follow-up, to enable direct remote control of the rudder actuators without the automatic servo feedback control loop. The ship had 2 separate rudders with their own dedicated control servo systems, but they could also be operated synchronously. The hydraulics could also be operated manually from within the respective steering gear rooms by physically switching the manoeuvring valves or using a hydraulic hand pump.

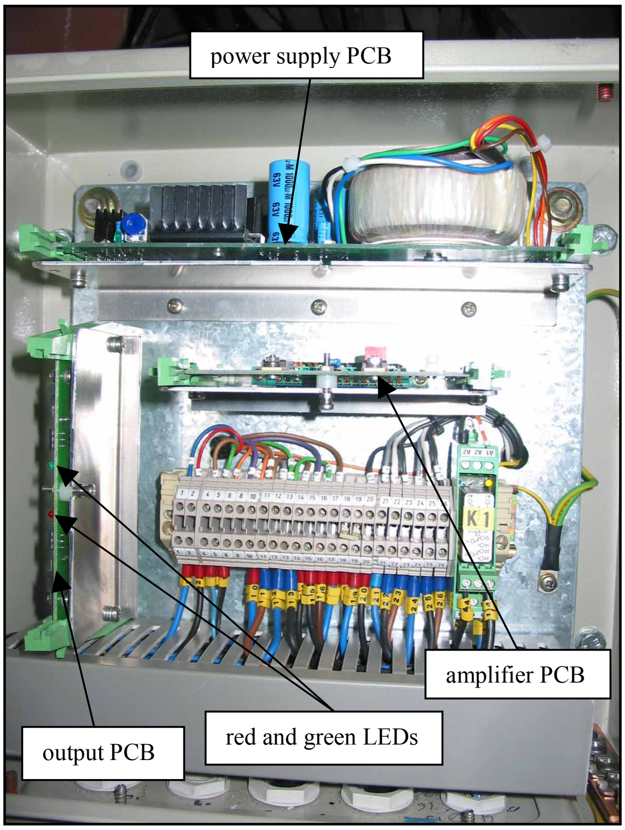


Figure 6
Interior of the port follow-up amplifier assembly cabinet

1.3.5 Remote alarm display and pump controls were located in the engine control room and bridge. All alarms associated with the rudder steering systems were displayed on these panels and some were repeated to and recorded by the engine room alarm system. The main power for each rudder control system was derived from the ship's power supply distribution to the respective pump starter unit, and then out to the peripheral devices.

1.3.6 The main power supplies and hydraulic control equipment were located in the respective port and starboard steering gear rooms. The servo follow-up amplifiers and the relay selection cabinet were located in the crawl space under the bridge. The main alarm panel was located in the engine control room. A slave alarm panel and the control panel inputs were located on the bridge. Once the control input was manually selected from one of the bridge stations all the interlocks were automatically made in the relay selection cabinet.

1.3.7 Within the servo follow-up amplifier cabinets (see Figure 6) there were 3 PCBs:

- a power supply board
- an amplifier board,
- an output board.

The output board had red and green LED status lights and also provided volt-free relay contacts to interface with the alarm systems. From the on board documentation the purpose of the LEDs was not clear but they appeared to indicate a healthy power supply status for the 24 VDC power supply.

1.3.8 The power supply for the solenoid drivers was located in the hydraulic pump starter units in the respective steering gear rooms. The power supply was fed from these units to the solenoid valves on the steering gear unit and then to the follow-up amplifier, located in the crawl space under the bridge, where it was electronically switched to the zero volt rail. The solenoid valves drew about 1 amp at 24 VDC on load.

1.3.9 Hydraulic vane motors attached to the rudderstock drove the rudders. Two separate and independently operated hydraulic pump motors provided the hydraulic oil pressure either alone or together to operate the vane motor on each rudder. The 2 hydraulic systems had their own pump and oil sump but shared a common bulk oil reservoir. The systems acted upon separate manoeuvring valves to direct the hydraulic oil to drive the rudder vane motor to port or starboard. The 2 manoeuvring valves were operated independently by the same servo system, which switched the port and starboard solenoid pilot valve to direct hydraulic oil to change the position of the main manoeuvring valve.

1.3.10 Whenever there was an error signal between the set-point rudder position from the bridge and the actual rudder position sensed by the rudder feedback unit mounted on the vane motor, the servo amplifier would switch one of the manoeuvring valve solenoid pilot valves on to rotate the rudder in a direction that would reduce the signal error towards zero.

1.4 Personnel information

05-202 Wellington Harbour

1.4.1 The Master went to sea in 1972 as a fisherman, progressing to work on Australian coastal vessels until he gained his Master's certificate in 1993 after which he joined Interislander. He had risen to the rank of Chief Officer in Interislander and had been appointed as a relieving Master in 2003.

1.4.2 The Third Officer had gone to sea in 1991, gaining his Master's certificate in 2000. He had joined Interislander in March 2004 and had served as a Third Officer on board the *Aratere* since then.

1.4.3 The helmsman had joined New Zealand Railways, a predecessor to Interislander, in 1977 as a deck boy and had progressed to the rating of able seaman. He had served in that capacity on board the *Aratere* since 1999.

1.4.4 The Chief Engineer served in overseas vessels until 1967, when he emigrated to New Zealand. He joined Rail Ferries, a predecessor to Interislander, in 1967. He gained his Chief Engineer's certificate in 1976, and had served in that capacity since 1977.

1.4.5 The Electrician had qualified as an electrical engineer in the United Kingdom before studying to become a marine radio officer. He then worked for a British company in its space and defence division before emigrating to New Zealand. He lectured in industrial electronics, electrical installation and radio communication at a New Zealand polytechnic before joining Interislander as a third Electrician in 1994. Since joining Interislander, he had served on several of the company's ferries.

05-204 Queen Charlotte Sound.

1.4.6 The Master went to sea in 1971 and gained his Master's certificate in 1981 after which he joined Interislander. He had been appointed as Master in 1994, and had served in that capacity since then on Interislander ferries.

1.4.7 The Chief Engineer was the same person who was the Chief Engineer during the incident on 9 February 2005.

1.4.8 The Electrician was the same person who was the Electrician during the incident on 9 February 2005

1.5 Climatic and tidal conditions

05-202 Wellington Harbour

1.5.1 The weather at the time of the incident was variously described by the bridge team on board the *Aratere* as being a moderate north-east to north-north-easterly breeze of about 15 kt with a slight sea and good visibility.

1.5.2 The predicted tides for Wellington, detailed in the New Zealand Nautical Almanac for 9 February 2005, were:

Wellington							
Low Water		High Water		Low Water		High Water	
1059	0.5 m	1705	1.6 m	2311	0.5 m	0532 (10th)	1.8 m

1.5.3 The range of tides tabulated in the New Zealand Nautical Almanac for Wellington was 1.03 m for the spring range and 0.93 m for the neap range. The range at the time of the incident was 1.1 m and therefore a large spring tide.

1.5.4 Tidal stream rates were shown on the chart for specific geographical positions designated by a magenta diamond shape enclosing a letter, known as a tidal diamond. The rates shown are for average spring or neap tides referred to high water at Wellington. If the tidal range is greater than normal (e.g., full or new moon coinciding with perigee) the rates will be increased roughly in proportion. The spring rates for relevant diamonds as shown in Figure 1 were:

Position	Time	Direction	Rate
Diamond "B"	2005	278°	0.4 kt
Diamond "D"	2005	044°	0.3 kt

1.5.5 The flood and ebb stream currents, where they run generally in opposite directions, are depicted on the chart by means of arrows with the rate of flow of the stream in knots alongside. "Feathers" on the tail of the arrow depict the flood stream.

05-204 Queen Charlotte Sound

1.5.6 The weather at the time of the incident was described as being partly cloudy with a south-westerly breeze of about 10 kt with a slight sea.

1.5.7 The predicted tides for Picton, detailed in the New Zealand Nautical Almanac for 19/20 February 2005, were:

Picton							
High Water		Low Water		High Water		Low Water	
1613	1.1	2158 (19th)	0.6 m	0412 (20th)	1.0 m	1157	0.6 m

1.5.8 The range of tides tabulated in the New Zealand Nautical Almanac for Wellington was 1.44 m for the spring range and 0.54 m for the neap range. The range at the time of the incident was 0.4 m and therefore a small neap tide.

1.5.9 The Marlborough District Council Harbourmaster considered the tidal current in Picton Harbour to have a maximum rate of about 0.5 kt flowing in a circulating movement around the harbour. The movement was clockwise on the flood tide and anti-clockwise on the ebb tide. The tide at the time of the incident was flooding and being a neap tide would not attain the maximum flow rate.

1.6 Damage

1.6.1 The *Aratere* sustained no damage during either incident.

1.7 Bridge Resource Management

1.7.1 Bridge Resource Management (BRM) is the use and co-ordination of all the skills and resources available to the bridge team to achieve the established goal of optimum safety and efficiency.

1.7.2 The use of BRM helps eliminate the potential for one-person error, and aids the flow of information between members of the bridge team, and between the bridge team and the outside world. Part of the flow of information between members of the bridge team is challenge and response and the use of closed-loop communications to ensure that orders and information are heard and understood.

1.7.3 When used effectively, BRM ensures that all the bridge team members share a common view of the intended passage, maintain situational awareness, anticipate dangerous situations, acquire all relevant information and act upon it in a timely manner, avoid an error chain being formed, and aims to prevent preoccupation with minor problems.

2 Analysis

05-202

2.1 Although the helmsman stated that he experienced no difficulties in maintaining the course as the ship started to enter Wellington Harbour, he probably had been compensating for the malfunction of the port rudder by increasing the amount of port helm he applied. He probably considered that the ship was being affected by the tidal currents in the area and required more helm to counteract these.

2.2 The weather and visibility were good at the time of the incident and the experienced helmsman’s decision to steer by eye with occasional glances at the compass repeater and helm indicators, was a reasonable decision in the circumstances.

2.3 During the helmsman’s occasional glances at the helm indicators on his console, his eye would be drawn more to the starboard indicator than the port indicator because its brighter illumination made it easier to read. As the starboard rudder did not malfunction, he was probably unaware that the port rudder was not working in synchronisation with the starboard rudder.

2.4 The helmsman appropriately brought the bridge team's attention to the fact that he was having difficulty in maintaining the desired course, as soon as he became aware of the problem.

2.5 The Master quickly assessed the situation and decided to leave the main shipping route and steer into safe, deep water to the north and east. His actions were appropriate and taken in good time and in consideration of the fast ferry approaching from astern.

2.6 Had the Master not taken the ship out of the main shipping route, the *Aratere* may have become a significant hazard for the fast ferry closing from astern.

2.7 The Chief Engineer, Electrician and other engineers reacted appropriately to the malfunction and contained the situation by manually isolating the port rudder to allow the ship to berth safely with the minimum of delay.

2.8 When the port rudder was isolated the ship was still making headway, albeit slowly, and was turning to starboard. It was therefore reasonable for the Master to continue the swing to starboard and con the ship around in a controlled turn before continuing on to berth the ship at the ferry terminal.

05-204

2.9 On the 20 February sailing from Picton, the Master and bridge team soon realised that the port rudder was malfunctioning and the Master, in conjunction with the bridge team, made the decision to take the ship to the nearby anchorage area out of the main shipping route. The action taken was reasonable and the ship did not continue on passage until the Master and engineers, the operating managers and the regulatory authorities considered it safe to do so.

Both incidents

2.10 In both incidents, the bridge teams worked together well and showed good use of BRM. BRM, like all skills learnt, is susceptible to biases and errors such as "cutting corners" that can creep into actions when teams work together. Although both bridge teams exhibited good use of BRM it would be advantageous to have a programme of training and practice to reinforce BRM techniques amongst members of bridge navigation teams. A safety recommendation (043/05) was made by the Commission and accepted by Interislander to cover this training after the investigation into the near grounding of the *Aratere* (Marine Occurrence Report 04-214).

2.11 After the steering failure in Queen Charlotte Sound (05-204) the ship's crew checked the control signal input from several sources. The Electrician then decided that the problem was further downstream so checked the amplifier assembly under the bridge. The crew and technical reports indicated that the red and green LEDs on the output card were interpreted as port and starboard drive signals to the solenoid pilot valves. The port (presumably red) LED on the port follow-up amplifier assembly was not working, which was interpreted by the Electrician to mean that the output signal for the port drive direction was not working on the port rudder servo system. The action taken was to swap the output card between the two separate port and starboard servo systems, but it resulted in no change. The amplifier cards were swapped next and the fault disappeared, indicating that the edge connector on the port rudder's amplifier PCB may have been the problem.

2.12 The action taken after 05-204 followed a logical fault-finding technique, and the conclusion that the fault was a poor connection to the amplifier card was reasonable. This symptom was similar to the previous steering system failure in Wellington Harbour (05-202), which was probably caused by the same fault.

2.13 The main clue was the power supply LED in the port follow-up amplifier assembly being off. This indicates a power supply failure or a poor connection between the power supply board and the output board. The problem was that the purpose of this LED was not very clear. The crew thought that it indicated the lack of a port drive signal to the solenoid valves but it appeared more likely to indicate the failure of the negative 24 VDC power supply within the follow-up amplifier assembly. The action taken at this stage did not identify the fault but it went away. The fault appeared to be intermittent and was attributed to a poor connection to the edge connector on the amplifier board. It was more likely that the fault was a power supply problem within the follow-up amplifier assembly and unrelated to the amplifier card or its edge connector. The action of replacing the boards probably physically disturbed the actual fault and temporarily made the system work again.

2.14 The problem that occurred with the steering system on 9 February (05-202) was most likely caused by the same fault that caused the 05-204 steering failure.

2.15 The amplifier and output boards were examined visually and no fault was seen. The technicians may not have had the test facilities to set up an operational test, and the lack of clear documentation may also have been a hindrance, but a visual inspection would not have confirmed that the cards were operational. This inspection would have only revealed an obvious component failure or dry joint so it could only be concluded that these types of fault were not present but that the cards could still be faulty.

2.16 During checks made while the ship sailed, the shore technicians observed that the LEDs on the output card were flickering on and off and suspected it was caused by AC ripple. Some capacitors were replaced but it did not fix the intermittent fault. The shore technicians also replaced the same capacitors on the starboard follow-up amplifier assembly.

2.17 Although not clearly stated, the shore technicians' report appeared to say that the LEDs were still flickering and a diode bridge on the power supply in the follow-up amplifier assembly was found to be faulty (intermittent connection) and replaced. A temporary replacement was fitted then a proper replacement fitted when the ship berthed. The output amplifier was also replaced at the same time. This did not fix the intermittent problem. Several errors were then discovered in the accuracy of the servo tracking system, but repairs seemed to concentrate upon the follow-up amplifier assembly under the bridge and ignored the pump starter units, solenoid power supply, relay cabinet and interconnecting cables.

2.18 The fault was an intermittent one so it may still exist or it may have been accidentally fixed while fault-finding. The problem was that the documentation did not accurately reflect the installed equipment on the *Aratere,* so fault-finding is a process of educated guesses to eliminate progressively a fault within a geographically spread system where the fault-finders are not familiar with its structure. The 24 VDC power supply seems to have been where the problem was located and the "flickering" LEDs would indicate that it was something intermittent such as wiring connections or a component dry joint. The assumption that the LEDs were an indication of the solenoid drive signal seems to have been incorrect and led the fault-finders to believe that the solenoids were losing their drive signal. It is more probable to assume that the LEDs were an indication of a power supply failure to the bridge control signal input and indication devices. The effect would be the same with the inability of the steering system to rotate the port rudder to port, but the fault would be in the sensing side of the control system rather than the actuation of the rudder rotation. The faulty diode bridge may have been the main cause of both steering system failures but only if the diode bridge were the one in the follow-up amplifier assembly.

3 Findings

Findings are listed in order of development, not in order of priority.

3.1 The actions of the Master and crew were appropriate in both incidents, taking the ship out of the main shipping channel and isolating, or apparently rectifying, the fault before continuing safely on passage.

3.2 The action taken after the 20 February incident (05-204) followed a logical fault-finding technique, and the conclusion that the fault was due to a poor connection to the amplifier card was reasonable.

3.3 A dirty edge connector on the port rudder's amplifier PCB may have caused the steering malfunction in both incidents.

3.4 The fault was more likely to be a power supply problem within the follow-up amplifier assembly, and unrelated to the amplifier card or its edge connector.

3.5 The faulty diode bridge on the power supply in the port follow-up amplifier assembly may have been the main cause of both steering malfunctions.

3.6 The action of replacing the boards probably physically disturbed the actual fault and rectified it.

3.7 Alignment of the servo system was required, but it is unlikely that this was connected with the steering malfunction.

3.8 The safety of the ship and its occupants was not compromised during the incidents.

3.9 The ship was correctly certificated and manned during both incidents.

4 Safety Actions

4.1 Since the incident, Toll NZ Consolidated Limited has implemented the following actions:

- replaced suspect capacitors on both the port and starboard servo system power supplies
- replaced the bridge diode network on the port servo system power supply
- replaced the amplifier integrated circuit on the port amplifier PCB
- carried out a full system alignment following the manufacturer's instructions
- corrected errors and adjusted the helm servos
- appointed specialists, currently considered to be the world leaders in BRM, who have instituted a programme of BRM training to achieve Interislander's goal of excellence in this field and safe navigation. Completion of the first phase of training was expected by November 2005.

4.2 In view of the safety actions taken by Toll NZ Consolidated Limited no safety recommendations have been made to the operator.

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Hon W P Jeffries
Chief Commissioner

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