Report 00-211

harbour tug *Waka Kume*

loss of control

Auckland Harbour

19 November 2000

Abstract

At about 0400 on 19 November 2000, the Auckland Harbour tug *Waka Kume*, with 2 crew aboard, was made fast to the port quarter of a ship berthing at the Fergusson Container Terminal. As the ship was moving astern towards the berth the pilot decided to abort the approach due to the bow thruster on the ship not being able to hold the bow up into the wind and tide. When the pilot put the ship's engine ahead, and the tug skipper attempted to adjust the movement of the tug to follow, the tug suffered a loss of control causing it to rapidly rotate to starboard through about 360 degrees, wrapping the towline around the superstructure. When the tug skipper had regained control of the tug the towline was let go and the ship was berthed without further incident. There were no injuries to the crew, but the tug suffered extensive damage to the superstructure, starboard funnel and some deck fittings.

Safety issues identified included:

- the number of minor faults discovered in the control system for the tug's port azimuth unit
- the adequacy of emergency training given to the tug crews
- the continuity of the training given to the tug crews
- the need for ongoing peer reviews for tug crews.

Safety recommendations were made to Ports of Auckland Limited to address the safety issues.

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

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Waka Kume's* sister ship *Waipapa

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List of Abbreviations

CO_2	carbon dioxide
kW	kilowatt(s)
m	metre(s)
mm	millimetre(s)
rpm	revolutions per minute
t	tonne(s)
UTC	universal time coordinated
VHF	very high frequency

Glossary

becker rudder	a rudder fitted with a flap on the trailing edge
bollard pull	measure of the static pull a vessel can exert
dolphin	structure used for mooring ships
knot	one nautical mile per hour
kort nozzle	solid shroud around the propeller of a vessel
monkey island	deck on top of wheelhouse
port	left hand side when facing forward
quarter	that part of a ship between the beam and stern
slipway	frame on tracks used for hauling vessels out of the water
starboard	right hand side when facing forward
Voith Schneider	tug with a cycloidal propulsion system

Data Summary

Vessel particulars:

Name:	*Waka Kume*
Type:	harbour tug
Classification:	Lloyds Register SSC 100 A1
Owner:	Ports of Auckland Limited
Operating limits:	Northland, Great Barrier and Auckland inshore limits
Length overall:	22.35 m
Beam:	9.2 m
Depth:	4.15 m
Draught (hull):	3.15 m
Displacement:	338 t
Construction:	steel hull, aluminium superstructure
Built:	April 2000 by Northport Engineering, Whangarei, New Zealand
Propulsion:	2 Caterpillar 3516 EUI diesel engines, each producing 1640 kW at 1800 rpm
Azimuthing drives:	2 Ulstein Aquamaster 1650H, Z drive units, each fitted with a 2164 mm diameter fixed-pitch propeller
Speed:	12 knots
Bollard pull:	50 t

Location:	Fergusson Wharf, Auckland Harbour
Date and time:	Sunday 19 November 2000 at about 0415[1]
Persons on board:	crew: 2
Injuries:	nil
Damage:	extensive to wheelhouse, starboard funnel, port handrails, deck fittings and the towline
Investigator-in-charge:	Captain W A Lyons

[1] All times in this report refer to New Zealand Daylight Time (UTC + 13 hours) and are expressed in the 24 hour mode.

1. Factual Information

1.1 History of the accident

1.1.1 On Saturday 18 November 2000, and during the early hours of Sunday 19 November the Auckland harbour tug *Waka Kume* assisted with 9 shipping movements without incident.

1.1.2 At about 0330 on Sunday morning a Ports of Auckland Limited (POAL) harbour pilot boarded the inbound container vessel *Spirit of Enterprise*, which was to berth starboard side alongside berth FX at Fergusson Container terminal. There were no other ships berthed at the terminal and 4 container cranes were positioned at the north end of berth FZ (see Figure 1).

1.1.3 When the *Spirit of Enterprise* was off Devonport Wharf the *Waka Kume* manoeuvred alongside and made fast to the ship's port quarter using the tug's towline. The towline ran directly from the towing winch on the bow of the tug, through the leads and up to the ship. Once made fast, the *Waka Kume* followed the ship down the harbour with no weight on the towline.

1.1.4 The berthing was to be a routine movement so the pilot and tug skipper did not discuss the operation. The *Spirit of Enterprise* was about 108 m long with a gross tonnage of 4529 t, and was equipped with a single variable pitch propeller, becker rudder and a bow thruster.

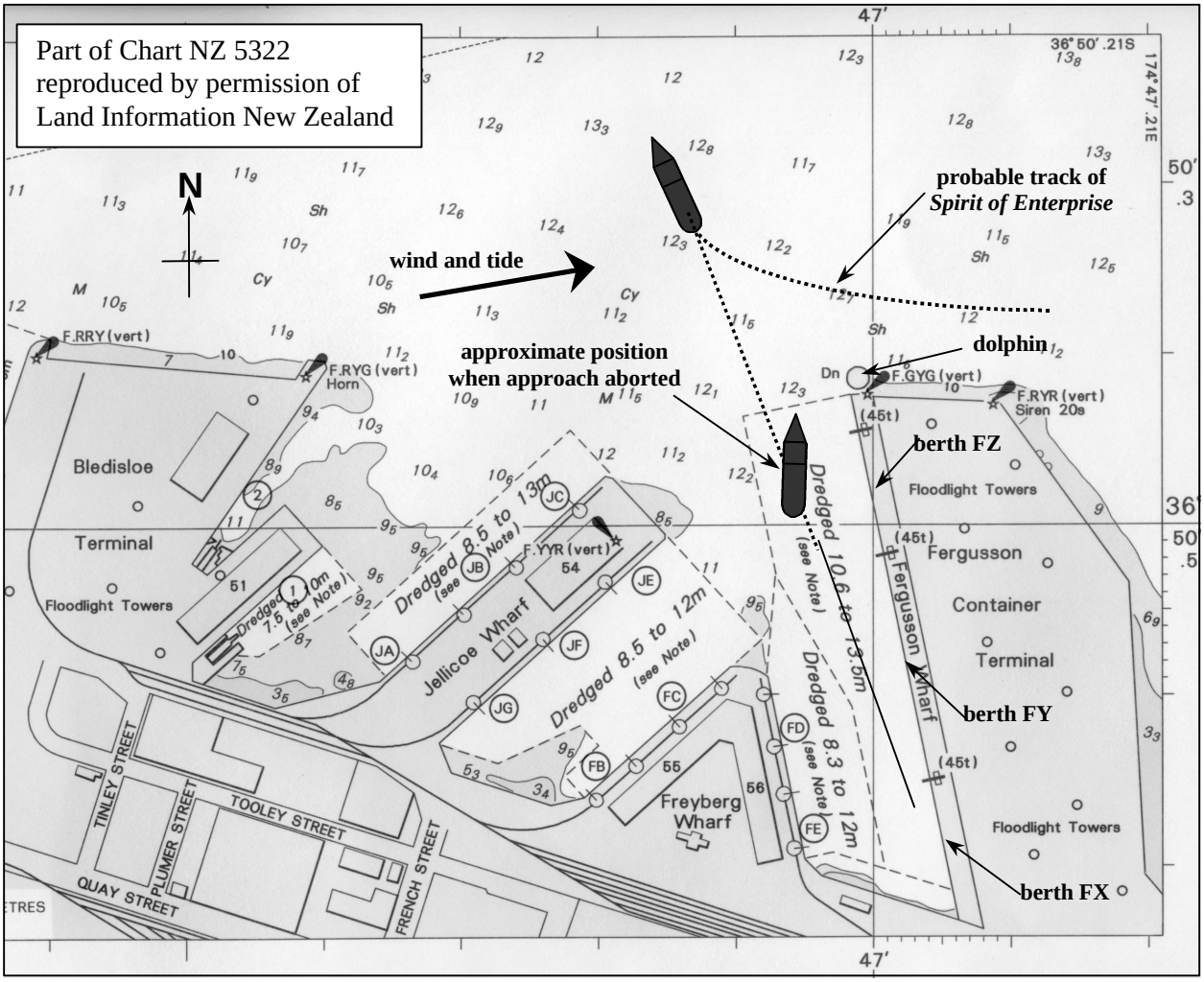

Figure 1
Part of Chart NZ 5322 showing location of accident

1.1.5 The weather conditions at the time were a west-south-west wind of about 30-35 knots with good visibility. High tide was predicted for 0157 and the ebb tide was estimated to be flowing at about 2.5 knots at the time of the accident, which resulted in the wind and tide acting broadly in the same direction.

1.1.6 The pilot conned the *Spirit of Enterprise* past the dolphin off the end of Fergusson Wharf, reducing speed to about 3 knots. When the stern was clear of the dolphin he turned the ship to starboard using the tug to pull the stern to port and the bow thruster to push the bow to starboard. When the ship was aligned with Fergusson Wharf the pilot put the engine astern in order to move towards the berth. He ordered the tug to cease pulling and used the bow thruster, thrusting the bow to port, to counteract the effects of the wind and tide.

1.1.7 The *Waka Kume* was lying about right angles to the ship; the skipper was manoeuvring it sideways to starboard, with no weight on the towline, to follow the astern movement of the ship.

1.1.8 When the bridge of the ship was about 100 m inside the end of the wharf the pilot contacted the *Waka Kume* to check that there was no weight on the towline, which the tug skipper confirmed. Shortly after the pilot decided to abort the approach as the bow of the *Spirit of Enterprise* was falling off to starboard faster than he had anticipated and he was aware of the container cranes parked at the end of the wharf.

1.1.9 Without informing the tug of his intentions the pilot initially put the ship's engine to half ahead followed shortly afterwards by full ahead.

1.1.10 The skipper of the *Waka Kume* saw the wash from the ship's propeller and realised that its engine was going ahead. Immediately the tug skipper adjusted the position of the azimuth units to stop the starboard movement of the tug and start it moving to port with the ship.

1.1.11 The tug skipper could see that the bow of the ship was falling off to starboard and wanted to avoid putting any weight on the towline as he manoeuvred. At the same time he wanted to turn the bow of the tug to starboard, through about 90 degrees to lie parallel with the ship in order to make it easier to follow as the ship gathered speed.

1.1.12 While the tug skipper was adjusting the direction and rpm of the azimuth units, the tug suffered a loss of directional control. The skipper and engineer later recalled that the port azimuth unit had frozen in a direction of thrust of about 235 degrees relative to the bow, the starboard azimuth unit was thrusting ahead, and both azimuth units were on at least half power.

1.1.13 The skipper informed the engineer, who was on the starboard side of the wheelhouse console, that he was experiencing a problem with the port azimuth unit and asked him to come around and operate the jog control for the unit to try and rectify the problem. The jog control was a back-up system for rotating the azimuth units.

1.1.14 The tug continued rotating to starboard, wrapping the towline around the port side of the wheelhouse, across the after end of the superstructure, up and around the back of the starboard funnel, and then forward along the starboard side of the wheelhouse, eventually riding up over the monkey island. The weight came on the towline causing damage to the superstructure, starboard funnel and deck fittings.

1.1.15 When the skipper realised that the weight had come on the towline he instructed the engineer to activate the tow winch brake emergency release and slack the line back, which he did immediately.

1.1.16 By engaging and disengaging the port jog control the skipper regained control of the port azimuth unit. The skipper was then able to regain full control of the tug and start rotating it to port to unwind the towline.

1.1.17 As the incident occurred in a matter of about 30 seconds the skipper could not recall later what direction or power setting he moved the combi-levers to. He did recall that he did not reduce the rpm of the azimuth units immediately. The port combi-lever appeared to be functioning correctly again immediately after the jog control was activated.

1.1.18 The pilot aboard the *Spirit of Enterprise* was on the starboard side of the bridge and initially was unaware of the problems the tug was experiencing. When the ship was clear of the dolphin the pilot stopped the engine. He estimated the speed of the ship was about 2-3 knots at that time. He then contacted the tug and was informed of their problems. When the tug had completed unwinding the towline it was let go from the ship and the engineer wound the towline back onto the winch drum.

1.1.19 The *Waka Kume* stood by to assist with the berthing, but was only required to push the vessel alongside once the approach was completed.

1.1.20 After the *Spirit of Enterprise* was secure the *Waka Kume* was dismissed by the pilot and returned to its berth at Admiralty Steps. The tug was then taken out of service for repairs and further investigation of the control system problems.

1.2 Damage

1.2.1 Damage sustained in the accident was caused by the towline contacting the tug's superstructure, starboard funnel and deck fittings and then coming under load.

1.2.2 The damage included the following:

- broken handrails on both sides of the steps from the starboard side of the fore deck to the wheelhouse
- broken windows on both sides of the wheelhouse
- broken whistle klaxon on monkey island
- damage to the starboard stay bracket for the mast
- damage to starboard forward and port aft deck spot lights
- crush damage to the corner above the access to the CO_2 store
- crush damage to the starboard engine room ventilator
- crush damage to the starboard funnel
- crush damage to the starboard after corner of the wheelhouse
- damage to the towline.

(see Figures 2 and 3).

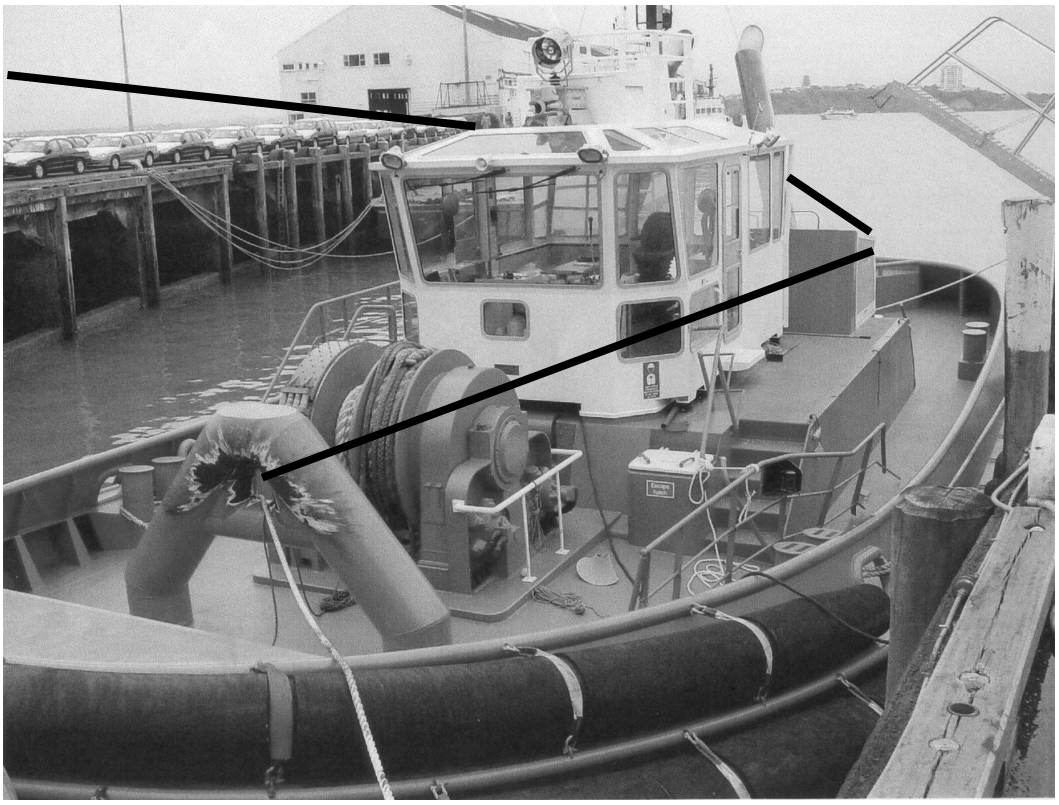

Figure 2
***Waka Kume* showing direction of towline and damage to port side**

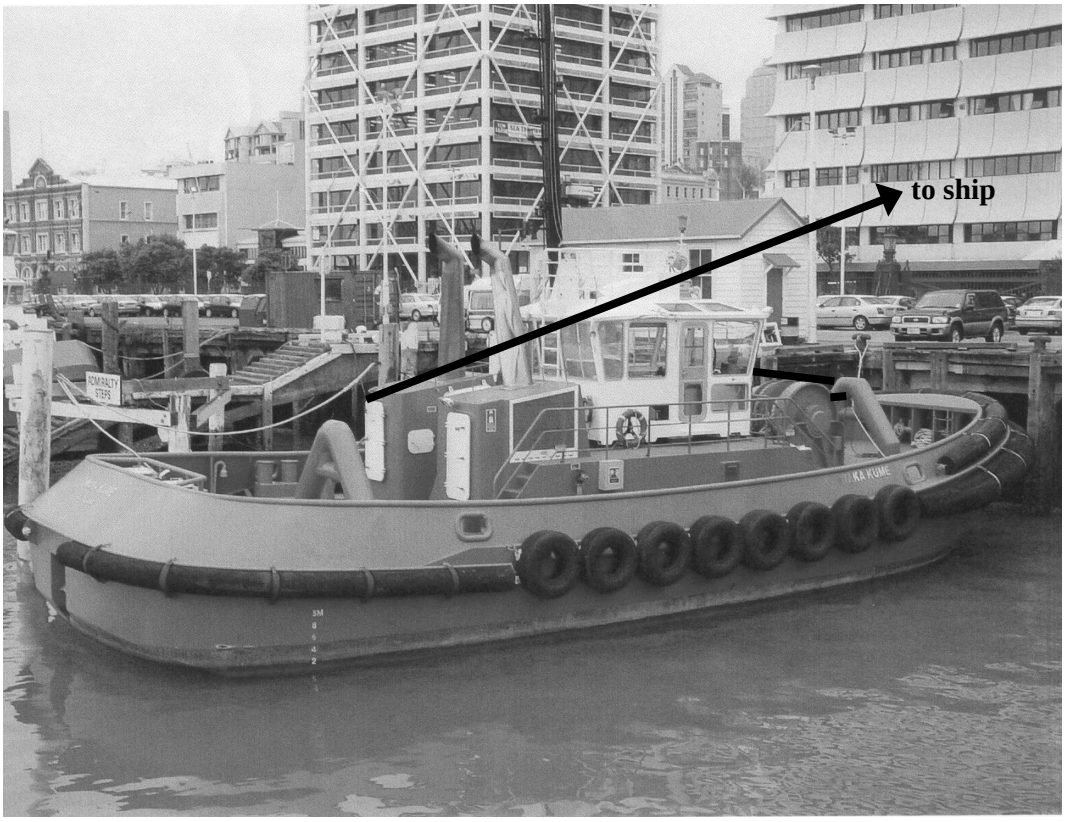

Figure 3
***Waka Kume* showing direction of towline and damage aft end and starboard side**

1.3 Vessel information

1.3.1 The *Waka Kume* was the second of 3 tugs built at Northport Engineering in Whangarei for POAL. It was delivered in April 2000. The design was based on tugs that had operated in Vancouver, Canada for about the past 15 years.

1.3.2 The tugs had 2 azimuth drive units at the stern and were known as reverse tractor tugs. This type of tug usually operates with the towing point towards the assisted ship and the propulsion units away from the assisted ship. This configuration made them highly manoeuvrable. They were capable of travelling sideways at about 5 knots (see Figure 4).

1.3.3 The propulsion system consisted of two 1640 kW Caterpillar engines each driving an Ulstein 1650 H azimuth unit capable of turning through 360 degrees. Each propeller was 4-bladed with fixed pitch and a diameter of 2184 mm. Both propellers were enclosed in kort nozzles. The control system for the azimuth units was an Ulstein Z-Con electronic remote control system.

1.3.4 The wheelhouse had close to 360-degree visibility. There were also windows in the deckhead above and to each side of the driving position.

1.3.5 The wheelhouse control console was split to allow the operator to stand or sit between the controls. Each side of the console housed a combi-lever and the associated engine controls, gauges and emergency stops for that unit. The very high frequency (VHF) radio could be activated by a foot pedal (see Figure 5).

1.3.6 The towing winch was situated on the fore deck in front of the driving position and was capable of a 12 t dynamic pull and 120 t static brake load. It held about 100 m of 88 mm diameter polyester/polypropylene rope connected to a 15 m long 48 mm diameter Spectra tail, which was passed to the ship. The winch control lever and emergency release were situated on the starboard console. When assisting ships the *Waka Kume* towed directly from the winch drum, adjusting the length of towline as necessary.

1.3.7 The engine room contained the 2 Caterpillar engines and auxiliary equipment. The 2 azimuth units were situated in separate compartments and were connected to the Caterpillar engines by drive shafts.

1.3.8 The *Waka Kume* had a valid safe ship management certificate issued by POAL on 28 April 2000 and valid until 28 April 2004. On 6 September 2000 the Maritime Safety Authority conducted a flag state inspection of the tug and found no deficiencies.

1.4 Manoeuvring

1.4.1 The operator controlled each azimuth unit with a combi-lever that controlled the clutch, thrust direction and rpm of each azimuth unit. The combi-lever consisted of a rotating base that controlled the direction of thrust and a lever that controlled the clutch and propeller rpm. The handle of the lever was ovoid with the sharper end indicating the direction of thrust (see Figure 6).

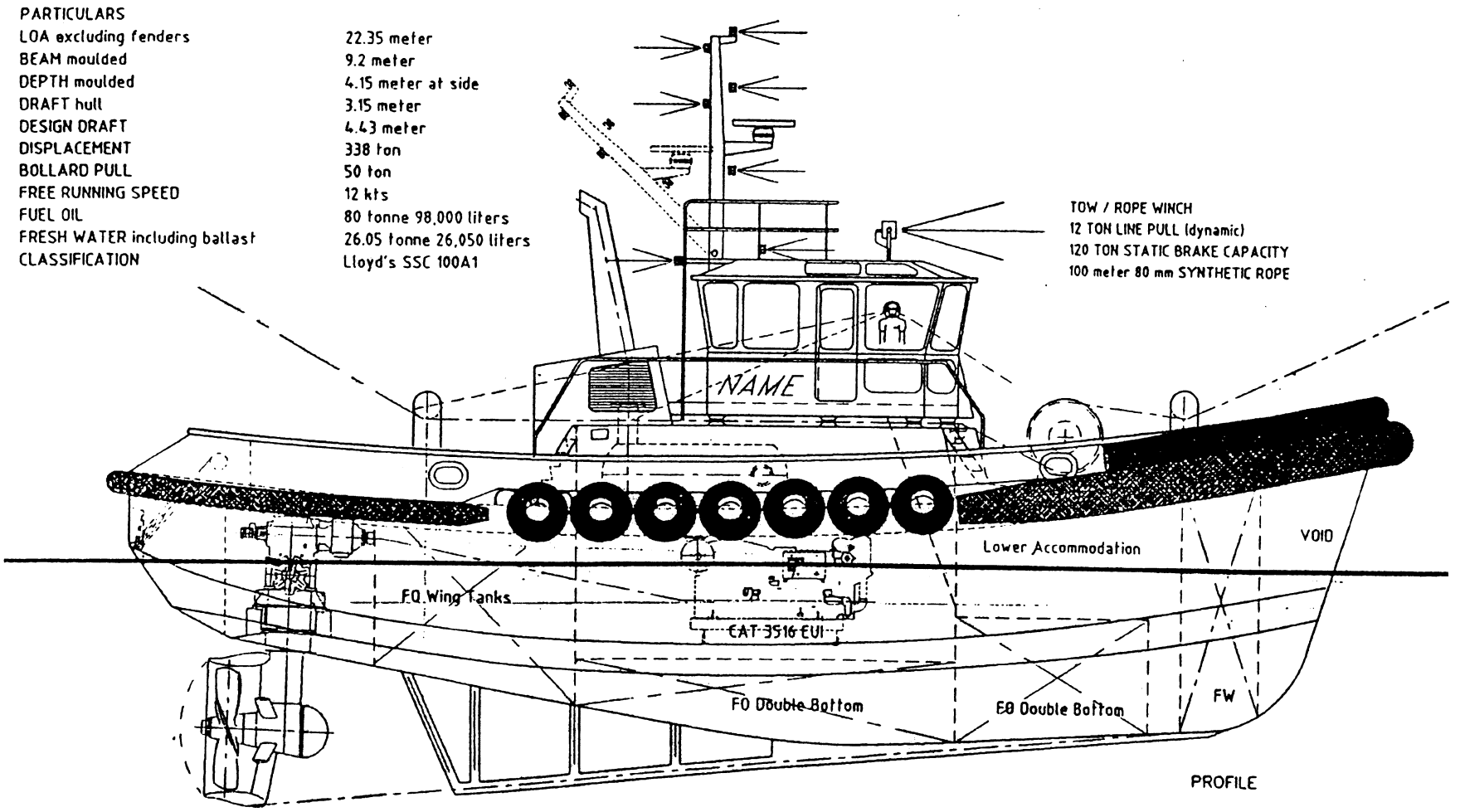

Figure 4
Drawing of *Waka Kume*

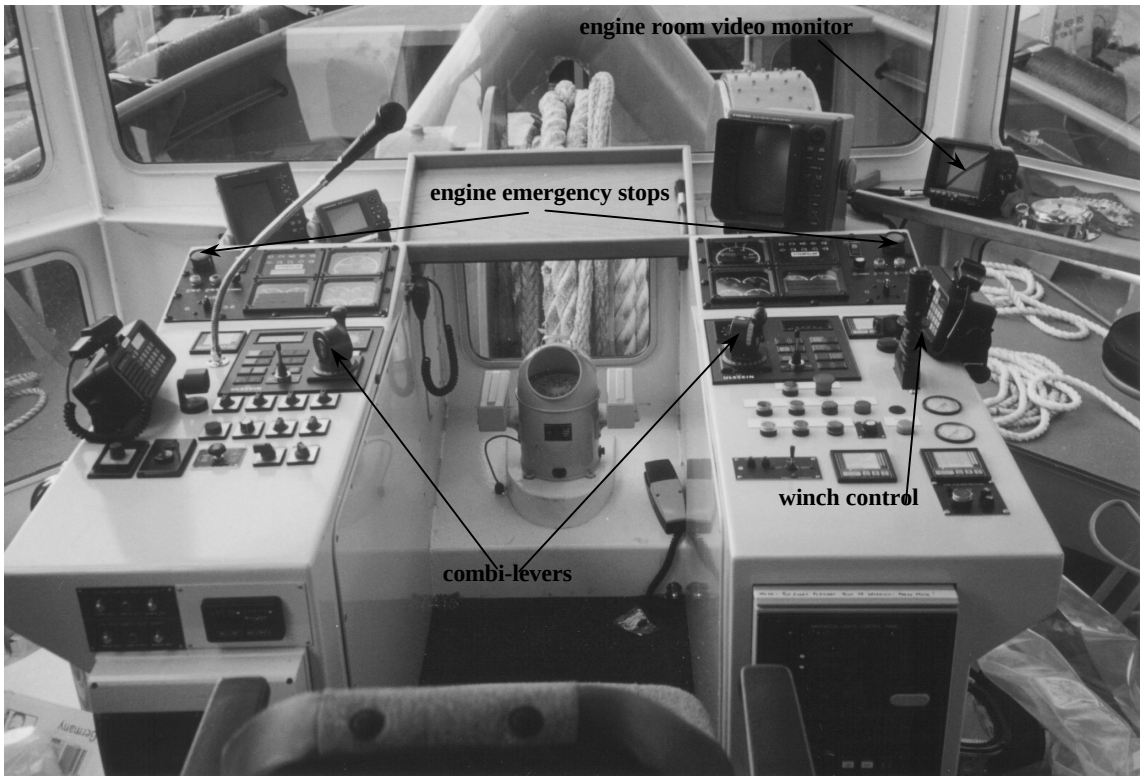

Figure 5
Wheelhouse console

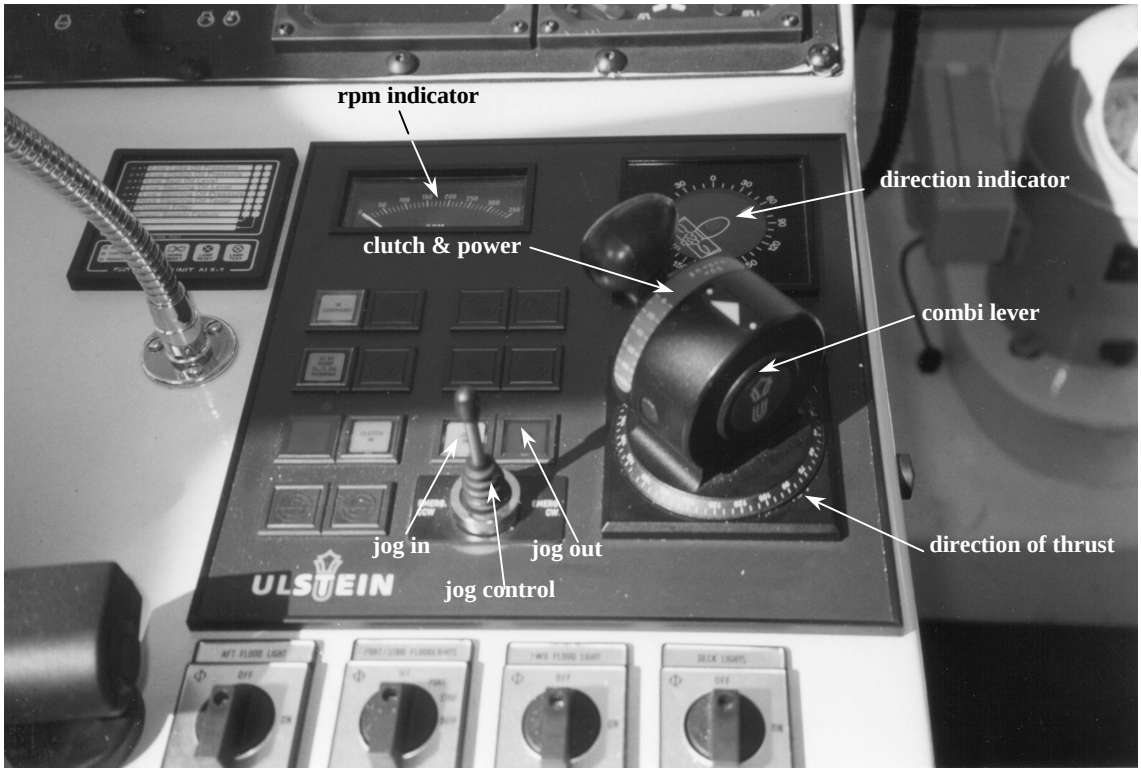

Figure 6
Port combi-lever and associated controls

1.4.2 When the engine was clutched out the lever was at an angle of about 25 degrees away from the direction of thrust, when clutched in it was vertical. To increase the rpm the lever was pushed towards the direction of thrust, obtaining maximum rpm when the lever was horizontal.

1.4.3 There was an auxiliary steering control known as the jog control. This consisted of a joystick, mounted close outboard of each combi-lever. The jog control was engaged by pushing a jog in button and disengaged by pushing a jog out button. When engaged the joystick rotated the azimuth unit clockwise if pushed right and anticlockwise if pushed left.

1.5 Operating procedures

1.5.1 When assisting routine shipping movements within the port the tug had a complement of 2 crew. This could be increased as deemed necessary by the tug skipper or the marine services manager.

1.5.2 The 2 crew consisted of a skipper and engineer known as operator 1 and operator 2. When assisting ships, operator 1 drove the tug and handled the communications while operator 2 handled the towline and operated the towing winch. The intention of POAL at the time of the accident was to further the training of both operators to enable them to be interchangeable as necessary.

1.5.3 When underway the tug was steered and manoeuvred by adjusting the direction of thrust and rpm of each azimuth unit using the combi-levers.

1.5.4 Before the new tugs arrived the skipper had mainly operated the Voith Schneider tugs *Daldy* and *Tamaki*, and the *Hauraki*, which had a similar propulsion system to the *Waka Kume* but a uni-lever control system that was computer assisted. The uni-lever control consisted of a single joystick that was put in the direction the tug was required to move and the computer software decided the configuration of the azimuth units to efficiently achieve the command. The power was applied by operating a separate control.

1.5.5 The *Waka Kume* was about 7 m shorter in length than the *Daldy*, *Tamaki* and *Hauraki* but had more than twice the bollard pull of the *Daldy* and *Tamaki* and 10 t more than the *Hauraki*.

1.6 History of azimuth control problems

1.6.1 On 14 June 2000, the starboard azimuth unit developed a fault. When control of the azimuth unit was transferred from the engine room to the wheelhouse the unit became clutched in at full rpm. This resulted in the tug causing extensive damage to the wharf. The fault was found to be a loose screw in the combi-lever.

1.6.2 The *Waka Kume* departed Auckland on 23 October 2000 to undergo warranty work in Whangarei. The work consisted mainly of minor modifications and repair work. After the 19 November accident the POAL marine services engineer stated that no work was undertaken on either the control systems for the azimuth units or any other component that could affect the control systems.

1.6.3 The tug returned to Auckland on 12 November and commenced work immediately. On 14 November 2000 it was reported that the port azimuth unit was “hunting” when rotated and would not settle on the required direction. The problem was assumed to be dirt particles in the proportional valve of the hydraulic system. The filters were all changed and the azimuth unit tested. It appeared to be functioning correctly so the tug commenced operations. That night the problem reoccurred so the tug ceased operating again.

1.6.4 On 15 November a technician from Ulstein travelled down from Whangarei to ascertain the problem. He found a loose coupling in the control feedback unit that he assumed was the cause of the problem. The tug was again tested and appeared to be functioning correctly so it commenced operating again. That night another fault occurred whereby the port azimuth unit froze in one direction and did not respond to the combi-lever control. The tug ceased operating again and the technician was contacted.

1.6.5 On 16 November the technician returned from Whangarei to observe the tug operating. He changed the feedback synchroniser and the indicator synchroniser and at the same time discovered a loose terminal in the control junction box. The technician also noticed a badly terminated wire so he requested all the wires in the control junction box be re-terminated; this was completed by a local contractor. The tug was again tested and appeared to be operating correctly so the technician returned to Whangarei.

1.6.6 On 17 November while berthing a ship the port azimuth unit froze intermittently 3 times. It was found that engaging the jog control, rotating the azimuth unit slightly with the jog lever and then disengaging the jog control could rectify the problem. This had the effect of bypassing the electronics to the combi-lever. The technician was again notified of the problem. He requested that someone check the wires that had been re-terminated while he returned to Auckland. When the technician arrived the *Waka Kume* was taken for further trials. After a period of time the problem recurred and the technician was able to trace it to an incorrectly mounted relay on the interface card. The technician made temporary repairs and the tug worked for the rest of the day, completing 5 shipping movements without incident.

1.6.7 On 18 November the *Waka Kume* completed 3 shipping movements in the morning before a replacement interface card arrived and was fitted. The tug then completed a further 6 shipping movements without incident.

1.6.8 On Sunday 19 November, after the accident, the technician checked the port azimuth control system and could find no fault. The azimuth units were run for about 2 hours alongside the wharf and then the tug was taken out and tested but still no fault occurred.

1.6.9 Later that day the tug was taken out of service to repair the damage caused during the accident. While the repairs were being undertaken the tug was on a slipway. The port azimuth unit was dismantled to repair an oil seal that was leaking. Part of this procedure involved disconnecting the wiring to the control system for the azimuth unit. No further adjustments were made to the system.

1.6.10 On Friday 8 December the repairs to the port azimuth thruster were completed and the *Waka Kume* returned to its berth at Admiralty Steps. Another technician from Ulstein was in attendance. He reconnected the wiring, checked the alignment of the units to the controls and checked the operation of the jog controls. While the tug was alongside he rotated the port azimuth unit using the combi-lever for about 2 hours to see if the fault recurred, which it did not.

1.6.11 On 9 December the *Waka Kume* was taken out into the harbour for trials. The port azimuth unit was operated continuously for about 2 hours under varying loads without incident.

1.6.12 On 11 December the repairs to the damage on the *Waka Kume* were almost complete and the azimuth units were again tested without incident.

1.6.13 On 12 December the *Waka Kume* was used for 4 shipping movements with the technician and training skipper on board. The tug again operated without incident. By then it was assumed that the fault had been rectified and the tug was fully operational again.

1.6.14 While the tug was berthing at Admiralty Steps on 18 December the port azimuth unit froze again for about 15 seconds before correcting itself. Ulstein was contacted and thought that this incident may have been an isolated incident caused by dirt particles in the hydraulic system that had cleared and would have been trapped in the filters.

1.6.15 In his service report on the malfunctions the first Ulstein technician summarised the faults he found as follows:

> IN CONCLUSION
>
> There were several faults on the port steering system not all of them showed up immediately.
>
> - First fault — To much gain. Causing overshoot.
> - Second fault — Loose middle coupling. This did not cause any seen problem.
> - Third fault — Steering valve null out of position. This did not cause any seen problem.
> - Fourth fault — Bad connection in unit junction box. This was the cause of the wandering steering.
> - Fifth fault — Top feedback coupling slack. This did not cause any seen problem.
> - Sixth fault — Bad contact in K6 relay. This caused the steering to stop working.

1.6.16 Both the Ulstein representatives were convinced that there was no fault in the control system for the port azimuth unit at the time of the accident. The first technician wrote in his report the following:

> I checked over the controls but all was working, I was informed that the steering was working fine, but the damage was caused they claim by the same loss of steering signal.
> I was asked what I thought and stated that I did not think the controls had failed . . .

The second technician wrote in his report:

> Told them that I think it was O/P [operator] error.

1.7 Manoeuvring tests

1.7.1 During the investigation into the accident the Commission requested that tests be conducted to ascertain approximate length of time taken to complete certain manoeuvres. The training skipper was in control of the tug and the following were the results:

- turn the azimuth unit through 360 degrees — 15 seconds
- turn the tug through 270 degrees using both units at half power — 17 seconds
- turn the tug through 360 degrees using both units at full power — 12 seconds

1.7.2 The training skipper was also asked to simulate the manoeuvre that would have been required to follow the *Spirit of Enterprise* at the time of the accident. He was able to stop the sideways to starboard movement and commence moving to port with the tug still at right angles to a ship in about 10 seconds. The training skipper was also able to manoeuvre the *Waka Kume* using the starboard azimuth unit only.

1.8 Personnel information

1.8.1 The skipper of the *Waka Kume* had been at sea since 1962. He had been employed in the merchant navy as able seaman, and on fishing vessels for a variety of companies. He joined the Auckland Harbour Board in 1988 and had been skipper on the harbour tugs for 4 years prior to the accident. In July 1999 he gained a mate of a deep sea fishing vessel qualification and had held a second class diesel trawler engineer qualification for about 20 years. He had been skipper on the *Waipapa*, sister tug to the *Waka Kume* from January 2000 until the *Waka Kume* arrived in April, when he transferred to it.

1.8.2 The engineer on the *Waka Kume* began his seagoing career in 1970 as junior engineer on general cargo vessels. In 1975 he was employed by the Auckland Harbour Board, spending the first 2 years as maintenance engineer in the workshop. He was then employed as engineer aboard the floating crane, where he spent 10 years before being transferred to the harbour tugs. He had been engineer on the *Waipapa* until the *Waka Kume* arrived. He gained a third-class steam engineer qualification in 1975 and second coastal motor qualification in 1997.

1.8.3 The pilot completed an apprenticeship with Union Steam Ship Company of New Zealand Limited in 1972 and spent the next 5 years working for various shipping companies. In 1977 he returned to Union Company where he remained until he was employed by Port Otago Limited as a pilot/relieving tug master in 1987. In January 1998 he joined Ports of Auckland Limited as a pilot. He gained a master foreign going certificate in 1986.

1.8.4 The training skipper was Canadian. He had been employed on tugs for the past 33 years, the last 15 on tugs similar to the *Waka Kume*. He had been employed by Tiger Tugs in Vancouver for the previous 3 years as tug skipper and training skipper.

1.9 Roster

1.9.1 The tug crew worked a roster of 4 day shifts from 0500 to 1700, then 2 days off followed by 3 night shifts from 1700 to 0500. They then had the fourth night and 2 days off before commencing the cycle again. The accident occurred on the skipper's last night shift of the cycle.

1.9.2 If there were no shipping movements during the night shift the crew could go home or if there was a gap between shipping movements, they could rest. The night before the accident the skipper had arrived home at about midnight. The night of the accident they had worked continuously from 1700 until about 2030 and then had about a 3 hour break before commencing work again at 0030 and continuing until the accident occurred.

1.9.3 The skipper later stated that at the time of the accident he did not think he was fatigued but was "probably getting a bit weary".

1.10 Training

1.10.1 As these tugs were a new concept and nobody in New Zealand had experience in driving them, POAL brought an experienced training skipper from Canada to teach the local skippers how to operate them with maximum effectiveness and efficiency.

1.10.2 In January 2000, when the sister tug *Waipapa* was commissioned, the training skipper was employed by POAL to teach 4 skippers how to operate the tug. The intention was that those 4 skippers would then train the other skippers and engineers.

1.10.3 The initial training was conducted over a period of 30 days. The 4 skippers were first taught how to manoeuvre the tug using a wharf as a reference point. They practiced approaching and departing a given position and how to hold the tug in one position relative to the wharf.

1.10.4 As they advanced they were taught how to keep the tug on station relative to a moving ship. This was achieved by coming alongside ships as they approached the berth or staying alongside ships longer than was usual as they departed the berth. They were then taught how to utilise and control the azimuth units to gain the maximum efficiency with the least power.

1.10.5 All through the training the training skipper emphasised the need for forward planning when assisting a ship. He taught the skippers how to recognise the areas of potential danger while operating alongside a ship and how to utilise the azimuth units in the most efficient way to gain maximum efficiency and still facilitate an escape route if necessary.

1.10.6 The original 4 skippers completed an average of about 30 shipping movements while being supervised by the training skipper. The skipper at the time of the accident was only included in the training programme for the last week and consequently only completed about 4 shipping movements under the supervision of the training skipper. The original 4 skippers undertook the remainder of the latter's training.

1.10.7 The training skipper later stated that in his experience it took an average of about 8 days training before a skipper became fully proficient at manoeuvring the tug alongside a ship unassisted.

1.10.8 Since the original training was undertaken POAL have developed a comprehensive training manual that all operators have to complete before driving the tugs solo for shipping movements. The training manual was divided into modules that covered all aspects of familiarisation with the equipment, operating procedures and peer reviews of the skippers. Each section had to be signed off by the skipper and the training skipper.

1.10.9 The original 4 skippers to be trained and the skipper at the time of the accident did not have the manual at the time of their training, but the POAL marine services manager later stated that they would have covered all the modules in their training before operating on their own.

1.10.10 In the manual was a module entitled Emergency Procedures & Operations. This module broadly covered emergency situations the operator may have encountered. The section relative to mechanical or control failures was covered in one section entitled engine failure.

2. Analysis

2.1 The cause of this accident has not been conclusively identified. The skipper and engineer claimed that the port azimuth unit froze, but the 2 Ulstein technicians could not simulate the problem after the replacement interface card was fitted, despite hours of testing and trials. They both later reported that they thought the accident was caused by operator technique. Since the tug began operations again the problem has not reoccurred, other than a malfunction on 18 December that was thought to be an isolated hydraulic problem.

2.2 The design and power of the *Waka Kume* and its sister tugs were a departure from the more conventional harbour tugs the skipper had been used to operating. As there was nobody in New Zealand familiar with operating tugs like the *Waka Kume* it was wise of POAL to engage the expertise of the Canadian training skipper.

2.3 The propulsion control systems on the *Waka Kume* were different to those aboard the older tugs in that the skipper had to constantly operate each combi-lever simultaneously in order to maintain control of the tug. At the same time he had to determine the optimum direction and power to apply to each azimuth thruster to achieve the required result and still leave himself an escape route should the need arise. Compared to the *Hauraki* the skipper virtually replaced the computer.

2.4 While the power and quick response of tugs such as the *Waka Kume* make them more efficient at manoeuvring and assisting ships, the same power and responsiveness could equally cause them to get into difficulties faster if an equipment failure or operator error occurred.

2.5 Each combi-lever required a rotational movement for direction of thrust and a vertical movement for propeller rpm, which meant the skipper had to simultaneously adjust each combi-lever in a 3-dimensional mode to control the tug. This had to be achieved mainly by "feel", as while manoeuvring the skipper had to visually monitor the position of the tug relative to the ship and the weight on the towline. At the same time he had to operate the VHF radio.

2.6 The standard combi-levers were sensitive due to their small size. The azimuth units could be rotated through 360 degrees with a similar movement as is required to operate a tap. The propeller rpm could be increased from clutched in to maximum with a relatively small movement of the thumb. These small physical movements controlled a large amount of power.

2.7 The sensitivity of the combi-levers and the power they controlled coupled with the quick response of the tug to that power left little margin for error. A malfunction of the control system or an operator error left little time for the skipper to ascertain the situation and take appropriate action. This was highlighted in the accident, where the skipper had the tug under full control and less than 30 seconds later it had turned through about 360 degrees, with the towline wrapping around the wheelhouse.

2.8 The skipper's initial reaction when he realised there was a problem could have been to reduce the power or declutch the faulty azimuth unit. This would have given him better control of the tug and more time to ascertain the problem. If all else failed both units could have been declutched and at worse the tug would have been towed by the ship. Slacking the towline back would also have increased the time for the problem to be rectified, or given time to contact the ship and inform the pilot of the problem. Any of these options would have been better than what eventuated.

2.9 Fortunately the towline caught on the corner of the superstructure, above the access to the CO_2 system, a relatively strong point, before passing across the aft end of the wheelhouse. If the line had wrapped around both funnels the damage to the wheelhouse could have been significantly worse and may have endangered the safety of the skipper and engineer inside.

2.10 Although the training manual had not been completed at the time the original 4 skippers were instructed by the training skipper, their training virtually covered the contents of the manual. The training skipper emphasised the need to always have a planned escape route and taught the skippers how to manoeuvre the tug with this in mind. However, the training only briefly touched on engine or control malfunctions and manoeuvring with one azimuth unit.

2.11 When manoeuvring the tug it was possible to achieve the same end result by utilising the 2 azimuth units in a number of combinations of direction and power, some more efficient and safer than others. The training skipper taught the operators how to utilise the power and direction of thrust on each azimuth unit in the most efficient manner; at the same time still facilitating an escape route if necessary. In simple terms it was better to use the direction of thrust efficiently as the first option and increase the power as the second.

2.12 When the training skipper instructed the first 4 skippers he taught them all to utilise the azimuth units in virtually the same way, in what he believed was the most efficient, economical and safe method of manoeuvring the tug. After the initial training they began operating alone and each fell into their own comfort zone, developing their own preferred style. This was evident to the training skipper when he returned to give the skippers further tuition after the accident. The skipper for the accident trip received the equivalent of 4 jobs training from the training skipper and the remainder of his training from the original 4 skippers, who had each developed their own operating styles, which were not consistent with their original training. It was highly likely that the skipper of the *Waka Kume* during the accident trip had not received adequate consistent training to prepare him for what eventuated on the morning of the accident, whatever the cause.

2.13 From the time the *Waka Kume* had been commissioned until it returned from Whangarei on 12 November there had been no significant electronic problems in the control systems for the azimuth units. As no work was done on the control systems in Whangarei it could be assumed that their condition would be unchanged. However, when a vessel is undergoing repairs in a shipyard it is usually a hive of activity with contractors and sub-contractors of all descriptions conducting their various tasks at the same time. It is possible that during this period the control system could have suffered some damage or unintended interference.

2.14 From the time the problem first occurred until the time of the accident a number of irregularities were corrected in the system, some of which were identified while searching for the cause of the accident, but were thought not to have contributed to it. After the accident the original fault did not reoccur. The fault that did occur on 18 December was put down to a hydraulic problem. It is of concern that so many minor faults were present in the system whether they directly contributed to the problem or not.

2.15 While on the slipway after the accident, repairs were made to a leaking oil seal in the port azimuth unit. These repairs required all the cabling from the control system to be disconnected from the unit. During these repairs it is possible that a loose or faulty connection was inadvertently rectified without being noticed, thus solving the problem.

2.16 Activating the jog switch was known to rectify the initial problem of the port unit freezing in one direction, which was caused by the faulty relay. While this would suggest the original problem recurred, it is possible that a similar unrelated problem occurred at the time of the accident, such as the temporary hydraulic fault that occurred on 18 December. Events were happening quickly and the skipper was in a state of high workload, as was evident by him asking the engineer to walk around the console and activate the jog control, something he could have done himself instantly with a slight movement of his hand. It is likely that the skipper was making rapid adjustments with both combi-levers at this time, and that his recollection of exactly what response he got from the azimuth units could be unreliable.

2.17 There is conflicting evidence as to whether the fault to the port azimuth unit was rectified. The original Ulstein technician reported that the fault was caused by a malfunctioning relay and was rectified by changing the interface card that contained the relay. After the accident the second Ulstein technician attended the vessel and could find no fault in the control system. Both thought the accident was caused by operator technique.

2.18 The skipper and engineer on the *Waka Kume* at the time of the accident both reported that the fault had recurred again at the time of the accident. After the accident the system was again inspected and extensively tested but the fault did not recur, nor had it recurred at the time of writing this report. This leaves 3 possible scenarios; either the original fault recurred but was rectified when the port azimuth unit was dismantled while the tug was on the slipway, or a fault unrelated to the original fault occurred, such as happened on 18 December, or the fault did not occur and the accident was caused by operator technique.

2.19 Both the skipper and engineer later stated that the fault was temporarily rectified by the engineer activating the jog control, by which time the tug had turned through about 360 degrees. Whatever the cause of the problem the consequences of it could have been minimised if the skipper had reduced the power and had the towline slacked. By not doing this it appears that there was a period of indecision in the wheelhouse of sufficient length of time to enable the tug to turn through about 360 degrees.

2.20 The accident occurred at about 0400, about one hour before the skipper was due to finish his night shifts and take time off. Prior to the accident he had worked 2 periods of continuous duty with a 3-hour break in between. It is unlikely that he was critically fatigued at the time of the accident based on the duration of hours worked or his rostered work cycle.

2.21 After the accident the skipper said he did not feel fatigued but felt a little weary. Subjective fatigue is a poor indicator of any performance decrement and people are poor judges of how fatigued they are. The trough in the circadian rhythm[2] patterns of performance would have occurred at the time of the morning the accident occurred. The effects of the disruption to the circadian rhythm pattern would probably have been more significant than any effects of fatigue. The effects of any mild fatigue coupled with circadian rhythm performance decrement can include:

- slower reaction times
- impaired judgement
- slowed decision-making
- impaired concentration.

2.22 The arrival of the *Spirit of Enterprise* was to be a routine berthing of a relatively small ship and the last shipping movement before the skipper took time off. It can be human nature for people to relax when an objective is in sight. A person can be capable of operating perfectly well when fatigued while sufficiently stimulated, but once relaxed the effects of fatigue or disruption to circadian rhythm can prevail.

2.23 The first indication the skipper got that the berthing of the *Spirit of Enterprise* was not going to plan was when he saw the wash from the propeller after the pilot put the ship's engine ahead. At that point he had to stop the tug from travelling sideways to starboard and follow the ship; under normal circumstances a relatively simple operation. The tug would have been considerably faster to respond to the change in direction than the ship, as was proved by the training skipper after the accident.

2.24 The pilot and tug skipper did not discuss the berthing of the *Spirit of Enterprise* in depth as it was to be a routine operation. However, it would have been prudent of the pilot to warn the tug that the bow thruster was not holding the bow against the wind and tide and that he may need to abort the approach. If this had been done the tug skipper would have been aware of the impending change of direction and would have been more alert to a possible deviation from the routine berthing.

[2] the human bodies cyclical pattern of activity and performance related to the time of day.

3. Findings

3.1 The *Waka Kume* was operating under a safe ship management system and had a current maritime document at the time of the accident.

3.2 The crew of the *Waka Kume* held the appropriate qualifications for their positions.

3.3 The crew of the *Waka Kume* were probably not suffering from any appreciable fatigue at the time of the accident but their performance may have been impaired due to the accident occurring during early morning when circadian rhythms are typically low.

3.4 The *Waka Kume* had significantly different handling characteristics to the tugs the skipper had previously operated. The training he had received on tugs such as the *Waka Kume* lacked continuity and consistency.

3.5 The skipper of the *Waka Kume* received sufficient training to operate the tug in normal situations but was not adequately trained to handle high workload situations such as emergencies.

3.6 The *Waka Kume* had a number of faults in the control system for the port azimuth unit, but it could not be established if these contributed to the loss of control.

3.7 The *Waka Kume* entered a uncontrolled rotation in response to the azimuth unit configuration, which resulted in serious damage to the superstructure caused by the towline under load.

3.8 The cause for the loss of control was not established, but was either a malfunction of the port azimuth unit control system or operator technique.

3.9 A number of faults existed in the control system for the port azimuth unit prior to the accident, which were thought to have been rectified and could not be replicated after the accident.

3.10 Regardless of why the port azimuth unit was configured to cause the *Waka Kume* to rotate, there were a number of options available to the skipper to prevent the accident.

4. Safety Actions

4.1 After the repairs to the *Waka Kume* were completed, the Canadian training skipper, who had been in Tauranga instructing tug skippers in that port how to operate a sister tug to the *Waka Kume*, was contacted by POAL. He was asked to come to Auckland and assist with operating the tug while the fault-finding trials were undertaken. While in Auckland it was decided that he should stay and further train all the available operators, including the skipper for the accident trip. The training was conducted over a period of 3 weeks and focused mainly on emergency procedures and operating the tugs on one azimuth unit.

5. Safety Recommendations

5.1 On 3 May 2001 the Commission recommended to the manager marine services for Ports of Auckland Limited that he:

5.1.1 include in the tug operator training manual detailed modules covering:

- engine and control system failures
- response to engine and control system failures
- handling the tug with one operational azimuth unit (014/01)

5.1.2 introduce a system of regular, documented peer review to ensure that all operators are handling the tugs in the most effective and safe manner. The system should include periodic review of the Ports of Auckland Limited training skippers by independent experts in the operation of similar tugs. (015/01)

5.2 On 28 May 2001 the manager marine services for Ports of Auckland Limited replied:

5.2.1 In response to your final safety recommendations we are pleased to advise the following:

1. Updates to the tug operator training manuals shall be carried out as follows:

- engine control system failures, this section shall be expanded.
- response to engine control system failures, this section shall be expanded
- handling the tug with one azimuthing unit, this task shall be given greater emphasis
- introduce a system of peer review, this is being done

2. The requirement to review Ports of Auckland Ltd training skippers by independent experts is not practical. The trainer we originally used was from Canada no other trainer exists in NZ. Many of our staff have gained good skill levels with these vessels and will be adequate for use in peer reviews.

Approved for publication 16 May 2001

Hon. W P Jeffries
Chief Commissioner