ATSB
Australian Transport Safety Bureau

AUSTRALIAN TRANSPORT SAFETY BUREAU

MARINE SAFETY INVESTIGATION
REPORT 153

Independent investigation into the
collision between the British flag motor vessel

# Ariake

## and the tug

# Redcliffe


in Brisbane River, Queensland
on 24 January 2000

COMMONWEALTH DEPARTMENT OF TRANSPORT AND REGIONAL SERVICE

**Department of Transport and Regional Services**

**Australian Transport Safety Bureau**

Report No 153

# Navigation (Marine Casualty) Regulations investigation into the collision between the British flag motor vessel *Ariake* and the tug *Redcliffe* in the Brisbane River, Queensland, on 24 January 2000

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***Redcliffe* at Whyte Island tug base**

# Summary

On the morning of 24 January 2000, the British flag, twin screw, container vessel *Ariake* was inbound to number 1 berth at Fisherman Islands container terminal, in the Brisbane River. A pilot was conducting the navigation of the vessel. The passage through Moreton Bay was routine and the conditions were good with very little wind.

At 0616 the vessel passed the Entrance Beacons and proceeded into the river, passing the Inner Bar Beacons at 0647. During this passage the pilot was advised by Port Control that there would be a delay berthing *Ariake* as another vessel, *MSC China*, was still on number 1 berth and would not be clear until 0730.

*Ariake*'s engines had been reduced to dead slow ahead by the time the Inner Bar was passed and at 0650 two Brisbane tugs, *Austral Salvor* and *Redcliffe* were made fast to *Ariake*'s port shoulder and port quarter respectively. From 0652 to 0655 the pilot put *Ariake*'s engines dead slow astern to stop the vessel off number 6 berth and allow the inbound dredge *Sir Thomas Hilley*, to pass down the starboard side.

At approximately 0654, with *Ariake* making slight headway, and both main engines going astern, the tug *Redcliffe* was washed in under *Ariake*'s stern counter. The tug's fire curtain piping, on the starboard forward side of the deckhouse, made contact with the ship's shell plating. The stern of the tug also started to drift to port and away from the ship's side. The tug master responded to the contact by moving the tug's 'Uni-Lever' joystick control to provide astern/starboard thrust. His intention was to bring the tug's bow away from the side of the ship.

The tug responded rapidly to the 'Uni-Lever' command and moved astern with its stern swinging to starboard. The movement astern continued until tension came on the short towline. The tug's bow was then pulled into the ship's side. At this point *Redcliffe*'s crucifix bollards located on the starboard shoulder, made contact with *Ariake*'s shell plating adjacent to the transom. With its bow tethered by the towline, the tug pivoted on the crucifix bollards which tore a hole in *Ariake*'s shell plating approximately 3 m above the waterline. At the same time, the short towline parted allowing *Redcliffe* to move clear of *Ariake*.

*Redcliffe*'s master contacted *Ariake* to say that he had parted his line and that there was damage to both *Ariake* and *Redcliffe*. The tug crew hastily rigged another towline and *Redcliffe* was re-secured to *Ariake*'s port quarter at 0704. *Ariake* was subsequently swung and berthed starboard side to number 1 berth with the two tugs finally being slipped at 0759. The remainder of the berthing operation was completed without incident.

# Sources of Information

The master and crew of *Ariake*

The tug master of *Redcliffe*

The pilot and Brisbane Marine Pilots Pty Ltd

Queensland Tug and Salvage Co. Pty Ltd

Queensland Department of Transport

## References

The Shiphandlers Guide, Captain R.W. Rowe, FNI

Australian National Tide Tables

## Acknowlegments

Portion of chart Aus 237 reproduced with permission of the Hydrographic Office, RAN.

# Narrative

## *Ariake*

*Ariake* is a British flag container vessel of 34 345 tonnes summer deadweight at a design draught of 10.5 m. The vessel, built in 1976 at the Flender Werft A.G. shipyard in Germany, is owned by P&O Nedlloyd Ltd, and managed by P&O Swire Containers Ltd, Sydney. *Ariake* is classed with Lloyd's register as a ✠100 A1 vessel with ✠LMC[1] and UMS[2] notations. The ship has an overall length of 237.8 m, a moulded breadth of 32.2 m, and a depth of 16.48 m to the second deck. The vessel has a total container capacity of 1818 TEU's (twenty foot equivalent units) with fully cellular stowage.

*Ariake* is powered by two reversible M.A.N. K8 SZ 90/160A slow speed diesel engines developing a total of 39 140 kW at 122 revolutions per minute (rpm). Each main engine drives a fixed pitch propeller that is outward turning when going ahead. The vessel's service speed is 25 knots at 116 rpm on each main engine. There is a single rudder located amidships between the two propellers. *Ariake* is also equipped with an 880 kW bowthruster.

*Ariake* has a crew of 31 with a master and three deck officers, chief and four watchkeeping engineers, bosun and five seamen, seven engine room ratings, chief steward/purser and six catering staff and two trainees. The deck officers and engineers keep traditional four on/ eight off watches at sea. In port the second and third mates divide the cargo watches, and the engineers break watches to carry out maintenance work.

The vessel trades on a 5 week fixed schedule liner service between Sydney, Melbourne, Brisbane, in Australia, Yokohama, Yokkaichi, Nagoya, Osaka, in Japan, and Pusan in Korea.

## *Redcliffe*

The motor tug *Redcliffe*, (fig. 1), (formerly *W J Trotter*), was built by Carrington Slipway in Newcastle, and entered service in 1986 for Queensland Tug and Salvage Co. Pty Ltd of Brisbane. Queensland Tug and Salvage Co. Pty Ltd is a subsidiary of Howard Smith Towage. *Redcliffe* is classed ✠A1 E Towing Service, with ✠AMS[3] and ✠ACCU[4] notations, with the American Bureau of Shipping. The tug is 33.92 m in length, has a beam of 10.82 m, a moulded depth of 5.39 m and a light displacement of 613 tonnes.

*Redcliffe* is powered by two eight-cylinder Yanmar diesel engines each developing 1 790 kW at 720 rpm. Each main engine is clutched into an azimuth stern drive unit. These 'Z' drive units, manufactured by 'Duckpeller', consist of upper and lower gearbox and shaft assemblies connected by a vertical drive shaft to form a 'Z' shaped propeller drive train which can be rotated

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1 Notation assigned when machinery is constructed and installed under Lloyd's Special Survey in accordance with Lloyd's rules.

2 Notation denotes ship may be operated with the machinery spaces unattended.

3 Notation assigned when machinery is constructed and installed under American Bureau of Shipping survey in accordance with their rules.

4 Notation denotes vessel may be operated with the machinery space unattended.

through a full 360°. Each final horizontal drive shaft is connected to a fixed-pitch propeller inside a Kort nozzle.

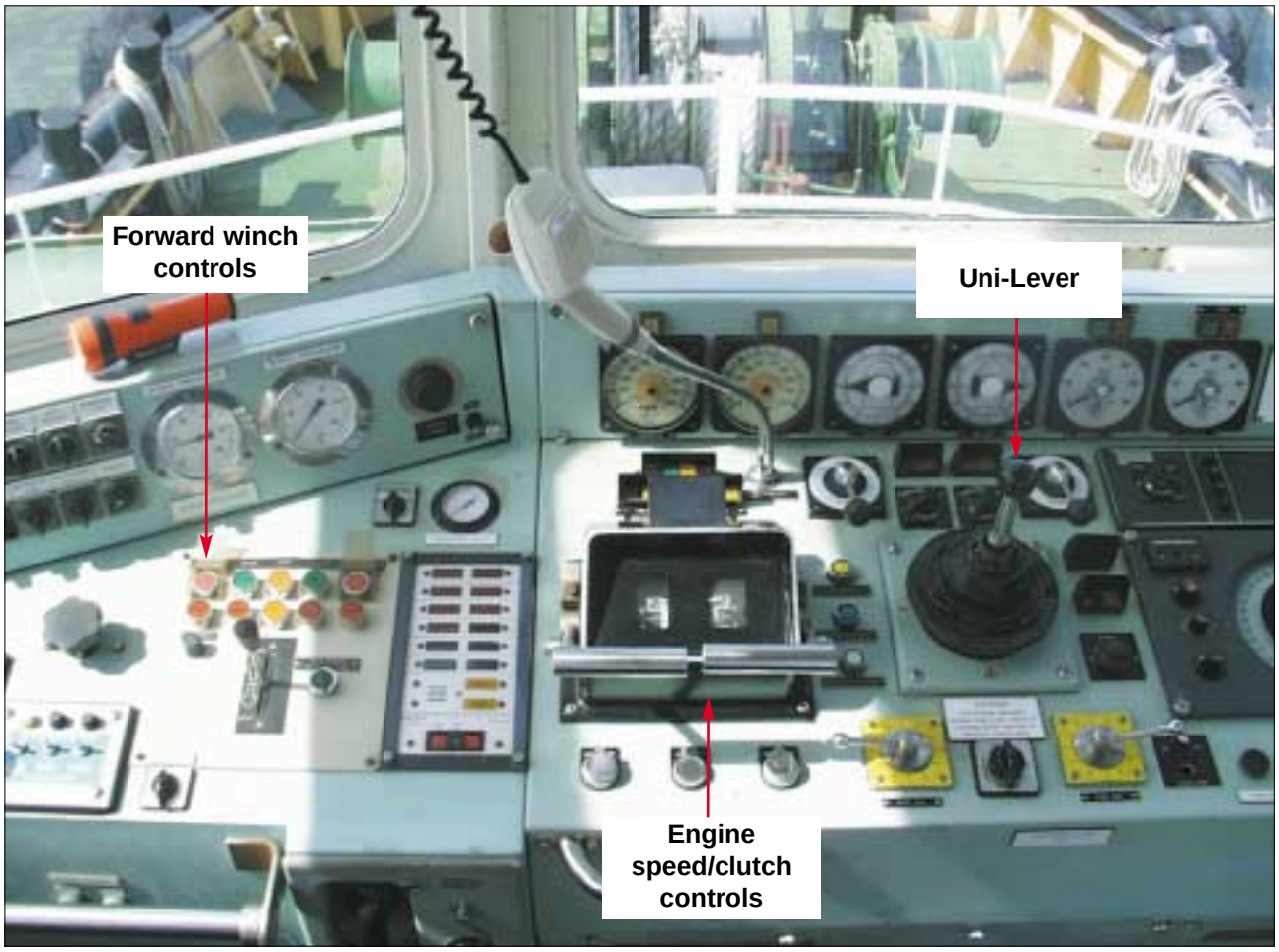
In normal circumstances, the rotation of the stern drive units, and the consequent vectoring of the propeller thrusts, is effected by a sophisticated control system with a joystick ('Uni-Lever') input. The 'Uni-Lever' is mounted on the forward console of the tug wheelhouse (fig. 2), and can be used to control the direction of the tug as well as its speed through the water for a given engine speed setting. The general principle is that the tug will move in the direction in which the 'Uni-Lever' is placed, with a combination of rotational and translational movement made possible by the control system vectoring the propeller thrusts in various ways.

Speed control, and thus propeller thrust, is also independent for each main engine. There are combined clutch and engine speed control levers located on the wheelhouse console adjacent to the 'Uni-Lever'. The tug's manoeuvrability may be further enhanced by the tug master varying the speed of each engine in combination with the various 'Uni-Lever' settings.

*Redcliffe*'s bollard pull is 64 tonnes when towing from the stern hook and 61 tonnes when the tow is connected over the bow. The usual mode of operation when manoeuvring ships in port is to use the tug in a 'push-pull' configuration with the tow connected over the bow.

The forward winch is located centrally on the tug's foredeck. The winch is fully

**FIGURE 2**
***Redcliffe's* forward bridge control**



hydraulically actuated with a 'split' drum arrangement comprised of a 'working drum' and a 'storage drum'. When the tow is connected over the bow, the towline is led through a substantial 'A' frame fairlead located amidships at the tug's bow and then onto the working drum of the forward winch. Only one layer of line is permitted on the working drum during 'pulling' operations as the winch is designed to transmit the tug's rated bollard pull based on the diameter of working drum with a single layer of line. The forward winch may be operated from two control positions; locally on the foredeck, or in the wheelhouse from a control station on the forward console just outboard of the main engine speed/clutch control levers. The winch controls at both stations include; heave and lower, clutch and brake. The console in the wheelhouse is also fitted with an emergency stop and winch quick release.

The crew of *Redcliffe* normally consists of the master, an engineer and two integrated ratings. The master stays at the tug controls during all operations, the engineer attends any engine room alarms and assists the integrated ratings handling lines etc. as required. *Redcliffe*'s tug master at the time of the incident had 36 years experience handling tugs and had been in Brisbane since 1980. He has had extensive experience driving the two large Brisbane 'Duckpeller' tugs.

## The incident

### *Ariake*

*Ariake* left Melbourne, bound for Brisbane, on the morning of 22 January 2000. *Ariake*'s departure draughts were 9.6 m forward and 10.1 m aft. The voyage north was uneventful and the ship made such good time that they stopped and drifted off the New South Wales north coast between 1700 and 1900 on the evening of 23 January.

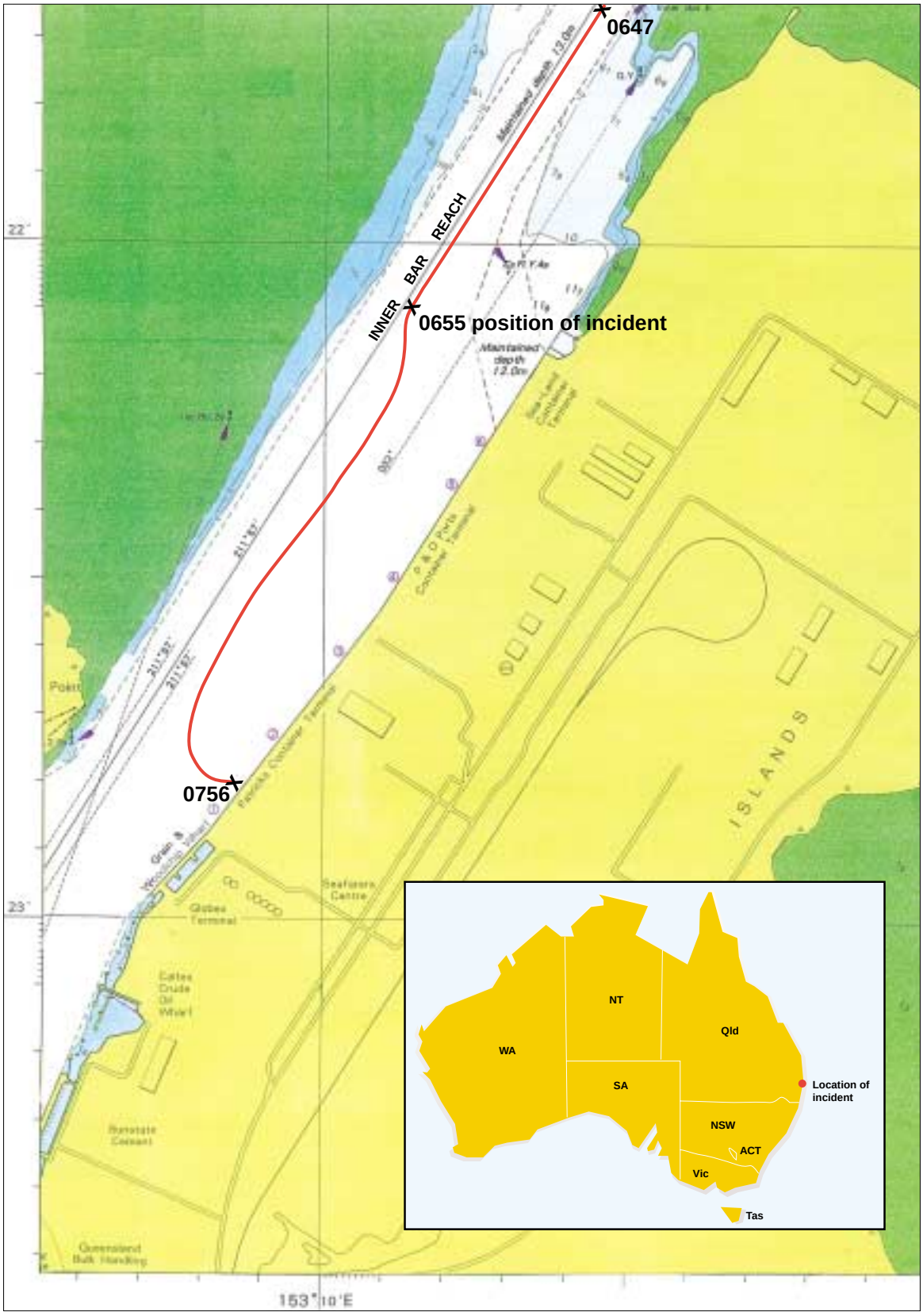
At 0300 on 24 January 2000 a Brisbane marine pilot boarded *Ariake* and took over the navigation of the vessel. The pilot was given a pilot card by the ship's staff that contained the vessel-specific information he would need to pilot the vessel. The pilot, in turn, gave *Ariake*'s master a Port of Brisbane Passage Plan containing the details of the passage from the pilot boarding ground to the berth at Fisherman Islands. The passage plan included the various courses to be followed, the disposition of the tugs, and tidal information. The pilot card indicated low water, at the Brisbane Bar, would be at 0531.

The pilot was also equipped with a portable DGPS (Differential Global Positioning System) unit that displayed and recorded the ship's position during the passage.

The Fairway Buoy was passed at 0333 and *Ariake* proceeded up the Northwest Channel inbound to Fisherman Islands container terminal. On the way through Moreton Bay the pilot contacted harbour control to confirm the availability of the wharf labour for tying up. He was informed that number 1 berth was partially occupied by *MSC China*, which would be 'warped' along the wharf to clear the berth by 0715.

As they were now well ahead of schedule, the pilot decided to take a round turn outside the Entrance Beacons. *Ariake* then passed the Entrance Beacons at 0616 and proceeded down the Entrance Channel. At 0627, as they were passing the 'Coffee Pots' proceeding into the Outer Bar Reach, the pilot again called harbour control to check on the status of the berth. He was informed that there would be a further 15 minute delay to their berthing time as *MSC China* had not moved off number 1 berth. The pilot decided to continue the Outer Bar Reach passage at 'slow ahead' and then 'dead slow ahead'. He ordered 'stop engines' just after

**FIGURE 3**
***Ariake's* approximate track to No. 1 berth Fisherman Islands**



*Ariake* passed the Inner Bar Beacons at 0647, (fig. 3).

### *Redcliffe*

*Redcliffe*'s crew started work on the night shift at 1900 the previous evening, 23 January 2000. The shift had been reasonably busy with five 'jobs' being completed prior to the berthing of *Ariake*. The berthing of *Ariake* was to be the last job of the shift. At 0630 on the way down the river from the tug base, *Redcliffe*'s tug master made contact with the pilot aboard *Ariake* and was instructed to make the tug fast, on the port quarter of the ship. *Austral Salvor*, *Redcliffe*'s sister tug, was allocated the port shoulder position.

At 0650, inside the Inner Bar beacons, *Austral Salvor* and *Redcliffe* met *Ariake* and 'lashed up' in their respective positions. The tug master on *Redcliffe* had decided to use a short towline for the operation that had approximately 3–4 m of slack with the tug on station alongside the vessel. The towline consisted of an 80 mm nylon double braid mainline (or 'superline') with a doubled 44 mm 'Plasma' tail, led from the forward winch to the tug's forward 'A' frame fairlead and then through *Ariake*'s after port panama lead and onto the bits just inboard of the lead.

*Ariake* continued to make slow headway in the channel and was being followed by the dredge *Sir Thomas Hilley*. The pilot made contact with the master of the dredge and the decision was made to stop *Ariake* off number 6 berth Fisherman Islands and let the dredge pass down the starboard side. The pilot notified the tugs of his intention to go astern on ship's engines and, at 0652, ordered 'dead slow astern', to stop the ship off number 6 berth.

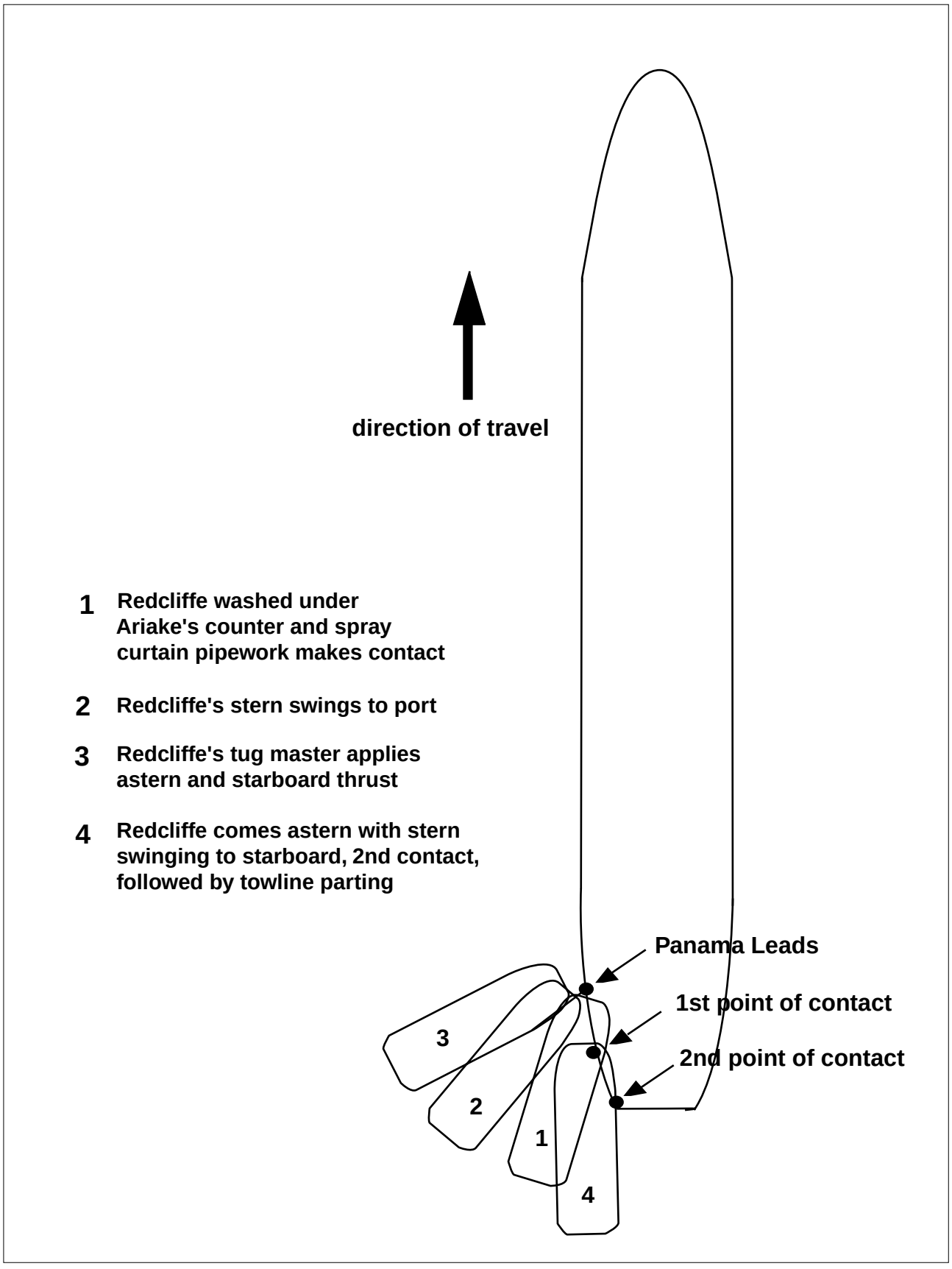
## Collision

At approximately 0654, *Redcliffe* was on station alongside *Ariake*'s port quarter when the tug master became aware that the tug was being washed in under *Ariake*'s stern counter. As the bow of the tug drifted in under the counter the fire curtain sprayer pipe-work at the forward starboard side of the tug's deckhouse made contact with the ship's shell plating. At this point the stern started drifting to port so that the tug was almost at right angles to the ship.

The tug master felt that he had to get out of the situation as quickly as possible and he 'powered up' and put the 'Uni-Lever' astern and to starboard. Astern power came on quickly and when weight came on the short towline, the tug's bow was pulled into the side of the ship. Up to this point the tug master thought that he would have sufficient towline length to slip around *Ariake*'s stern. The transverse thrust to starboard caused the tug to roll to starboard. As the tug came upright, still swinging to starboard on the tight towline, the starboard crucifix bollards made contact with the ship's side shell plating. The point of impact was just forward of the transom approximately 3 m above the waterline.

Once the crucifix bollards had made contact, they acted as a pivot point with most of the tug's length overhanging *Ariake*'s stern and the bow tethered by the towline. For a short time, *Redcliffe* continued to swing on the crucifix bollards, increasing the weight on the bollards and towline. With the increasing weight, the bollards were forced into the ship's side causing scoring, an indentation and a tear, approximately 400 mm in length, in the shell plating. *Redcliffe*'s crucifix bollards were set in and deformed in the process. The

**FIGURE 4**
***Ariake/Redcliffe* collision reconstruction**



weight on the towline was sufficient for the bit on *Ariake*'s deck to be 'strangled' (deformed around its circumference). With a little more swing and increasing weight, the towline parted between the tug's fairlead and the ship's panama lead (see fig. 4).

Once the towline parted, *Redcliffe* was free to clear the stern of *Ariake*. The tug master made contact with the pilot, shortly after 0655, to report that the towline had parted and that the ship and tug had sustained damage. The tug's crew quickly set about end-for-ending the tug's towline and reconnecting the tow.

At 0704, *Redcliffe* was re-secured to *Ariake*'s port quarter and the ship was moved up the river. *Ariake* was swung, port about, off number 1 berth Fisherman Islands, between 0717 and 0727. By 0730, the ship was alongside the berth, and the first headline was being run. Berthing was completed at 0756 and the tugs were slipped at 0759.

**FIGURE 5**
**Damage to *Redcliffe***

**FIGURE 6**
**Damage to *Ariake's* hull plating**

**FIGURE 7**
**Damage to *Ariake's* mooring bits**

# Comment and analysis

## Evidence

*Redcliffe* was inspected and damage was noted to the fire curtain pipe-work at the starboard forward corner of the deckhouse and also damage to the crucifix bollards located on the starboard shoulder (fig. 5). The tug is not equipped with any form of course recorder or engine manoeuvre recording equipment that may have assisted with the analysis of the incident. The tug master was the only member of the crew present on the bridge at the time of the incident and thus the investigation is reliant on his recollection of his actions and events at the time of the incident.

*Ariake* was inspected and damage was noted to the shell plating at the port quarter just forward of the transom bar strake including the hole (fig. 6). The mooring bit on the port quarter was inspected and showed a deformation around most of its circumference consistent with the diameter and position of the tug's towline (fig. 7). The vessel was equipped with a course recorder and an engine movement recorder. The times for the engine movements and the ship's heading at the time of the incident can be verified from these records. At the time of the incident the second mate was standing on the poop deck with some other members of the ship's crew in preparation for the mooring operation and witnessed the movements of the tug at the time of the incident.

The ship's position, speed, and course around the time of the collision were verified using records obtained from the pilot's DGPS electronic chart display unit.

The Brisbane harbour master's office provided a tape recording of some of the relevant VHF channel 16 communications between *Ariake*, harbour control and the two tugs. Unfortunately, the working channel used by the ship and tugs during the berthing was not monitored and thus the communications between the tugs and the pilot at the time of the incident were not recorded.

An events and causal factors chart for the collision between *Ariake* and *Redcliffe*, is reproduced in figure 8.

## Passage to the berth

On the morning of 24 January the pilot's instructions were to berth *Ariake* starboard-side-to number 1 berth at Fisherman Islands container terminal. His plan was to take the tugs in the usual position, passing the Inner Bar Beacons, then move into position off number 1 berth Fisherman Islands, swing the ship 'port about', and utilize the tugs and the ship's bow thruster to position the ship alongside the berth. The tide at the Brisbane bar was low at 0531 with 0.25 m above datum. By the time *Ariake* was in Inner Bar Reach at 0650, the tidal prediction indicated that the tide had turned and had started to flood.

The pilot's intended manoeuvre is a standard one when berthing ships at Fisherman Islands on a slack or flooding tide. The manoeuvre requires the tugs to 'lash up' on the port side of the ship, forward and aft, with the forward tug pulling and the after tug pushing to swing the ship. Once the ship has been turned across the channel, the relative speeds of the faster mid-channel current acting on the stern, and the slower current close to the wharf acting on the bow, put a net turning moment on the ship that assists the swing. The large 'Duckpeller' tugs in Brisbane are particularly suitable for this type of manoeuvre as they deliver

similar bollard pulls, ahead and astern, when operating in the 'push-pull' mode with the tow connected over the bow. The tugs use short lines and stay in position on the port side of the ship throughout the whole operation.

On the morning of 24 January, *Ariake* met the tugs inside the Inner Bar Beacons. The ship's engines were stopped at 0650 (according to the engine logger) and the bridge log notes that by 0651, *Redcliffe* was lashed up on the ship's port quarter. The initial 'tie up' had been routine. At this point, *Ariake* was drifting up Inner Bar Reach at approximately 3–4 knots with both engines stopped. When the pilot was informed that there would be further delay in moving *MSC China* he prudently conferred with the master of *Sir Thomas Hilley*, the dredge which was following *Ariake* into the river, before making the decision to stop the ship off number 6 berth. Both tug masters were informed of his intention to go astern and then he ordered 'slow astern' on both main engines. The engine logger on *Ariake* records this astern movement as 30–40 rpm astern on both engines at 0652.

## The collision

When the pilot ordered 'slow astern' at 0652, *Redcliffe* was keeping station alongside *Ariake*'s port quarter. The tug master stated that he felt the tug being affected by the ship's propeller wash after the engines had started astern. Then shortly afterwards, the tug was washed 'bodily' in under the counter of the ship and contact was made between the ship's hull and the tug's fire curtain pipe-work. The second mate on the ship's poop stated that he observed the tug's stern swinging to port at this time until the tug was almost at right angles to the ship.

The ship's speed through the water immediately before the collision would have been less than 2 knots ahead and thus hydrodynamic 'interaction' between the two vessels is not considered to be a factor in the incident.

*Ariake*'s propellers are 4 bladed with diameters of 6.45 m at the tips. The port propeller turns clockwise when going astern. Being twin screw, with a substantial hull flare at the stern means *Ariake*'s port propeller is relatively close to the panama lead on the port quarter. At *Ariake*'s arrival draught of 10.1 m aft, the propeller immersion would have been around 2 m at the top of rotation. When going astern the bulk of the propeller 'race', or wash, is directed forward along the line of the hull and then outward as the stern flare meets the parallel mid-body of the ship. There is also some lateral wash created by the 'paddlewheel effect' of the propeller, which is directed in an athwartships direction. When the port propeller is turning astern, the lateral wash is directed towards the ship in the area adjacent to the propeller on the port quarter.

Considering the reported sequence of events, it is likely that *Redcliffe* was initially effected by the lateral wash created by the ship's propeller going astern when positioned alongside *Ariake*'s port quarter. The effect of the lateral wash at the port quarter could well have caused the tug to move 'bodily' in under the stern counter as stated by the tug master. However it is difficult to reconcile the second mate's observation of the tug's stern drifting to port at this point. A possible explanation is that

5 The forces exerted by varying water pressure zones around a ship that is making headway on another vessel in close proximity, in this case the tug.

there may have been some reaction between the ship's hull and the starboard thrust being produced by the starboard 'Duckpeller' in the neutral position which pushed the tug's stern out. Alternatively, the tug master may have initially moved the 'Uni-Lever' to apply some port thrust to move the tug's stern out and away from the ship's port propeller although he did not recall such a manoeuvre.

When *Redcliffe* was in close proximity to *Ariake*'s port quarter with the main engines running, the tug's handling would have been significantly effected by the interaction between the ship's propeller wash and the thrust being produced by the tug's 'Duckpeller' units.

The sequence of events after the initial contact between the tug and the ship was difficult to reconcile from the statements of the witnesses but at about this time the pilot ordered 'stop engines' and *Ariake*'s engine movement logger records the time as 0655.

Once *Redcliffe* had made the first contact with *Ariake*'s stern the tug master's response was to try to move the tug out from under the ship's stern counter as quickly as possible. He increased power and moved the 'Uni-Lever' from the neutral to the astern and starboard position. The tug master thought that he might be able to come astern and move the tug clear around the ship's stern. The tug responded quickly to the 'Uni-Lever' input, and the increased power, and came astern with its stern swinging to starboard. With the ship still making slight headway, the tug's relative speed increased rapidly until it reached the full extent of the towline and was restrained. It is probable the tug master was alarmed by the initial contact and, as a result, his instinctive response was probably excessive.

When the tug had reached the full extent of the towline, its bow became effectively tethered. With more astern movement, the bow of the tug was pulled towards the side of the ship. The tug also rolled to starboard at this time as a result of the weight on the towline and the starboard thrust being produced by the 'Duckpellers'. As the tug rolled back to port, the crucifix bollards located on the starboard shoulder of the tug, approximately 3.5 m astern and outboard of the 'A' frame fairlead at the bow, made contact with *Ariake*'s shell plating and then acted as the fulcrum for the tug's swing.

At this point, the tug's propeller thrust would have been acting on the 24–25 m 'lever' from the crucifix bollards back to the centre-line of the 'Duckpellers'. The towline, on the other side of the fulcrum, was acting on the 3–4 m 'lever' from the crucifix bollards to the forward fairlead. Simple mechanics suggests that only 20–25 tonnes of thrust at the stern of the tug would have been sufficient to part the, 'Plasma' towline tail with its 142 tonne minimum tensile strength.

## Other factors

### Winch quick release

The tug master indicated that the time between the first contact, between the spray curtain pipe-work and the ship's hull, and the towline parting was 10–15 seconds. He also stated that the towline parted very soon after the crucifix bollards made contact with the ship's hull. If more towline had been run off the working drum quickly at the time of the first contact *Redcliffe* would have been able to move clear of the ship without causing further damage.

The tug master had two options to release more towline: either to order the deck crew

to pay-out on the line using the local winch controls; or, alternatively to use the towline quick release. Communication with the deck crew is via hand-held UHF radios. In an emergency situation, the time taken to communicate with the crew, and for them to respond, is critical. Given the speed of events it is unlikely that the deck crew could have responded quickly enough using the local winch controls. The tug master however, had time to operate the winch quick release on the wheelhouse console which is designed for such contingencies.

The forward winch controls are located on the forward console in the wheel house outboard of the main engine speed /clutch controls. The controls include a quick release button that disengages the winch clutch and then releases the brake 2 seconds later to free-spool the winch drum. The brake is partially re-engaged 6 seconds later to control the speed of the free-spooling winch drum. The winch quick release mechanism is designed to allow a tug to move clear of a vessel quickly in an emergency. The quick release button is red and covered with a clear plastic flap to prevent inadvertent actuation. It is company policy to test the emergency functions of the winch control regularly and the tug masters are aware of their effects.

*Redcliffe*'s tug master stated that it was his practice to occasionally lift the plastic cover on the winch quick release if he felt that the 'job' was 'dicey' and there was some chance of getting the tug caught under a ship's counter. In this instance he didn't feel that *Ariake* required any special consideration and had not lifted the cover of the quick release button in preparation for the towage operation.

The tug master's workload immediately after the tug had been washed in under *Ariake*'s counter was extremely high with both hands being used to control the 'Uni-Lever' and engine throttles. His full attention would have been focused outside the wheelhouse on the position of the tug relative to the side of the ship. It is doubtful if he even gave serious consideration to the option of using the quick release given his physical and mental workload and the speed of events. He was also concerned that if he had slackened the towline there was a risk of fouling the ship's port propeller.

### Length and strength of towline

*Redcliffe*'s tug master stated that the towline he used at the time of the incident had approximately 3–4 m of slack. His initial reaction after the first contact was to bring the tug astern, thinking that there may be enough towline to move the tug clear around the ship's stern. Had the towline been longer, the tug may well have passed clear around the ship's stern and caused little or no damage. The strength of the towline also meant that there was substantially more damage caused by the collision than would have been the case previously, when more conventional tails were used.

Almost all of the towage operations performed by the 'Duckpeller' tugs in Brisbane utilize the forward winch with the tow being connected over the bow. The length of towline to be used for each towage operation is determined beforehand by the tug master. The usual practice is to keep the towline as short as possible to enable the tug to respond quickly to a change in the mode of operation from 'pushing' to 'pulling'. The short line also minimizes the risk of fouling the line on obstructions on the tug or the ship. Once the tug master has stipulated the length of towline required for an operation, the deck crew ensure that the correct amount of line is moved from the winch's storage drum to the working drum. If the towline length needs to be varied during an

operation, the tug master usually directs the crew to pay-out or haul-in line on the working drum using the local controls.

Brisbane tugs have recently started to use a doubled 44 mm diameter 'Plasma[6]' tail or 'grommet' spliced into the end of their 80 mm nylon double braid 'superlines'. 'Plasma' is a new type of synthetic rope constructed of high modulus polyethylene fibres. The rope has been designed specifically for applications in the towing industry where lighter, smaller diameter ropes, with high tensile strength, minimal stretch, and superior abrasion resistance are required. 'Plasma' exhibits less than 4 % elongation when loaded as compared to 30 % for the conventional nylon double braid line. The tail is designed to act as a strong sacrificial piece capable of withstanding the abrasive wear from repeated use on ship's bits and leads. The tails are expensive items and are normally only replaced after 1500 operations. The towline in use at the time of the incident had completed 299 'jobs'.

The short towline used for most towage operations means that the tail often makes up more than half of the total towline length. When there is such a short length of the nylon double braid 'superline' off the working drum, the high proportion of 'Plasma' tail of the total towline length, results in a towline with minimal elongation under load. This reduction in stretch, from the more conventional lines used previously, has meant the new towline tails have necessitated a modified approach to the handling of the tugs. In the pulling mode, tension must be applied more gradually to the towline to ensure that there are no shock loads placed on the line, the tug's towing winch or the ship's mooring equipment. Every tug master is conscious of the relatively high cost of replacing the 'Plasma' tails and all take steps to minimise the wear on them.

One of the advantages of using the 'Plasma' tails has been an improvement in the safety of deck operations. With 'Plasma's' substantially higher strength and wear resistance, there is significantly less risk of parting a flawed towline under load. In addition, the low elongation in the towline means that there is considerably less line recoil or whip if it should part. There have been a number of serious flail injuries in the towage industry in the past when towlines have parted and recoiled to strike crewmembers on the deck of the tug and/or the deck of the ship being serviced.

### Ship design

There is a trend in modern ship design towards increasing bow and stern flare, particularly container ships where an extreme bow flare is necessary to deflect seas away from the decks. Vessels with a pronounced flare at the bow and stern are poorly designed from a towage point of view with few effective places where a tug can safely 'land' to connect a tow or to 'push up'. Some tug masters indicated an increased level of apprehension, when allocated the stern position, approaching vessels with a pronounced stern counter. A steep stern flare often renders the tug's fenders useless with the ship's counter being higher than the fender line of the tug. Vessels with a relatively high freeboard exacerbate this problem for the tug masters. The risk is that the tug will become trapped under the ship's counter generally resulting in damage to the ship's hull and the tug's superstructure.

[6] Trade name of the line

Many of the tug masters have considered these problems of ship design and formed various informal contingency plans. One tug master kept a database on his past towage operations which indicated how good or bad the design of the ship's towage positions were. He used this information as a guide so he knew 'how much adrenaline he would need' for a towage operation involving that particular vessel in the future. *Redcliffe*'s tug master had also considered this problem and prepared himself on past occasions by using his 'lift the flap on the quick release button' plan.

*Ariake* has sufficient stern flare for it to be a significant factor in this incident. When *Redcliffe* initially drifted into the side of the ship the first point of contact with the ship's hull plating was the fire curtain pipe-work on the front of the deckhouse. This pipe-work is some 2.5 m inside, and 1.5 m above, the line of the tug's fenders. The second contact was with the tug's crucifix bollards. The crucifix bollards are 1 m inside and 0.5 m above the line of the tug's fenders at the point of contact. *Redcliffe*'s fenders were thus rendered ineffective at *Ariake*'s Brisbane arrival draught, given the design of the ship's stern.

In hindsight, it seems *Redcliffe*'s tug master may have underestimating the risks involved with his position at *Ariake*'s port quarter. He had not lifted the cover on the winch quick release despite the ship's high stern counter and the fact that the ship is twin screw with the associated risks posed by the proximity of the port propeller.

*Ariake*'s hull is painted brilliant white, which may have been another factor in the incident. The tug master thought the ship was making slight sternway at the time of the incident. The master, second mate and pilot's DGPS unit all indicated that ship was in fact making slight headway. The tug master's apparent confusion can possibly be explained by the difficulty associated with his visual perception of distance and relative speed when faced with *Ariake*'s featureless white hull. Certainly his judgement of the required control inputs may have been affected by this apparent misconception of the ship's relative speed.

## Fatigue

The permanent tug crews of the Queensland Tug and Salvage Company work a 15-day roster system. The crews work 3 night shifts from 1900 to 0700, 3 non-shift or stand-by days when they are called in only if required by the workload, 3 days on day shift from 0700 to 1900 and then 6 days off on leave. The change of shift/crew takes place when the tugs are alongside at the tug base.

*Redcliffe*'s tug master came off an extended period of leave over Christmas for his first night shift on the evening of 21 January. The first night was quiet with only one 'job' between 2125 and 2210. The tug master got some rest at the tug base after the 'job' and finished the shift on time at 0700. His second night on night shift was somewhat busier with 3 'jobs' but once again he returned to the tug base at 2250 and got some rest until the change of shift at 0700. His third night shift, the shift when the incident occurred, was substantially busier with *Ariake* being the last of 6 'jobs'. The 'jobs' prior to *Ariake* were fairly evenly spaced throughout the evening and thus the tug master had not had the opportunity for any significant period of rest.

*Redcliffe*'s master's schedule for the previous 72 hours would suggest that he was well rested starting the night shift on the evening of 23 January. At the time of the incident he did not feel overly weary. However, after the

long night shift, it is likely he was experiencing some effects of fatigue when the incident occurred at 0655 on the morning of 24 January. These effects may have included; lower psychomotor reaction times, slower decision making, and impairment of judgement.

## Procedures

The tugs operated by Queensland Tug and Salvage Company in Brisbane are operated under Howard Smith Towage's company policy, operational instructions and standing orders. Each tug is supplied with a vessel-specific procedure manual which describes the responsibilities of the personnel, procedures for operating the major proprietary equipment, and various other instructions and warnings. The procedure manual is a 'controlled' document and is periodically updated to reflect changes of procedures etc. All of the tug crews are expected to be fully conversant with the contents of the procedure manual and the company policy with regard to the operation of the tugs. The procedure manual does not contain detailed procedures for every tug operation and includes in its introduction the following statement:

> 1.1.7 The instructions and information contained in this manual do not and cannot cover every contingency, and there will remain many events and circumstances which will have to be dealt with by the exercise of common sense and good seamanship.

In addition to written procedures the Company has an ongoing training and check program to ensure that tug masters maintain a prescribed level of operational competence. A 'check' tug master periodically accompanies the other tug masters on 'jobs' to ensure that they are operating the tug in accordance with company policy and accepted safe practice.

The tug master on *Redcliffe* on the morning of 24 January was 'current' and operating the tug in accordance with accepted practice and the procedures detailed in the procedure manual.

## Human factors issues

Since their introduction in 1986, the two large 'Duckpeller' tugs in Brisbane have been involved in a number of collisions with ships during towage operations. Given the total number of towage operations completed in the port, these incidents have been relatively infrequent, however some recent incidents have involved a loss of control of the tug. On 27 April 1998, the Marine Incident Investigation Unit investigated a collision between, *Redcliffe*'s sister tug *Austral Salvor* and the coastal products tanker *Barrington* (report number 132). On 15 December 1999 the Brisbane Regional Harbour Master's Office investigated another collision between *Austral Salvor* and the container ship *Arafura*.

Outwardly these incidents differ significantly from the collision between *Redcliffe* and *Ariake* on 24 January. However, in both of these cases the operation of the 'Uni-Lever' control system was found to be a factor. After seeing the operation of these tugs and speaking to a number of the tug masters it became apparent to the investigation that there may be some ergonomic and perceptual problems associated with the operation of the tug's manoeuvring system and particularly the 'Uni-Lever'. Help was sought in identifying the problems from a 'human factors' expert from the Australian Transport Safety Bureau. He spent some time considering the operation of the tugs and talking to some of the tug masters and provided the following report.

## Human factors aspects of the 'Uni-Lever' system

### Introduction

This brief examines some of the human factors concerns that have been prevalent in the operation of the azimuth stern drive control system ('Uni-Lever') on board the Brisbane tugs *Redcliffe* and *Austral Salvor*. The following factors, which may have been implicated in other tug occurrences where the 'Uni-Lever' system was being utilised, were not considered in the scope of this brief study:

- Crew stress and fatigue (for example 12 hour shifts, standing up for prolonged periods at controls may produce the impairment of cognitive skills such as judgement, decision-making, memory, self-regulation, self-awareness, impaired psychomotor coordination and reaction times);
- Anthropometric limitations (such as excessively tall tug masters with implications for elbow flexion and control displacement feel, that is, precise motor control may be more difficult for very tall masters - above 95th percentile);
- The reduction of perceptual cues during night operations, glare from lighting;
- Other adverse environmental factors such as rough sea states, tidal movement, high winds, other weather;
- Communication difficulties with the pilot, deck crew and other tugs;
- Initial tug training;
- Competency standards and procedures;
- Management of tug master's proficiency and ongoing check and training, particularly for emergencies or loss of control situations;
- Company operating culture and the operating philosophy promulgated by the senior check and training tug master; and
- Informal heuristic utilised by tug masters to minimise mental workload (for example, electing to use asymmetric thrust to assist tug lateral movement rather than using the 'Sideways Control' mode).

The various incidents in the past have been the result of a combination of a number of factors. Consequently, it is very difficult to implicate any single predominating factor in these occurrences. The tug masters were all considered very capable, experienced, and current at the time of the occurrences. This brief will focus solely on the 'Uni-Lever' control system.

### Ergonomics of the 'Uni-Lever' system

It is often very difficult to isolate the potential impact of ergonomic issues on operator performance. The 'Uni-Lever' system appears to conform to sound ergonomic principles. The 'Uni-Lever', engine speed/clutch controls and associated instruments demonstrated:

- control-display alignment and compatibility (with one exception);
- lever and throttle are designed with appropriate control force resistance, throw range, and size;
- the tug's wheelhouse has good outside visibility from the operating position for daylight operations (unknown for night), with minimal obstructions;
- instruments clearly marked, large faces; and

- towline quick release could be closer (preferably mounted on or near the 'Uni-Lever').

The only major concern is during 'sideways' displacement of the 'Uni-Lever' when the tug is lashed up to a vessel. For example, if the lever is moved from a full starboard position to a full port position without passing through the neutral position, the tug will enter an uncontrollable spin to the right. The tug will actually turn 360º in 26 seconds at moderate thrust settings. This 'over-controlling' in a difficult situation may have been a factor in at least one of the past incidents and has been well documented in the tug company's procedure manual with appropriate warnings.

The over-controlling in response to difficult situations may be induced by initial errors of estimation (judging closure rates, drift rates), orientation of thrusters, planning for loss of control, and awareness of hazards that may require large displacements of the 'Uni-Lever'. Tug masters appear to employ a variety of individualised techniques to minimise the risk of control problems. For example, one tug master would only make small sideways 'Uni-Lever' movements about the centre position with asymmetric thrust assistance when lashed up to a vessel.

### Information-processing problems

Rasmussen (1982; 1983) has proposed that there are three levels at which people perform their actions. These levels are skill-based performance, rule-based performance and knowledge-based performance. Slips and lapses tend to occur at the skill-based level. At the skill-based level, people conduct routine, highly practised or automatic tasks, with an occasional conscious check on progress. Rule-based performance is based upon matching signs and symptoms of a problem to some stored or pre-packaged solution. Finally, the knowledge-based level is activated when the problem space is novel and very difficult. This level requires time consuming and effortful processing.

Errors tend to occur as a result of forgetting, inattention, and/or incomplete knowledge. Skills-based slips are unintentional actions that occur during the execution of familiar and automated tasks. Some tug masters may be failing to recognise the potential for or anticipating controllability problems when in 'sideways' mode. The tug masters may be unintentionally overcontrolling the 'Uni-Lever' in sideways operations. This may be symptomatic of the training regime.

### Alternative courses of action for impending loss of control situations

The tug company's normal operating procedures do not actively promote courses of action which may provide an evasive option for tug masters who encounter uncomfortable or unfamiliar situations with elevated levels of uncertainty. For example, de-clutching the tug will eliminate the 'Duckpeller' thrust and may help prevent or minimise an impending collision with a vessel. The operating procedures do not encourage de-clutching. In addition, there is no clear instruction with regard to the operation of the winch quick release although the procedures stipulate that the quick release must be tested periodically. Furthermore, there may also be a reluctance amongst tug masters to execute certain emergency procedures because of the embarrassment involved (protection of professional reputation/pride).

The tug masters may prefer to try all else to regain control of the tug when they begin to experience controllability difficulties rather than releasing the line, the brake, or de-clutching. Furthermore, it is unknown how

detailed and frequent the experiential training of such emergency manoeuvres is or how often they are discussed (without criticism) and practised. The tug masters may be fully aware of such options but if their experiential exposure to such options is minimal, they may not be considered in a time of high stress. Moreover, the most dominant schema or habitual response will be activated.

## Recommendations

The organisational or latent factors prevalent in this incident have not been examined but such factors generally have the potential to be of greater significance if any safety action were to be recommended and implemented. The following safety actions or defences are neither prescriptive nor exhaustive. The following items are only suggestions or considerations that may help alleviate some of the problems identified in the incidents:

- Clarify, document, and standardise the suite of options for impending loss of control situations in the 'Duckpeller' tugs; and
- Increase the frequency of experiential training for such options.

The above suggestions need to be considered within the organisational climate confronting the Queensland Tug and Salvage Company.

# Conclusions

These conclusions identify the different factors contributing to the incident and should not be read as apportioning blame or liability to any particular organisation or individual.

The collision between the Brisbane tug *Redcliffe* and the container ship *Ariake* on 24 January 2000 was a result of a number of factors which include but are not limited to:

1. The tug was initially 'washed in' under the ship's stern counter as a result of the astern movement on the ship's port main engine between 0652 and 0655.

2. The tug master misjudged his response to the initial impact of the spray curtain pipe-work which resulted in the second impact when most of the damage to the tug and ship occurred.

3. The short, strong, towline may have contributed to the severity of the second collision.

4. The tug master was probably experiencing some effects of fatigue at the end of a reasonably busy night shift. This fatigue may have affected his perception, judgement and response when handling the tug at close quarters with the ship.

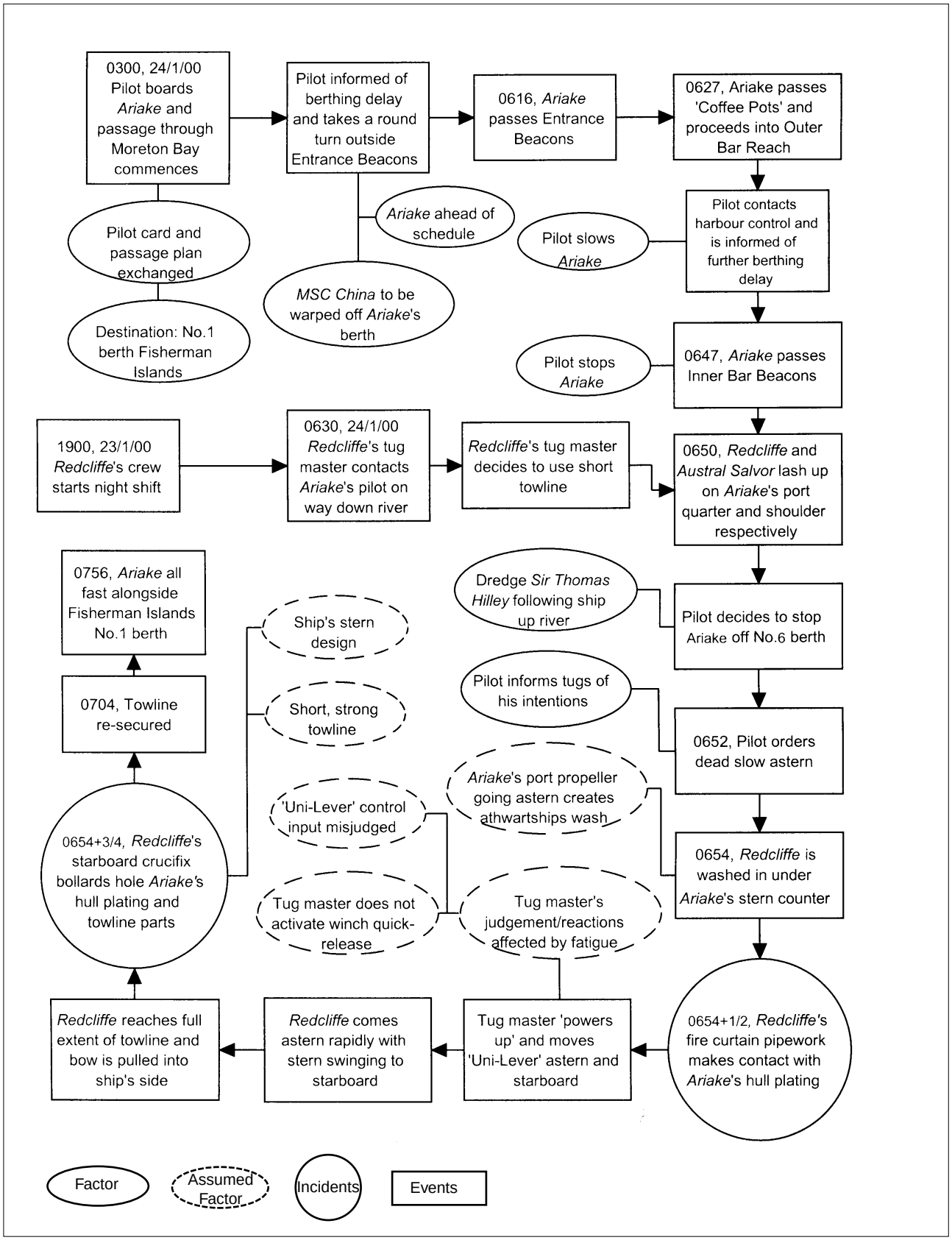
5. The tug master did not use the emergency options that were available to him, which may have mitigated the severity of the second collision, chiefly, the forward winch 'quick release' control.

6. The tug's fendering system was rendered ineffective as a result of the; ship's stern design, arrival draught and the tug's port quarter towing position.

Also:

7. There are still some apparent 'human factors' issues with the control of the large 'Duckpeller' tugs in Brisbane and further training is indicated for tug masters in emergency procedures.

**FIGURE 8**
***Ariake/Redcliffe* collision events and causal factor chart**



# Submissions

Under sub-regulation 16(3) of the Navigation (Marine Casualty) Regulations, if a report, or part of a report, relates to a person's affairs to a material extent, the Inspector must, if it is reasonable to do so, give that person a copy of the report or the relevant part of the report. Sub-regulation 16(4) provides that such a person may provide written comments or information relating to the report.

The final draft of the report was sent to the following:

The tug Master, *Redcliffe*

The Master and Second Mate, *Ariake*

The Operations Manager, Queensland Tug and Salvage Co. Pty Ltd

The General Manager P&O Swire Containers

Australian Maritime Safety Authority

A submission was received from the Queensland Tug and Salvage Co. Pty Ltd. The text of the draft was amended as appropriate.

# Details of *Ariake*

| | |
|---|---|
| Name | *Ariake* |
| IMO No. | 7417551 |
| Flag | British |
| Classification Society | Lloyds Register |
| Vessel type | Container ship |
| Owner | P&O Nedlloyd Ltd |
| Year of build | 1976 |
| Builder | Flender Werft A.G. Lubeck, Germany |
| Gross tonnage | 37 286 |
| Summer deadweight | 34 345 tonnes |
| Length overall | 237.80 m |
| Breadth, moulded | 32.20 m |
| Depth (to second deck) | 16.48 m |
| Draught (summer) | 10.5 m |
| Engine | 2 x M.A.N. K8 SZ 90/160A |
| Engine power | 2 x 19 570 kW |
| Service speed | 25 knots @ 116 rpm |
| Crew | 31 (Australian and Papuan officers Filipino and Chinese crew) |

# Details of *Redcliffe*

| | |
|---|---|
| Name | *Redcliffe* (formerly *WJ Trotter*) |
| IMO No. | 8501397 |
| Flag | Australian |
| Classification Society | American Bureau of Shipping |
| Vessel type | Stern drive Omni-directional tug |
| Owner | Queensland Tug & Salvage Co. Pty Ltd |
| Operator | Queensland Tug & Salvage Co. Pty Ltd |
| Year of build | 1986 |
| Builder | Carrington Slipway, Newcastle |
| Gross tonnage | 470 |
| Net tonnage | 141 |
| Light Displacement | 613 tonnes |
| Displacement max | 966 tonnes |
| Length overall | 33.92 m |
| Breadth, moulded | 10.82 m |
| Depth, moulded | 5.39 m |
| Draught (summer) | 5.3 m |
| Engine | Two Yanmar 8Z280-ET |
| Engine power | 2 x 1 790 kW |
| Bollard pull (stern hook) | 64 tonnes |
| Bollard pull (bow) | 61 tonnes |
| Speed | 13 knots (free running) |
| Crew | 4 (Australian) |