Report No 157

# Navigation (Marine Casualty) Regulations

Report of the investigation into

the contact between the Maltese flag bulk cargo vessel

*Amarantos*

and the wharf at

Wallaroo in South Australia

on 10 April 2000

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**FIGURE 1**
*Amarantos*

# Summary

On the morning of 10 April 2000 the 64 957 tonne, Maltese flag, panamax bulk carrier *Amarantos* was inbound to the port of Wallaroo at the eastern side of the Spencer Gulf, South Australia. The vessel was in ballast and intending to load 20 000 tonnes of wheat for export to Iraq.

The main engine was prepared for the arrival stand-by and tested astern at 0510; the chief engineer was conducting engine manoeuvring from the control room.

A Ports Corp South Australia pilot boarded the vessel outside the Wallaroo entrance channel. At 0612, after the pilot had made his way to the bridge, a pilot/master information exchange took place. The pilot took charge of the navigation and brought the ship on to an easterly heading to enter the port south of the shipping channel.

At 0645, *Amarantos* was met by the two harbour tugs, *Kalanbi* and *Ungarra*, south of the number 11 channel beacons. *Kalanbi*, the marginally smaller of the two tugs was 'made fast' to the ship's bow and *Ungarra* to the stern.

*Amarantos* continued a 'normal' approach to the Wallaroo jetty and, at 0708, the master of the vessel noted the ship's speed at 3 knots ahead with the ship approximately 500 m north-east of the berth. The pilot was turning the ship, at this time, onto a southerly heading to approach the berth nearly at right angles. Off the berth he intended using the tugs and the effect of the transverse thrust of the propeller with the engine going astern, to berth 'port-side-to'.

Despite putting the engine astern and the tugs attempting to turn *Amarantos*, the ship maintained a nearly steady course. Initially this did not concern the pilot, but with the bow 30 m from the wharf, he ordered all personnel to be cleared from the jetty, as contact seemed inevitable.

At a time logged by the ship's crew as 0720, *Amarantos* made contact with the Wallaroo jetty causing substantial damage to the jetty deck timbers, piles, and the grain loader and its supporting superstructure mounted on the jetty. The vessel struck the jetty almost at right angles and continued on into the jetty for a distance of 3.5–4 m. The ship sustained only minor non-structural damage in the incident.

*Amarantos* moved clear of the jetty immediately after the contact, and was subsequently berthed by the pilot alongside the number 2 north berth with all lines ashore at 0820.

# Sources of information

The master and crew of *Amarantos*

The pilot

The master of the tug *Kalanbi*

The master of the tug *Ungarra*

The Wallaroo wharf supervisor

Ports Corp South Australia

The Australian Maritime College

The Australian Maritime Safety Authority

Transport South Australia

Bureau of Meteorology

Dr Jeff Brock, Consultant Adviser Aviation Medicine, Director General Defence Health Service

Dr Stan Gottschalk, Australian Maritime College

Wartsila NSD, Sydney

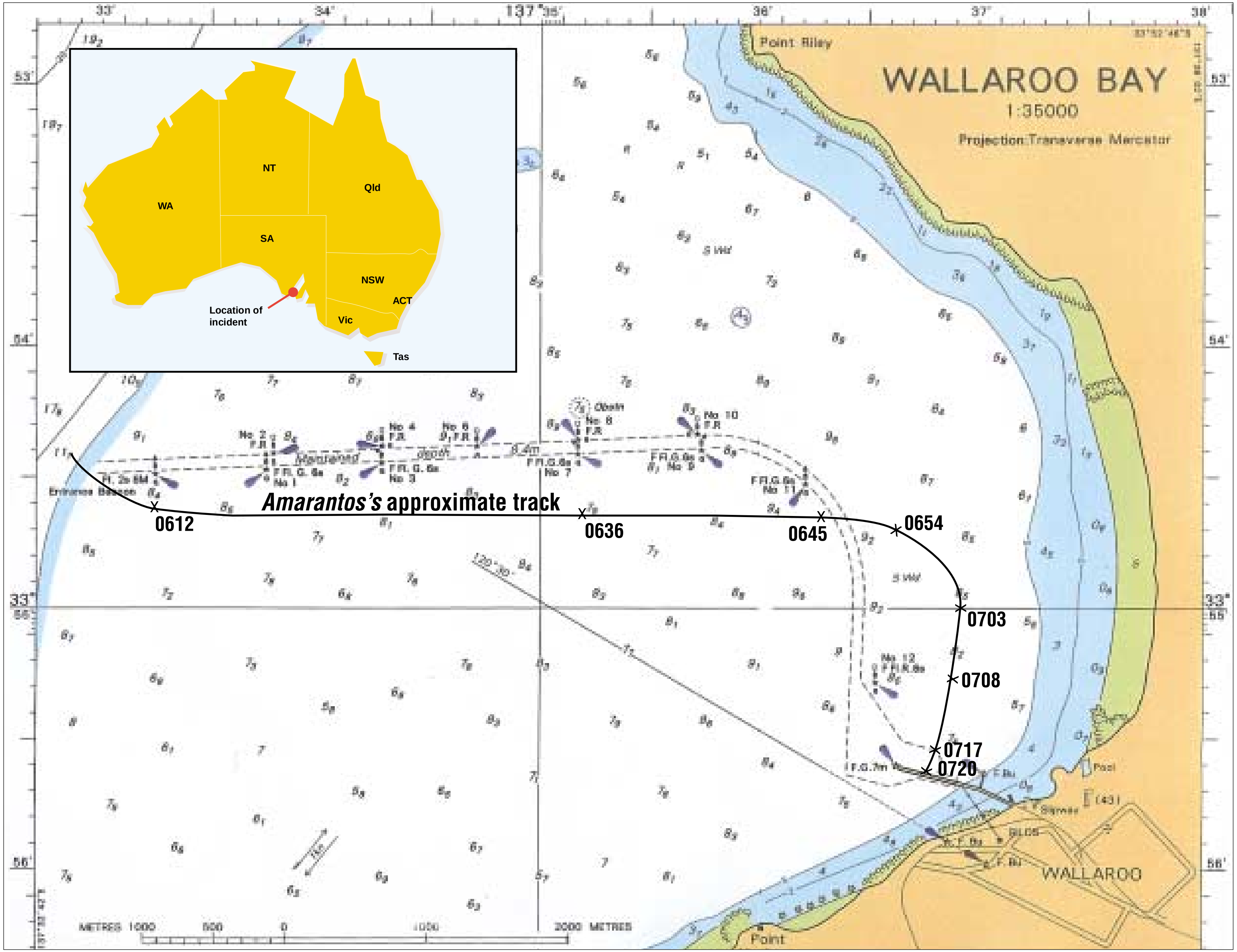

### Acknowledgment

Cover photograph of *Amarantos* supplied by the Advertiser newspaper, Adelaide

The investigation was conducted with the help of, and on behalf of, Malta Maritime Authority, under the provisions of IMO resolution A.849(20), ‘Code for the Investigation of Marine Casualties and Incidents’.

The Australian Transport Safety Bureau is grateful for the assistance provided by the staff at the Australian Maritime College’s ship simulator unit which was used to reconstructed the incident in the analysis.

FIGURE 2
Port of Wallaroo & *Amarantos*' s approximate track



# Narrative

## *Amarantos*

*Amarantos* (fig. 1) is a Maltese flag panamax bulk carrier of 64 957 deadweight tonnes at its summer draught of 13.3285 m. The vessel is owned by *Amarantos* Shipping Co. Ltd of Valletta, Malta, and the registered agents are Dileship Marine Corporation of Piraeus, Greece. It is classed with Lloyd's Register as a ✠100A1 bulk carrier strengthened for heavy cargoes, with ✠ LMC[1] and UMS[2] notations.

*Amarantos* was built in 1980 by Mitsubishi Heavy Industries Ltd in Kobe, Japan. The ship has an overall length of 224.00 m, a moulded breadth of 31.80 m and a moulded depth of 18.35 m. The vessel is powered by a 6-cylinder Sulzer 6RND76M single acting, direct reversing, 2-stroke diesel engine, of 10 592 kW. The main engine drives a single fixed-pitch right hand propeller giving a service speed of 14.75 knots.

The vessel is of standard bulk carrier design with seven cargo holds that are located forward of the accommodation superstructure. *Amarantos*'s bow-to-bridge distance is 182.80 m. The top of the forecastle bulwark overhangs the most forward part of the bulbous bow by approximately 4.8 m. The top of the forecastle bulwark is 23.3 m above the keel.

*Amarantos* has a crew of 23, with a master and three mates, chief and four engineers, boatswain and six deck ratings, three engine room ratings and four catering staff. The mates maintain a traditional '4 on, 8 off', watchkeeping routine.

At the time of the incident, the master of *Amarantos* held a Greek Master Class 1 certificate of competency and had 26 years experience as master. He had been on the vessel for a total of 15 months including the previous 5 months on the current crew 'swing'.

The Ports Corp South Australia pilot on board *Amarantos* at the time of the incident held pilot's licences for the South Australian ports of Wallaroo, Port Pirie, Port Giles, Thevenard, Port Lincoln, and Adelaide. He had 31 years experience as a marine pilot and had served as harbour master at Wallaroo for 2 years, from 1976 to 1978.

## Wallaroo

Wallaroo is located on the eastern side of the Spencer Gulf on the Yorke Peninsula approximately 80 miles[3] north-west of Adelaide (fig. 2). The port of Wallaroo's main function is to service the wheat farming industry in the local area by handling the export of grain and the import of farming phosphates. The shipping facilities in the port consist mainly of a jetty and a grain loader, with its associated conveyors and storage silos.

The Wallaroo jetty is owned by Ports Corp South Australia and was built in 1957/58. It is 867 m in length and has three ship berths on each side numbered 1, 2 and 3 north and south. The jetty runs west-north-west from the shore into Wallaroo Bay. A grain conveyor and ship loader, owned by South Australian Co-operative Bulk Handling, forms a superstructure on much of the jetty

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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 Miles referred as Nautical miles = 1 852 metres.

and extends to a point 195 m from jetty head. The grain conveyor takes grain from silos on the shore to the south of the jetty, to the grain loader located adjacent to the number 2 north berth.

The gain loader consists of an elevated main conveyor house and five slewing loading booms. The main conveyor house is mounted on a steel superstructure 11.5 m above the jetty and the loading booms are spaced at 22 m intervals along the main conveyor house. Grain is fed out from the main conveyor belt into the slewing loading booms, and then into the ship's holds. Each boom conveyor has an enclosed control position adjacent to main conveyor house and a central control station is located on top of the main conveyor house on the span between the third and fourth loading booms. When not in use, the loading booms are 'stowed' alongside the main conveyor house.

The port of Wallaroo has a shipping channel approximately 6 790 m long which is marked by beacons. The channel runs from a 300 m swinging basin north-west of the jetty head in a north-south direction west of number 12 beacon for a distance of about 1 500 m. It then turns to an alignment of 267°/087° at number 6 beacon through an arc of 1 400 m with a radius of turn of about 1 100 m. The distance from the number 6 beacon to the channel entrance beacon is about 3 890 m (2.1 miles). The channel and swinging basin, centred, have a depth of 8.5 m below datum. The depth of water at number 2 north berth is 9.5 m.

Pilotage is compulsory for the port of Wallaroo.

Vessels in ballast generally enter the port south of the channel and approach the jetty from east of the channel across the 'flats'. Those vessels berthing on the north side of the jetty secure the tug or tugs near number 11 beacon and turn in an arc to approach the jetty almost at right angles for the last 200–400 m. This approach crosses the 8 m depth contour into depths marginally below 8 m between 400 m and 250 m off the berth.

The conventional twin-screw tug *Kalanbi* is permanently stationed at Wallaroo. *Kalanbi* has a nominal bollard pull of 11.5 tonnes. The master of *Kalanbi*, at the time of the incident, had 20 years experience as a tug master and had a long and intimate knowledge of the port.

When berthing 'handy size' bulk carriers of less than 200 m in length, *Kalanbi* is used as the sole tug, often in conjunction with the ship's anchor. For panamax size vessels of 220 m and over, or vessels with a beam greater than 30 m, two tugs are used. An additional tug is sent from another port. The tug, which is usually used in Wallaroo, if an extra tug is required, is *Ungarra* from Port Pirie. *Ungarra* has a nominal bollard pull of 13 tonnes and is also a conventional twin-screw tug. The master on *Ungarra*, at the time of the incident, had 27 years experience on tugs, 17 years as master.

Ports Corp South Australia have standard operating procedures for all ships which detail a minimum number of essential personnel being present on the wharf during berthing operations.

## The incident

**19 March - 0600 10 April**

*Amarantos* departed Nantong, China, on 19 March 2000, after 3 weeks in a ship repair yard including 6 days in dry dock. The vessel was bound for Wallaroo in South Australia to load a part cargo of 20 000 tonnes of wheat for export to Iraq. The voyage south had been uneventful and *Amarantos* arrived at the anchorage off Port Wallaroo in the evening of 6 April. *Amarantos* was due to berth on the morning of 10 April.

In the late afternoon of 9 April, the pilot rostered to berth *Amarantos* left his home in Adelaide to travel to Wallaroo. He arrived at his motel, a few minutes from the Wallaroo jetty, in the early evening. He had a meal and then went to bed at about 2130.

At 2300 on 9 April, the tug *Ungarra* sailed from Port Pirie. *Ungarra* was to assist the Wallaroo-based tug *Kalanbi* with the berthing of *Amarantos*.

*Amarantos* remained at the anchorage until 0500 on 10 April. It then weighed anchor and proceeded to the pilot boarding ground. The main engine was tested astern at 0510. Main engine manoeuvring was being effected from the control room console as the chief engineer felt that this practice was more economical on starting air than using the automated bridge control system. Two steering pumps were in operation in preparation for the pilotage.

The pilot rose at 0445 and boarded the pilot launch at 0530. The launch then proceeded out to the pilot boarding ground to meet *Amarantos*. The crew of *Kalanbi* prepared the tug for the berthing operation and rendezvoused with *Ungarra*, which had arrived off the jetty, at about 0500.

At 0540, *Amarantos* was on an easterly course in a position north-west of the Wallaroo shipping channel entrance beacons and slowing down to take the pilot. There was a small choppy sea running and a north-easterly breeze, which was estimated at 5 knots. The pilot ladder was rigged on the port side. After the pilot launch came alongside the launch coxswain realised the ship would need to turn hard to port to create a 'lee' for the pilot to board.

**10 April 0612 to 0820**

A lee was made on a northerly heading and the pilot finally embarked. The pilot arrived on the bridge at about 0612 and after bringing the vessel around to complete the turn towards the entrance beacons, he ordered 'full ahead' and altered course to bring the ship south of the entrance channel. A master/pilot information exchange took place. The pilot described his planned passage to the berth including the courses to be followed and the proposed disposition of the tugs. The plan was to berth the vessel port-side-to the number 2 north berth alongside the grain loader at the Wallaroo jetty.

The master indicated to the pilot that the main engine was ready for manoeuvring and that the ship's crew had prepared an anchor for 'letting go'. By this time the first mate was stationed on the forecastle. The master stated that at this time the pilot was handed a pilot information card. The master did not indicate to the pilot that the main engine was being manoeuvred from the control room.

The pilot kept *Amarantos* on an easterly course parallel and to the south of the shipping channel, at 'full ahead', until 0625. He then ordered 'half ahead', then 'slow ahead' at 0627, 'dead slow ahead' at 0632 and finally 'engine stop' at 0636. The vessel was passing south of number 7 channel beacon at this time.

At about 0645, *Amarantos* met the tugs *Ungarra* and *Kalanbi* as the ship passed south of number 11 beacon. The tugs observed the ship approaching slowly. *Kalanbi*, the forward tug, allowed the ship to overhaul it and then took a mooring rope from *Amarantos*'s centre bow lead to connect the tow to its main deck towing hook. *Ungarra* took a line from the centre lead at the stern of the ship and connected the tow to its main towing hook. Both ropes supplied by the ship were in good condition and did not inhibit the operation of the tugs.

At about the time the tugs were made fast to the vessel, the mooring gang arrived at the jetty. The wharf supervisor (wharfinger), who had been in a hut on the jetty since 0530, came out and organised the forward and aft mooring crews. The mooring crews stood by as the ship manoeuvred off the berth with the wharfinger ready to call the distance to the berth for the pilot. The wharfinger stood at an angle to the approaching ship to allow him a better perspective.

At 0654, the pilot ordered 'dead slow ahead' and then 'engine stop' at 0703. About this time the pilot ordered starboard helm to start swinging the ship towards the berth. The ship was now approximately 1200 m north-east of the berth.

As the ship turned towards the berth, *Kalanbi* ran ahead with just enough weight on the rope to keep it clear of the water. *Ungarra* ran parallel to the ship's port quarter, again with the tow rope clear of the water.

At 0708 the pilot again ordered 'dead slow ahead'. The master stated that he had seen the vessel's speed indicated on the global positioning system (GPS) on the bridge as 3 knots ahead at this time. The vessel continued to swing and by this time was on a southerly heading and approaching the jetty almost at right angles.

The pilot ordered 'engine stop' at 0710, and the ship continued to drift in to the berth. The ship's movement book and the master indicated that the pilot also ordered 'dead slow astern' at 0710, however, the pilot was adamant that he did not order 'dead slow astern' at this time.

At 0715 the pilot ordered 'slow astern'. He felt the approach to the berth was going normally at this stage. The wharfinger was reporting the estimated distance between *Amarantos*'s stem and the jetty by VHF radio and, at this time, he indicated to the pilot that the ship was 200 m off the berth. The pilot was on the port bridge wing, looking at the main engine tachometer. The pilot's recollection was that when he rang 'slow astern' (at about 0715) he noticed that the main engine did not start astern for a period he estimated at 15-20 seconds. He called 'no engines' to the officer in the wheelhouse and ordered 'half astern'. The pilot then saw the tachometer move to indicate that the main engine had started astern. The crew noted the time of this engine movement as 0717. After he had seen the engine start astern, the pilot still felt that the berthing would proceed to a satisfactory conclusion.

When the vessel was 150 m off, and still at right angles to the berth, the pilot realised that the 'half astern' movement was having little effect on the ship's speed. He ordered 'full astern' and also full power on both tugs to swing the ship. The ship's staff logged the time at 0718.

The tugmaster on *Kalanbi* applied full power at the pilot's command with the tug at right angles to the starboard bow by this time. *Ungarra* was forward of the ship's port quarter and the tugmaster also applied full power and rudder to bring his tug around to be 90° to the ship's stern.

*Amarantos*'s mate, stationed on the forecastle head, was also keeping contact with the master by UHF radio, reporting the ship's distance from the jetty. The master stated that he passed this information on to the pilot on at least two occasions but the pilot did not recall any distances being relayed by the master at this time.

The ship continued to close on the jetty, with the combined power of the tugs making little progress in swinging the vessel. The pilot considered dropping an anchor at this stage but felt that it was too late to have any appreciable effect. With the ship now 70 m from the jetty, the master took the initiative and rang the chief engineer to order 'emergency full astern' revolutions.

The chief engineer promptly operated the main engine 'load program bypass' switch and increased the speed setting lever. The main engine was quickly brought to 105 rpm astern with the ship about 30 m off the jetty. The pilot glanced at the main engine tachometer at this time and noted that it was in the '3 o'clock' position (approximately 105 rpm astern). The wharfinger continued counting down the distance as the ship closed the jetty and when he told the pilot 'you are going to hit', the pilot told him to 'clear the jetty'.

At a time recorded as 0720 by the ship's crew, *Amarantos* made contact with the Wallaroo jetty and grain loader. The jetty and the grain loader superstructure were damaged substantially by the impact.

With the main engine still running at 105 rpm astern, *Amarantos* started to move astern almost immediately after the contact. The pilot remained calm and ordered main 'engine stop' at 0721. The two tugs continued to swing the ship alongside the jetty and after a 'dead slow astern' movement at 0724 and 'engine stop' at 0726, the pilot boat ran the first mooring line at 0728. The pilot continued to berth the ship and, after several more brief engine movements, *Amarantos* was alongside the number 2 and 3 north berths with the tugs being let go at 0800 and mooring completed at 0820.

When he was leaving the bridge, the pilot asked the master to sign the usual Ports Corp pilotage certificate; this request was followed by some discussion between the master and pilot regarding the cause of the incident. The master wrote a comment on the bottom of the pilotage certificate:

> Due to bad operation manoeuvring of the pilot.…the vessel touched the loading wharf and caused damage to the elevator and wharf.

The pilot stated that when he was leaving the ship, the second mate approached him and asked him to sign the pilot card. He said that this was the first time that he had seen this document.

**FIGURE 3**
**Wallaroo jetty and grain loader damage**

# Comment and analysis

## Evidence

### Site examination

*Amarantos* made contact with the jetty about 291 m from its western end, between pylons 2 and 3 supporting the grain loader main conveyor house (fig. 3). Contact was at a point where there were no fenders to protect the berth. Either side of the point of impact, there are substantial horizontal fenders. The angle of contact was 90° or within 15° of the perpendicular on a heading between 195° and 210°.

First contact appeared to have been made between the bulwark at the stem of the ship and the number 2 grain loading boom, which was housed alongside the second last span of the main conveyor house. This contact was followed almost simultaneously by the ship's bulbous bow on the landtie and decking timbers of the jetty itself. As *Amarantos*'s forward momentum continued, the loading boom was forced into the main conveyor house, resulting in a 2–3 m lateral deformation of the house and its supporting steel superstructure. The bulbous bow also continued to travel into the wooden jetty, breaking up the deck timbers for a distance of 3.5–4 m.

Despite significant damage to the jetty and grain elevator, Amarantos was found to have sustained only minor damage. There was scratched paint around the stem at, and just below, forecastle head level (about 18 m above the water line) and on the upper part of the bulbous bow, between the 8.4 m and 9.2 m draught marks (4–5 m above the waterline). The handrail at the top forecastle bulwark was also damaged with one end left lying on the forecastle deck.

The ship's arrival draughts were stated to be 4.25 m forward and 6.7 m aft giving a displacement of 29,850 tonnes. The eyewitnesses indicated that the ship seemed to stop and gain sternway almost immediately after the impact. This is consistent with the fact that those on the bridge or in the engine room felt no impact, and there was a relatively small degree of penetration of the jetty, given the displacement of the vessel.

## *Amarantos*

The evidence relating to the incident is almost entirely based on the subjective accounts of eyewitnesses. There is a lack of direct objective evidence and reliable documentation to substantiate the evidence given at interview by the pilot, master, first mate, second mate, chief engineer and helmsman.

*Amarantos* was equipped with a course recorder. This was operational, but had not been switched on since leaving Nantong and was not running on arrival Wallaroo. The engine control room was also equipped with an alarm logger, but this had not been operational for some time and was not repaired at the refit in Nantong. If available, the alarm logger may have provided corroborative evidence based on the record of any alarm condition during the incident. The ship was not equipped with an automatic engine movement recorder.

Engine movements were recorded manually both on the bridge and in the engine room in purpose-printed 'bell books', movement times being recorded to the nearest minute rather than half minute or less. The bridge clock was checked against the engine room clock by the investigators. The two clocks were within 6 seconds of each other at the time they were checked.

There was inconsistency in the way engine movements were recorded in the bridge bell book from port to port. Examination of both 'bell books' showed a lack of consistency in the way the movements were recorded over a number of passages under pilotage. Some entries were overwritten including some times recorded during the passage into Wallaroo.

Comparing the two bell books between 0500 and 0730 on 10 April, there is a significant mismatch of times up to 0654, after which the times largely coincide. No time of impact was recorded by the engine room, as none was felt. The time of impact in the bridge movement book appears to have been inserted at some time after 0721, putting in doubt this ship's record. In the engine room bell book the 'dead slow astern' movement at 0710 was written on the same line as the 'slow astern' movement whereas generally, though not exclusively, each movement time was recorded on a separate line.

Further, the bridge 'bell book' did not record the time of passing the channel beacons, nor were these marked on the ship's chart of the port approaches (Admiralty chart Aus 777 inset of port Wallaroo on a scale of 1:35000). Thus, it was not possible to check engine movements against positions and arrive at some independent assessment of the ship's speed at various critical times.

The inspector cannot rely on the bridge bell book as an accurate and contemporaneous record of the ship's movements.

After interviewing the chief engineer and pilot, investigators performed a test on the main engine to establish the time required to start the main engine astern after ahead running. After the usual system preparations, 'control room control' was selected on the manoeuvring console in the engine control room. The engine telegraph in the control room was then moved from 'slow ahead' to 'stop' and then 'slow astern'. This process was repeated several times with the engine being 'ready' for starting astern each time after a delay of 4–5 seconds. This type of main engine utilises a 'lost motion' camshaft system to achieve astern running. The 4–5 seconds delay is the time required for the camshaft to be rotated into the astern running position using engine oil pressure.

Following the incident all the personnel on the bridge were subject to a test by an alcohol breathalyser by the South Australian Police Service. All those tested returned a 'nil' reading.

## Other evidence

Other eyewitnesses including the wharf supervisor, the tug masters and the pilot launch coxswain provided accounts of the incident. Once again, there is no objective source of data. The investigation relies upon the limited times noted by the individuals involved.

No relevant times were recorded except the time the tugs took the ship's rope and that of the impact.

There is no weather observing station at Wallaroo. The Bureau of Meteorology estimated the wind direction and speed as between 060° and 090° at 5 knots. This estimation was based on observations for 0600–0730 at Maitland and Kadina and analysis of the synoptic weather, including low level; atmospheric wind and stability information. The estimation is also consistent with the wind estimated by the wharf supervisor and the tug masters.

Given the absence of objective data much of the analysis is based on the time of 0717 when the ship was estimated by the wharfinger to be 200 m from the jetty. In submission the pilot questioned the accuracy of the distance. The wharfinger stated that he stood at an angle to the ship's approach, rather than end on, to obtain a better perspective of distance. The wharfinger was a man of considerable experience and given the ship itself was 224 m in length the inspector accepts that the wharfinger's estimation of the distance was accurate within reasonable limits.

After considering the conflicting evidence available to the investigation, it was decided to recreate the incident on the Australian Maritime College's ship simulator. The aim of the simulation was to resolve some anomalies in the various accounts of the incident and to attempt to derive some independent, objective data.

Figure 6 shows the sequence of events and some factors involved in the incident.

## The pilotage

### Planned passage

When the pilot arrived on *Aramantos's* bridge at 0612, the pilot showed the master a folder containing his 'pro forma' passage plan for berthing at Wallaroo. This was in accordance with the operating procedures detailed in the Ports Corp South Australia 'Pilotage Port Adelaide Procedures'.

The inward passage takes a ship about 500 m south, and parallel to, the channel beacons from the Entrance Beacon, to number 7 beacon, on an easterly course. Ships take any tug(s) required, in the area south of number 11 beacon. A ship is then turned on a southerly course and makes an approach to the berth, either nearly at right angles or at a more oblique angle. This approach over the port Wallaroo 'Flats' is a standard passage and is prescribed in the Ports Corp South Australia document, Pilotage Port Adelaide Procedures, for vessels exceeding the port limits of 200 m in overall length or 30 m beam. The pilotage procedures also require that a minimum under keel clearance of 0.9 m or 10 per cent of draught be maintained, based on a minimum depth of 7.7 m below datum.

On 10 April, the pilot followed this standard procedure, choosing to approach the berth at right angles and relying on the transverse thrust generated by the right hand propeller turning astern to turn the vessel parallel to the berth. The tugs were to augment and control the transverse thrust of the propeller. As the tug power was limited, there was a need to complete the turn as close to the jetty as possible, dictated by the windage of the ship which would make pushing the ship against, or holding the ship off the jetty in any wind, difficult.

The pilot's estimation of the wind was north-easterly at 10 knots and the windage of the vessel in ballast meant he consciously took a route closer to the shore, using the 'finger jetty' at the eastern end of the main jetty as a guide. This approach was only marginally to the east of the standard approach. It did mean, however, that the ship would have been in water depths of 7.7 m, and 7.3 m below datum as it approached between 500 m and 200 m from the jetty. The predicted tidal height of 0.6 m, gave *Amarantos* a minimum under keel clearance of 1.2 m, 0.5 m more than the minimum stipulated in the pilotage procedures.

The tidal range at Wallaroo on the morning of 10 April was 0.1 m. The port experiences minimal tidal flow and on 10 April there would have been no tidal effect influencing the behaviour of the ship.

## Timing of events

In the absence of reliable records, the following analysis is based on the times of three events that were probably accurate to within one minute:

- 0634 (passing number 7 beacon) This is based on the pilot's statement that he routinely stopped a ship's engine and allowed the way to carry the ship to number 11 beacon to secure any tugs.
- 0717 (the pilot's order for 'half astern') The wharfinger and tug skippers stated they heard this on the VHF. This coincides with the time the wharfinger told the pilot the ship's bow was 200 m off the jetty.
- 0720 (the most likely time of impact). This was stated by the wharfinger and ship's staff, and is consistent with the probable speed of the ship.

## Ship's speed

Evidence as to speed and time is critical to the analysis of this incident.

At 0654, the pilot put the engine to 'dead slow ahead' for about 8 minutes. 'Dead slow ahead' revolutions (35 rpm) give a theoretical speed of 4.5 knots. However, the ship was turning towards the berth and would not have attained this speed in the time. Some forward moment would have been generated. The engine was then stopped at 0703 for 5 minutes before a further 2 minutes at 'dead slow ahead', at 0708.

The master stated that he had noticed on the GPS that the ship was making 3 knots headway at 0708. The pilot estimated the speed at just over 1 knot a couple of minutes past 0710. Neither of these statements can be accurately verified, however the pilot's estimation of 1 knot is inconsistent with the distance the ship had to travel to the jetty, and the times recorded for the subsequent events. The master's recollection of the GPS readout at 3 knots at 0708 seems far more reasonable considering the times supplied by other witnesses for the subsequent events. At the time of the incident global positioning 'selective availability'[4] meant that the GPS speed would probably have been accurate to ±0.3 knot.

It is probable that, at about 400 m from the jetty, the ship was making good a speed of between 2.5 knots (77 m/min) and 3 knots (92 m/min). This estimate is based on the approximate times on which this analysis is predicated; securing the tugs and the engine movements ordered between 0654 and 0710.

There are significant inconsistencies in the statements regarding *Amarantos*'s speed immediately before to the impact. The lack of damage to the ship, the fact that no impact/deceleration was felt on board and the eyewitness account that the ship seemed to go astern almost as soon as it contacted the jetty, all indicate a low impact speed. However, the evidence is that the ship penetrated the jetty for a distance of 3–4 m. At one knot (0.514 m/sec) it would have taken *Amarantos* six to eight seconds to travel the 3–4 m before coming astern. At impact speeds of half a knot or less, the time between the initial impact and coming astern would be over 15 seconds.

The inspector concludes that the ship was making more headway than the pilot thought when 200 m from the jetty. This speed was less than 3 knots (92 m/min) but more than 2 knots (61 m/min).

[4] Before 1 May 2000 the signal GPS satellites was degraded for non-US military use.

Considering the damaged sustained by the jetty and grain loader structures, the ship's speed at impact, was probably in the order of 0.5 of a knot.

## Ship's impulsion and manoeuvring

The engine was stopped at 0710 after which time no ahead movement was ordered until completing the berthing of the ship after the impact at 0720.

There is a significant conflict in the evidence regarding the next engine order. At 0710, according to the ship's bell books, the engine was put to 'dead slow astern' (35 rpm) and ran at this setting until 'slow ahead' (45 rpm) was rung at 0715. The pilot was adamant that no astern movement was ordered until 0715, when he ordered 'slow astern'. Despite the 0710 'dead slow astern' entry in the engine room bell book, the chief engineer also expressed some uncertainty about the timing of the first astern movement.

When the engine was first put astern there was a delay of 15 to 20 seconds in the engine response. The second mate, the chief engineer and pilot, confirmed the extent of this delay in separate interviews. The evidence would indicate that this delay occurred at 0715 when the pilot ordered 'slow astern'.

If the bell books are correct, and there was a 'dead slow astern' movement at 0710, it is not logical that the delay in response would have occurred at about 0715. The engine would have been already running astern for at least three minutes, probably longer depending on the accuracy of the manual recording. It also seems improbable that the ship would have maintained sufficient way to impact the jetty if the engine was running at 'dead slow astern' for 5 to 7 minutes before 0717, when the bow was reported as being 200 m from the jetty. After considering the evidence, the most logical conclusion is that the first astern movement was in fact 'slow astern' at 0715 and the engine starting delay occurred at this time.

The chief engineer, who was manoeuvring the main engine at the time of the incident, stated that it was 'normal' for the main engine to take 15–20 seconds to start astern after ahead running. This includes the 4–5 seconds required to rotate the camshaft from the ahead to the astern position. Advice obtained from Wärtsilä NSD Switzerland Ltd, the main engine designer, suggests that the usual time to rotate the camshaft from the ahead to the astern position is approximately 4 seconds. This advice confirms the time observed for this operation by the investigators. The engine designers also stated when using the automated engine starting system, a time of about 6 seconds for starting, when the engine telegraph is moved from 'stop' to 'slow astern', would be normal. The time required for the same operation, when manoeuvring manually from the control room, would be somewhat more given the additional times required to answer the telegraph, move the 'fuel' (speed setting) lever and actuate the starting air button. However, while the time of 15-20 seconds quoted for the operation may be excessive, it was a time independently given by the three witnesses.

When 100 m from the berth, the forward tug, *Kalanbi*, was already positioned at right angles to the bow when the order came to use maximum power. However, *Kalanbi* was made fast to *Amarantos* between 50 m and

60 m forward of the theoretical 'pivot point'[5] and would have exerted limited turning power, even at its full nominal bollard pull of 11 tonnes.

The stern tug, *Ungarra*, with a nominal bollard pull of 13 tonnes, was steaming parallel to the ship at about 45° forward of the quarter. When the order came to pull the stern to port, the tug increased power and then manoeuvred towards the perpendicular, a standard response. This manoeuvre would have taken some seconds, possibly up to 30 seconds to complete.

The initial force exerted by the stern tug would have tended to maintain the ship's headway. The forward propulsion force exerted by the tug would have decreased as the tug manoeuvred towards the perpendicular. Being a conventional tug, the tug master had to be conscious of the risk of capsize or 'girthing'.[6]

Both the pilot and the master described how the ship seemed to 'slide' maintaining a steady course despite the fact that there were three turning forces acting on the ship. The two tugs and the transverse thrust of the propeller theoretically should have combined to turn the ship to starboard, while the light north-easterly breeze, if it had any effect, would have tended to turn the ship to port with minimal effect. Whatever delay, if any, in the initial engine astern movement, the propeller was seen to be turning astern when the bow was about 200 m from the jetty, just under one ship's length. It is as though the net effect of the propeller was to offset the limited tug power and in fact turn the ship's bow to port. Rowe (1996) notes that when the engine is put astern in shallow water the effect of transverse thrust may be unpredictable and the bow may swing the wrong way. This is due to the dynamics of the water being deflected by the propeller off the seabed.[7]

The pilot, however, was not concerned that the manoeuvre was not immediately going as anticipated and did not consider it necessary, either to drop the starboard anchor or to apply full starboard rudder and kicking the engine ahead to start the starboard turn. He could also have ordered *Ungarra* to move astern and pull. At this time, 150 m to 100 m from the jetty, *Amarantos* was probably not travelling more than two knots. The manoeuvre would have been possible for the experienced tug master, although it would have taken a further 30 seconds or so to drive the tug into this position.

The pilot stated that after he had seen the engine start astern he still felt that the berthing would proceed to a satisfactory conclusion. He did not become concerned until the bow was about 70 m from the jetty. He did not order 'full astern' until approximately 0718 and the master, on his own initiative, ordered 'emergency full astern' after this.

When asked to explain the incident, he could only attribute the accident to a delay in the initial engine astern movement of about 15-20 seconds.

It is not unknown for an engine to fail to start on the first attempt when put astern and thus delay the required manoeuvre. It is reasonable to expect that a pilot would

5 Pivot point is that point in the ship's length will pivot when under a turning force. A ship not making way will pivot at its mid length. When making headway the pivot point is about 25 per cent of the length from the bow. When making stern way the pivot point is about 25 per cent of the ship's length from the stern.

6 Also known as 'girding' and 'girting'.

7 Rowe, R.W., The Shiphandler's Guide, The Nautical Institute, London, 1996, pg.26.

factor such an eventuality into his plan and allow for an appropriate approach speed.

Manoeuvring a ship in confined waters presents specific problems. Manoeuvring and controlling ships involve what might be considered 'delayed' systems.

The control of ships does pose a very peculiar set of problems. The ship is a 'slow system' in which feed-back is not available in a direct and immediate form due to the enormous inertia of the vessel and the fluid nature of its physical environment. The navigator must thus take action in anticipation of what the situation will be at some time in the future.[8]

Analysing this incident involves estimating the ship's speed at any particular time. The ship's log was not operating, although the GPS was (within the limits of selective availability). The ship was over a mile off the shore which had few if any marks or beacons to give some estimation of the rate of closing with the jetty. *Amarantos* was approaching the berth at right angles, giving the pilot no perspective from which to assess the speed (fig. 4).

## Simulation

In the absence of any satisfactory means of reconciling a number of differences between the ship's account, and the pilot's recollection, the pilotage manoeuvre closing the Wallaroo jetty was simulated at the Australian Maritime College (AMC) ship simulator. The simulation was conducted under the direction of the Manager, Ship Simulation.

**FIGURE 4**
**Pilot's perspective from port bridge wing**

[8] Bryant, D. De Bievre, et al (1998) The Human Element in Shipping Casualties Phase 11

Exact models of *Amarantos* and the Port of Wallaroo were not available for the simulation. A model bulk carrier of similar size and beam was used to represent *Amarantos* and a model of the port and jetty was built up from basic graphical components using the simulation software.

The constant factors included in the simulation were an under keel clearance of 1.2 m and astern power on four settings ('dead slow astern', 30 per cent; 'half astern', 52 per cent; 'full astern', 70 per cent; 'emergency full astern', 80 per cent). In each simulation the rudder remained in the midships position.

Twenty runs were recorded. Each run was started with the bow 400 m from the jetty, with the model on a course of 190°, with the engine stopped. Eight runs were made with an initial speed of 3 knots, eight runs with an initial speed of 2.7 knots and four runs at 2.8 knots. The critical point, based on the evidence of the wharfinger, was taken as being about 200 m from the jetty (0717 on 10 April). All twenty simulations allowed the model to run to this point before astern power was applied. Thereafter various astern engine movements and tug bollard pulls were simulated, based on the timing of movements recorded in *Amarantos*'s bell book.

Eight of the simulations (40 per cent) achieved an impact with the jetty. Twelve simulations resulted in the ship stopped off the berth or swinging clear of the berth.

At an initial speed of 3 knots, four impacts were achieved. The time of the impact averaged at 3 minutes 17 seconds after the bow crossed the 200 m line. The impact speed varied between 0.2 knots and 0.9 knots. Given the observed damage to the wharf and *Amarantos*'s displacement the simulated impact speed of 0.9 knots was considered too high. The critical issue seemed to be the time the model was left at 30 per cent astern power. The impacts were achieved when the engine was run at 30 per cent astern for between 45 and 60 seconds (average of 52 seconds). Greater astern power applied earlier resulted in no impact.

At an initial speed of 2.7 knots a north-easterly wind at 8 knots was introduced. The two impacts achieved in the eight runs took 03:45 mins and 03:48 mins respectively, with both impact speeds at 0.2 knots. On five of the runs the 30 per cent engine

| **Parameters** | | **Amarantos** | | **Model** |
|---|---|---|---|---|
| length | | 224 m | | 225 m |
| breadth | | 31.84 m | | 32 m |
| draught | | 4.25 m F 6.75 m A | | 3.05 m F 7.0 m A |
| Engine kW | | 10 592 kW | | 6 250 kW |
| Eng rpm | Ahead rpm | Astern rpm | Ahead rpm | Astern rpm (per cent) |
| Full (Sea) | 103 | - | - | - |
| Full (port) | 65 | 65 | 82 | 60 (70 per cent) |
| Half | 55 | 55 | 73 | 53 (52 per cent) |
| Slow | 45 | 45 | 56 | 39 |
| Dead Slow | 35 | 35 | 29 | 17 (30 per cent) |

power was left on for 70 seconds. Both impacts came from this group. It was found that the prolonged period at lower astern power could be offset by quicker use of 70 per cent astern power. Two identical runs were made with the only variable being the tug power. With increased tug power used to try and turn the ship an impact was achieved. The actual effect of the forward tug was minimal, but the stern tug in increasing power and manoeuvring towards the perpendicular seemed to provide a significant forward momentum that resulted in an impact. With the ship moving at less than one knot or stoped the tugs were able to turn the ship.

The four runs at an initial speed of 2.8 knots achieved two impacts at 03:30 mins and 03:35 minutes respectively with impact speed of 0.5 and 0.3 knots. Allowing the 30 per cent astern power to run for too long (70 seconds) seemed to be the key.

Acknowledging the limitations of the simulation, it demonstrated that a number of possible factors may have contributed to the incident.

- The speed of the ship at 400 m and 200 m from the jetty was probably faster than the pilot estimated.
- The ship was subject to shallow water effect in that the ship tended to maintain its heading. Turning moment did not occur in most runs until the ship's bow was between 60 m and 120 m from the jetty.
- In the still and light wind conditions of the day the two tugs were capable of safely berthing *Amarantos*, only providing the ship did not have headway of more than one knot.
- Even if the first application of stern power was delayed until 200 m from the jetty, forward motion could probably have been arrested by using half and full stern power.
- Despite a delay of 20 seconds, the situation was probably recoverable had more astern power been used earlier.
- The forward speed of the ship could have been affected by the stern tug towing forward of the beam.

The simulation also suggested that the difference between impacting the jetty and turning clear, but close as planned, was no more than ten seconds.

## Tugs

The tug power available was limited, nominally to 11 and 13 tonnes. It would be unlikely that either *Kalanbi* or *Ungarra* would generate their nominal bollard pull under such operational conditions. Despite their limited power, the computer simulation suggested that the tugs were able to manoeuvre the ship, in the conditions existing on the day, had *Amarantos*'s forward speed been less. However, there was absolutely no margin for error.

The nominally larger tug, *Ungarra* was positioned at the stern. Given that the pilot expected the ship to be making forward way, with the pivot point well forward of the longitudinal centre of gravity, the larger tug aft would have been the best disposition for the tugs given their available power.

The berthing manoeuvre is governed by the requirement to turn the ship sufficiently close to the jetty. The general view of the pilots is that the tugs are under-powered to either push, or hold, a ship against the prevailing wind, when positioned parallel to the jetty. The tugs have to be augmented by the ship's mooring lines when positioning the ship against a wind off the jetty.

In response to the draft report *Amarantos*'s owners submitted the following on required tug power:

> A standard work on tug assistance "Tug use in port" (published by the Nautical Institute in 1997) sets out a useful formula for calculating the minimum aggregate bollard pull of attending tugs…. The formula is as follows:
>
> **Required bollard pull (tons)= (displacement/100,000 x 60) + 40**
>
> For the "*AMARANTOS*" at a displacement of 29,850 m.t. upon arrival at Wallaroo, with draft 4.3 metres Forward and 6.75 metres Aft, a minimum safe bollard pull of 58 tons is recommended…. Therefore, even allowing for the alleged straightforward approach to the jetty at Wallaroo, the aggregate nominal power of the two tugs at 24 tons is clearly inadequate.

The inspector accepts the validity of the formula in the case of *Amarantos* but notes that there are many factors which influence the selection of tugs that are not suggested by the use of a formula. Industry advice is that for many ports, the selection of tugs for a given size of ship is done using rule-of-thumb methods and relies on the experience of the tug operator and the pilots conducting the pilotage. Factors that dictate tug power include not only the size and displacement of the vessel but the availability of tugs, prevailing weather and tides, the nature of the port and pilotage and the expected traffic during the pilotage.

Advice was sought from a tug operator in a busy port with a very restricted width of fairway and relatively strong winds and tides. He suggested that for a vessel with *Amarantos*'s displacement, length and beam, it would be usual in his port to use two tugs with an aggregate bollard pull of 120 tons. He indicated that the minimum bollard pull that would be used, only with good weather and tide conditions would be 80 tons.

In the case of Wallaroo, as a relatively open port with little or no traffic and current, the main consideration is the effect of the prevailing wind. An aggregate bollard pull of 58 tons, as suggested by the formula, would be reasonable in most circumstances and for most of the vessel movements through the port.

## Propeller efficiency

*Amarantos* entered Wallaroo with an aft draught of 6.75 m. This meant that the ship's propeller was not fully submerged with the top 100 to 150 mm of the blades being exposed at the top of their rotation (fig. 5). The propeller's efficiency with ahead or astern revolutions would have been diminished as a result of the partial immersion and tended to decrease further as the revolutions increased, particularly astern.

Fixed pitch propellers are designed to be most efficient when driving ahead at the main engine's rated speed. In *Amarantos*'s case, approximately 100 rpm ahead. When going astern, the propeller efficiency is decreased, particularly if the vessel is making forward way. If the relative velocity of the water with respect to the surface of the propeller blades is high enough, areas of low pressure are created on the 'back' of the blades (with respect to the direction of rotation) leading to the formation of 'cavities' filled with water vapour bubbles ie. 'cavitation'. Propellers running astern generally experience cavitation at lower relative velocities as a result of the cross sectional shape of the blades, which is optimised for ahead running. Cavitation leads to a reduction in propeller efficiency and can be further exacerbated if the blade

**FIGURE 5**
**Propeller immersion**

tips are exposed and air is entrained with each rotation.

Advice obtained from an expert in ship hydrodynamics stated with regard to *Amarantos*'s emergency astern movement:

> In addition to possible cavitation, the propeller would certainly have been aerating (which is draw-down of air to the blades as opposed to the local boiling of cavitation). This would also minimise the efficiency of the propeller at high rpm.

And further:

> ....the relatively high revolutions combined with the fact that the propellor had pierced the free surface make it very likely indeed that propellor performance would have been degraded due to aeration and possible cavitation.

When the main engine was first put 'slow astern' at 0715, *Amarantos*'s propeller would have been operating with diminished efficiency as a result of the ship's forward way and the partial immersion. As the engine revolutions were built up closing the wharf, the propeller's efficiency would have continued to diminish. At 'emergency full astern', 105 rpm, the propeller was probably cavitating in addition to aerating and the resulting relative efficiency would have been low.

*Amarantos*'s after draught was thus a further factor in the incident and contributed by slowing the vessel's deceleration in response to the astern movements approaching the jetty. Had the propeller been fully immersed it would have operated more efficiently. However this would have reduced the underkeel clearance resulting in other limitations in the ship's manoeuvrability. All of these factors need to be carefully considered by the port authority, the pilots and the masters of ships using the port.

It is likely that the ship's crew, with their previous experience of *Amarantos's* lightship manoeuvring characteristics, would have been aware of a slow response to astern movements at the vessel's Wallaroo arrival draughts. However, no information of this nature was conveyed to the pilot during the pilotage.

## Pilotage organisation

Seven pilots are based in Adelaide as employees of Ports Corp South Australia. In addition to piloting ships in Port Adelaide, they also provide pilot services to Port Giles, Wallaroo and Ardrossan. Pilotage at these ports is assigned on a roster basis. Two other pilots are based at out ports, Port Pirie and Port Lincoln. The pilots operate under procedural guidelines and in conformity to a fatigue management plan introduced in October 1999.

Wallaroo is principally a grain export port and hence the volume of grain shipped, and the number of ships visiting in any period depends upon the harvest. The number of berthing operations* for the financial year July 1999 to 10 April 2000 stood at 52.

In the last 12 months the pilot at Port Pirie, about 95 km to the north by road, undertook the largest portion of the Wallaroo pilotage with 25 to 30 per cent of berthing movements. The other pilots performed between 2 and 7 movements each.

## The Pilot – experience, fatigue and medical condition

*Amarantos*'s pilot was stationed in Port Adelaide. He had been the harbour master at Wallaroo between 1976 and 1978, but had been based in Port Adelaide since 1982. He was experienced and had handled a number of panamax size vessels in other ports in the Adelaide Port region. In the ten months prior to the incident he had berthed three ships at Wallaroo, one of which was the berthing in September 1999 of a panamax size vessel at number 2 North berth.

The pilot had worked a 77 hour week from 1 April to 7 April. He completed his duty at 0115 on Saturday 7 April. He was then not required for duty until 0530 on 10 April, providing a break of about 27 hours. Acute fatigue through rostered workload is therefore not considered a factor in this incident.

The pilot, who is nearing retirement age, had been passed fit by a medical examination under the South Australian Harbours and Navigation Act, 1993. He did not require glasses and the standard medical examination includes an eyesight test. He was on a course of prescribed medicine and advice from an expert in transport medicine was that at the prescribed dosages would have had no adverse effect on the pilot's performance.

## Ship size Wallaroo

Since the beginning of the 1996 financial year an average of 60 bulk carriers each year berthed at Wallaroo. In the financial year 1999 to the time of the incident a total of 52 berthing manoeuvres had been conducted at Wallaroo. Most of these bulk

*The number of berthing operations exceeds the number of ships as these figures account for re-positioning.

carriers are in a class of ship referred to as 'handy size'. These ships are mostly between 150 m and 200 m in length with a deadweight capacity typically between 30 000 and 45 000 tonnes. Handy size bulk carriers account for 74 per cent of ships berthing at Wallaroo.

From September 1999, larger bulk carriers known as 'panamax' (maximum size able to transit the Panama Canal) have been accepted into the port of Wallaroo to take part loads of grain. Six such bulk carriers had berthed at Wallaroo, including *Amarantos*. These ships are typically over 220 m in length with a beam of 30 m or more. These vessels generally have greater windage as a result of their increased length and freeboard.

Ports Corp South Australia conduct feasibility and modelling studies when introducing larger ships into more restricted ports such as Port Adelaide. The studies are aimed at mitigating the risks involved handling these vessels within the port confines. As Wallaroo is an open port with a relatively straightforward channel for loaded ships, such a study was not undertaken by Ports Corp prior to the introduction of panamax class vessels. Wallaroo has a relatively old jetty structure and the grain conveyor is close to the edge of the wharf. The inspector considers that a comprehensive risk assessment would have taken into account the risk of a ship's bow contacting the grain conveyor.

In May 1999 a report on the suitability of Wallaroo for the introduction of panamax class vessels was developed by a committee, the Deep Sea Port Investigation Committee. The committee was comprised of Ports Corp pilot staff and was formed to investigate the Deep Sea Ports proposal, an initiative by the South Australian Co-operative Bulk Handling, to deepen some of the South Australian ports in order to allow for the full loading of panamax class ships. The committee considered the risks associated with the berthing the larger vessels at Wallaroo and made a number of recommendations in the report relating to the safe handling of these vessels including refurbishment of the jetty and its fendering systems, mooring-dolphins, navigational aids and tugs.

With regard to the jetty, the committee recommended that the jetty structure be upgraded with the construction of six new mooring dolphins and six new berthing dolphins. The berthing dolphins to be 'of such a design to accommodate a measure of shearing stress as well as direct impact of a panamax vessel in light ballast condition of about 12 000 tonne displacement.'

The report recommends the use of two tugs for berthing manoeuvres and concludes with regard to the size of the tugs: '…two tugs of the 25/30 x bollard pull range would be the minimum desired tug assistance for safe berthing operations.'

The Wallaroo Deep Sea Port Investigation Committee report was initially submitted to a pilots meeting in June 1999. The format and content of the report was amended over succeeding months in 1999 and early 2000. Pilot meeting minutes for July, August, and October 1999 and January of 2000 note the progress of the report with the finalised report being received by the Ports Corp Division Manager, Port Operations, in late March 2000. At the time of the incident, the report had not been accepted, nor discussed, by Ports Corp South Australia management.

Ports Corp management declined to enter panamax vessels into Wallaroo for a period of time in 1999 as a result of some concerns over the strength of the jetty structure. The reintroduction of the larger vessels into the port was undertaken only after the floating fender adjacent to number 2 north berth was replaced by a more robust fixed fendering system.

## Procedures

### International Safety Management Code (ISM Code)

*Amarantos's* has a current Safety Management Certificate, valid to 31 October 2002. The ISM Code requires that the vessel has written procedures that are to be followed by the ship's staff for critical operations such as bridge and engine room watchkeeping, pre-arrival checks and procedures. In addition to having these procedures, for compliance with the ISM Code the vessel must keep a record, often in the form of a completed checklist, that these procedures have been followed each time by the ship's staff.

*Amarantos*'s 'Bridge Preparation for Arrival' procedure included the preparation of the 'Pilot card' and delegates this responsibility to the master. The 'Engine Room Preparation for Arrival' procedure includes the requirement to test the main engine astern. Both of these ISM Code procedures include a checklist. No evidence that these procedures had been followed prior to arriving in Wallaroo, in the form of the completed checklists, was presented to the investigation in Wallaroo. Some months later copies of the completed checklists were supplied by the owners of the ship in response to the draft investigation report.

The bridge procedure manual also makes specific provisions for when a pilot is on board. The procedure reads:

> RESPONSIBILITY
>
> The Master is ultimately responsible for the safety of the ship. The Pilot assists with navigation in confined waters, facilitates port approach, berthing and departure. The Master has the right to take over from the Pilot in circumstances he deems it necessary to do so.
>
> The Master and his team shall be aware of the Pilot's intentions and be in a position to control his actions in any stage of the passage…
>
> DESCRIPTION OF PROCEDURES
>
> The Master shall have a brief discussion with the Pilot. This shall include the Pilot's planned route, his anticipated speeds and ETA's, what assistance he expects from the shore and what contingencies he may have in mind. For his part the Master shall advise the Pilot of the handling characteristics of his ship, unusual features and relevant information. The Pilot Card shall be readily available (see Attachment).
>
> Attention must be paid by the OOW to the following:
>
> 1. Positions are frequently plotted on the chart.
> 2. The radar is on and properly adjusted and the range is not changed without the Pilot's knowledge.
> 3. The Pilot's orders are correctly understood and carried out.

The junior second mate arrived on the bridge to test the bridge equipment at 0500 in preparation for entering Wallaroo. At 0500 on 10 April, the main engine was put on stand-by and at 0510 was tested ahead. The ISM Code procedures required the engine to be also tested astern. Although the master and chief engineer stated that the engine was tested astern, the junior second mate could not recall if the engine was tested astern and such a movement was not logged.

There was no record maintained in the ship's bridge logbook of the state of the ship or the weather at 0500. The master recalled that it was calm with little wind when the pilot arrived at the ship at about 0540. The pilot and launch coxswain recalled that the wind was from the northeast at about 10 knots. In the open anchorage the coxswain found it difficult to lay the launch alongside the pilot ladder and so the ship was asked to make a lee by turning to port. The master remarked on this during his interview.

The quality of record keeping on many ships has deteriorated over recent years. Although there is no absolute requirement to maintain accurate records of engine movements and the ship's position, such records, properly maintained in pilotage waters, provide the ship, and its owners, with a valuable record on which to base a reconstruction of the passage.

## Bridge organisation

There is conflicting and ambiguous evidence of the pilot/master exchange. There was some form of exchange in that the pilot did show the master his pro-forma passage plan. It is not clear whether the pilot explained what his intentions were in the final approach to the berth.

Also there is no conclusive evidence to reconcile the differing accounts relating to the pilot card and when it was signed. What is evident is that there was little discussion regarding the characteristics of the ship, and no information on the card that the engine was to be controlled from the engine room console. There was minimal information on the pilot card.

The pilot had been trained in Bridge Resource Management techniques. He stated that he found them useful but a majority of ships and masters had no idea of the concept. The master in turn displayed virtually no inclination to work with the pilot. Initially the master was in the bridge, with the pilot, second mate and helmsman. The master was listening to the radio and the Greek election results. When the pilot went to the bridge wing the master remained in the bridge, chiefly close to the telegraph, and the evidence is that the radio was turned off at this time.

As the ship closed with the jetty, the first mate on the forecastle head relayed estimates of the distance of the jetty from the bow. The master stated that he relayed these distances to the pilot on two occasions but the pilot did not recall that any such information was forthcoming. The pilot could have requested that the ship's speed be watched and read out to him. Instead he relied on his judgement. There was little meaningful communication or support other than the relay of engine movement and helm orders.

The master's action of telephoning the chief engineer to order 'emergency full astern' probably reduced the extent of the damage to the jetty. However, the evidence is that there was no overall effective bridge teamwork.

# 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.

On 10 April, 2000 the bulk carrier *Amarantos* stuck the Wallaroo jetty within 15° of the perpendicular as a result of:

1. The pilot misjudged the speed of approach to the jetty.

2. The angle of approach at right angles to the jetty allowed only a minimal margin for error; a more oblique angle would have reduced the risk.

3. The tugs lacked both the manoeuvra-bility and power to either; arrest the ship's forward momentum and/or swing the ship off the jetty in time to avert the incident.

The following factors are seen as contributing to the incident:

4. The limited under keel clearance, combined with the ship's speed, negated the transverse thrust of the propeller.

5. The propeller was operating with diminished efficiency as a result of incomplete immersion at the ship's aft arrival draught.

6. No formal risk assessment had been completed for the berthing and unberthing of panamax size ships in the port of Wallaroo prior to the incident.

7. There was a lack of proper bridge resource management in that: the master, for the initial period of the pilotage, was more interested in listening to the radio; the pilot neither asked for, nor was told, the ship's speed from the GPS; communications between the master and the pilot were minimal.

Also:

8. The lack of objective evidence and sloppy record-keeping on board *Amarantos* complicated and extended the investigation.

# 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.

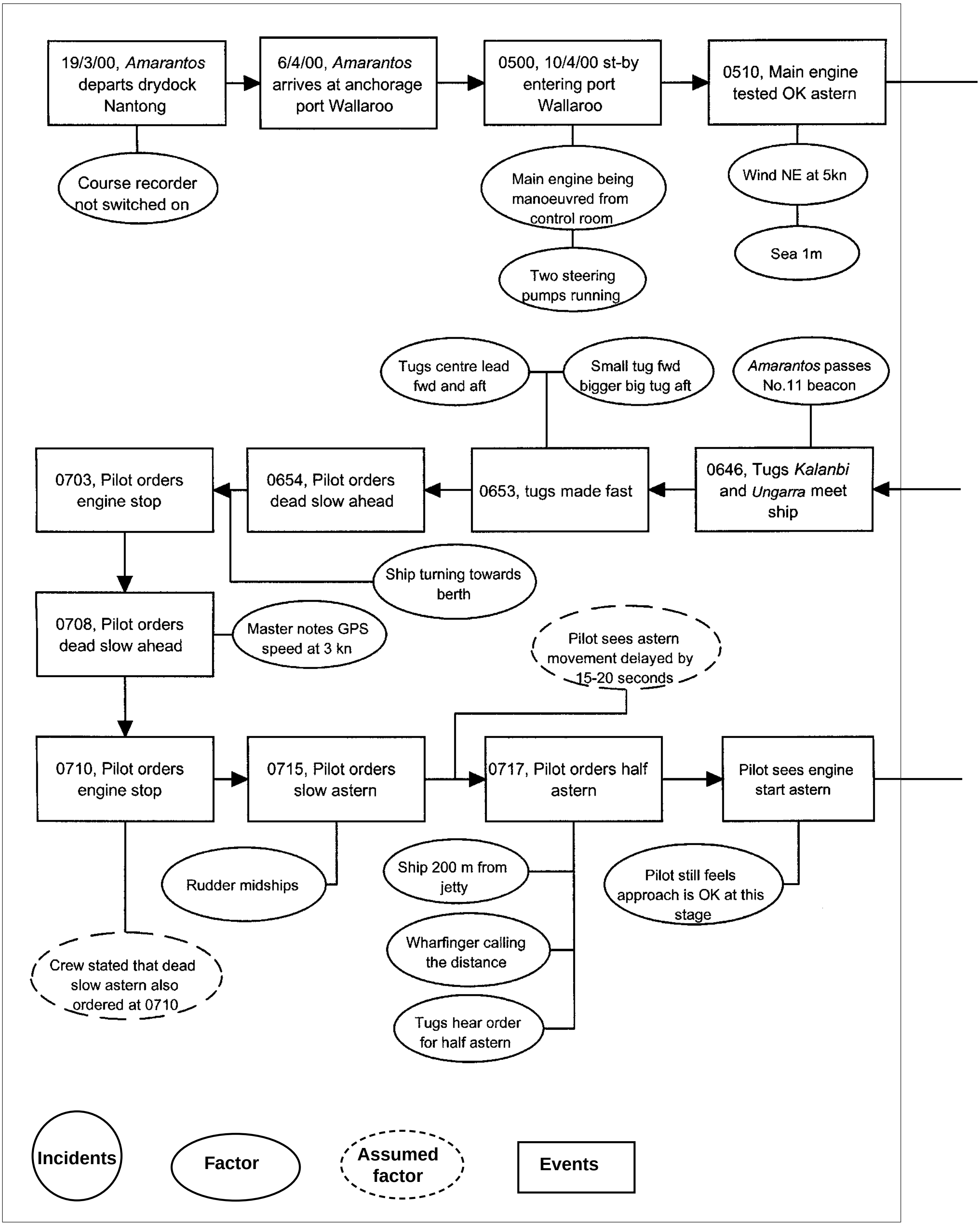
The final draft of the report was sent to the following:

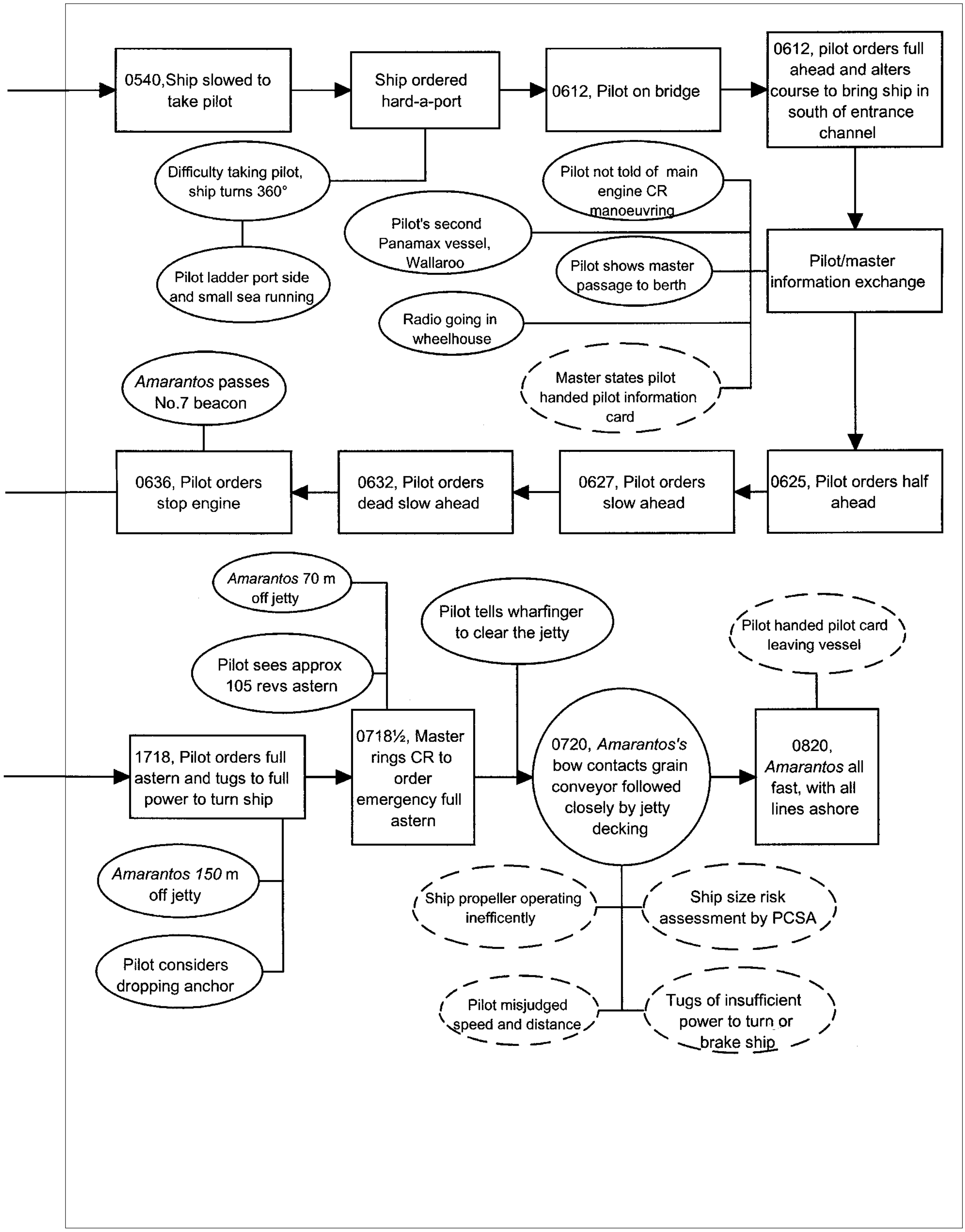
Copies of the draft report were sent to:

The pilot, tug masters and wharfinger. The owners, master, chief engineer and second mate of *Amarantos*. The management of Ports Corp South Australia. The Malta Maritime Authority and the Australian Maritime Safety Authority.

Submissions were received from the owners and master of *Amarantos*, the pilot, Ports Corp South Australia and the wharfinger. The draft was amended and submissions included as appropriate.

**FIGURE 6**
***Amarantos* events and causal factor chart**




0540,Ship slowed to take pilot
Ship ordered hard-a-port
0612, Pilot on bridge
0612, pilot orders full ahead and alters course to bring ship in south of entrance channel
Difficulty taking pilot, ship turns 360°
Pilot ladder port side and small sea running
Pilot not told of main engine CR manoeuvring
Pilot's second Panamax vessel, Wallaroo
Pilot shows master passage to berth
Radio going in wheelhouse
Pilot/master information exchange
Master states pilot handed pilot information card
*Amarantos* passes No.7 beacon
0636, Pilot orders stop engine
0632, Pilot orders dead slow ahead
0627, Pilot orders slow ahead
0625, Pilot orders half ahead
*Amarantos* 70 m off jetty
Pilot sees approx 105 revs astern
Pilot tells wharfinger to clear the jetty
Pilot handed pilot card leaving vessel
1718, Pilot orders full astern and tugs to full power to turn ship
0718½, Master rings CR to order emergency full astern
0720, *Amarantos's* bow contacts grain conveyor followed closely by jetty decking
0820, *Amarantos* all fast, with all lines ashore
*Amarantos 150* m off jetty
Pilot considers dropping anchor
Ship propeller operating inefficently
Ship size risk assessment by PCSA
Pilot misjudged speed and distance
Tugs of insufficient power to turn or brake ship

# Details of ship

| | |
|---|---|
| Name | *Amarantos* (formerly *Ikan Beliak*-97, *Ocean Pioneer*-87 and *Ikan Kerisi*-86) |
| IMO No. | 7918256 |
| Flag | Maltese |
| Classification Society | Lloyds |
| Vessel type | Panamax bulk carrier |
| Owner | Amarantos Shipping Co. Ltd, Valletta, Malta |
| Year of build | 1980 |
| Builder | Mitsubishi Heavy Industries Ltd, Kobe, Japan |
| Gross tonnage | 35 650 |
| Summer deadweight | 64 957 tonnes |
| Length overall | 224.00 m |
| Breadth, moulded | 31.80 m |
| Depth | 18.35 m |
| Draught (summer) | 13.328 m |
| Engine | Sulzer 6RND76M, 6-cylinder, 2-stroke, single acting |
| Engine power | 10 592 kW |
| Service speed | 14.75 knots |
| Crew | 23 (Greek, Ukrainian, Filipino) |