Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Marine Occurrence Investigation No. 204
Final

Independent investigation into the knockdown of the Australian sail training vessel

Windeward Bound

off Gabo Island, south-eastern Victoria

3 June 2004

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Independent investigation into the knockdown of the Australian sail training vessel *Windeward Bound* off Gabo Island, south-eastern Victoria, 3 June 2004.

Prepared by

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Abstract

On 3 June 2004, the Australian sail training ship *Windeward Bound* was off the Victorian coast, heading northeast at about six knots. The wind was from the northwest and the vessel was heeled between 10 and 15 degrees to starboard. The upper and lower topsails and the main and fore staysails were set. A cold front was expected that afternoon. The watch officer was assisted by a watch leader and two general purpose hands, one of whom was at the helm.

At 1726, when the ship was about 30 miles south of Gabo Island, the wind speed increased. The helmsman was instructed to run the vessel downwind. Shortly thereafter, the vessel yawed to port and the helmsman put the rudder hard over to starboard. The watch leader then took the helm and, as the vessel was now swinging to starboard, applied a 'considerable amount' of port rudder. When the vessel had started to swing to port, the watch leader put the rudder hard over to starboard to arrest the swing. A gust of near-hurricane force wind then heeled the vessel about 68 degrees to starboard.

The starboard side of the main deck was submerged and seawater entered a fuel tank through an open air pipe on deck. A quantity of seawater also entered the deckhouse and accommodation before doors to the deckhouse and accommodation were shut. The vessel was righted after several minutes using the main engine and rudder and by letting the sheets go.

There was a minor injury to a crew member during the incident and the main engine had been damaged after being run with little or no lubricating oil pressure when the vessel was heeled.

During the next twenty four hours contact was lost with authorities ashore. An air search was initiated in the afternoon on 4 June and *Windeward Bound* was found safe and heading for Jervis Bay, where it arrived late in the evening on 5 June.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, risk controls and organisational influences.

Contributing safety factor: a safety factor that, if it had not occurred or existed at the relevant time, then either: (a)the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Safety issues can broadly be classified in terms of their level of risk as follows:

- **Critical safety issue**: associated with an intolerable level of risk.
- **Significant safety issue**: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable.
- **Minor safety issue**: associated with a broadly acceptable level of risk.

EXECUTIVE SUMMARY

At 2045[1] on 1 June 2004, the Australian sail training ship *Windeward Bound*, with 16 persons on board, sailed from Low Head at the mouth of the Tamar River on the north coast of Tasmania, bound for Sydney, New South Wales.

On 3 June, *Windeward Bound* was off the Victorian coast, heading northeast at about six knots. The wind was from the northwest and the vessel was heeled between 10 and 15 degrees to starboard.

The lower topsail, the main and fore staysails were set and, at 1406, the upper topsail was also set. A cold front was expected that afternoon with an accompanying shift in wind direction and an increase in wind speed.

At 1600, at the change of watch, the wind was north-westerly at about 15 to 20 knots[2]. The watch officer was assisted by a watch leader and two general purpose hands, one of whom was at the helm.

By 1700, the wind had backed[3] to the southwest and increased in speed. The watch officer and watch leader discussed reducing sail but the master instructed the watch officer to strike[4] the upper topsail at the change of watch at 1800.

At 1726, when the ship was about 30 miles[5] south of Gabo Island, the wind speed increased. The helmsman was instructed to run the vessel downwind. Shortly thereafter, the vessel yawed to port and the helmsman put the rudder hard over to starboard. The watch leader then took the helm and, as the vessel was now swinging to starboard, applied a 'considerable amount' of port rudder. When the vessel had started to swing to port, the watch leader put the rudder hard over to starboard to arrest the swing. A gust of near-hurricane force wind then heeled the vessel about 68 degrees to starboard.

The starboard side of the main deck was submerged and seawater entered a fuel tank through an open air pipe on deck. A quantity of seawater also entered the deckhouse and accommodation before doors to the deckhouse and accommodation were shut. The vessel was righted after several minutes by using the main engine and the rudder and by letting the sheets[6] go.

The crew were unscathed apart from the watch leader, who suffered a dislocated finger. The main engine had been damaged after being run with little or no lubricating oil pressure while the vessel was heeled.

For the next twenty-four hours, or so, the vessel headed northeast, running downwind with the weather and sea with no sails set, until the weather had abated sufficiently to allow the vessel to turn towards the coast. During this time contact was lost with authorities ashore. An air search was initiated in the afternoon on 4 June and *Windeward Bound* was found safe and heading for Jervis Bay where it finally arrived late in the evening on 5 June.

1 All times are in ship's time (UTC + 10 hours).

2 Nautical miles per hour.

3 An anti-clockwise change in wind direction.

4 The act of lowering a sail.

5 A nautical mile of 1852 m.

6 Sheets – rope or line attached to the bottom corners of a sail, used to release it or to change its position.

The report identifies the following safety issues.

- The vessel did not meet the intact stability requirements with respect to its range of positive stability for operation in open waters.
- The vessel did not meet the intact stability requirements with respect to wind heel with bare poles.
- The vessel's approved stability book contained an incorrect assessment of the vessel's wind heel characteristics.
- The master did not adequately assess the weather forecasts and take appropriate measures to prepare the vessel and the crew for the onset of heavy weather associated with the cold front which moved through eastern Bass Strait on the afternoon of 3 June 2004.
- The considerations, with respect to the vessel meeting the intact stability requirements, taken by Marine and Safety Tasmania should have been made available to the Australian Maritime Safety Authority before the vessel was permitted to undertake an interstate voyage.
- The vessel's engine room and accommodation ventilation arrangements did not comply with the relevant requirements with respect to their closing arrangements.
- The vessel's battery locker ventilator and fuel tank air pipes were not fitted with adequate closing arrangements.
- The vessel was unable to transmit an AUSREP deviation report after the change of course to Jervis Bay during the afternoon of 4 June due to the fact that the generator was not operational and therefore the computer used to compile messages for the satellite communication system was not functioning.

Some safety action has already been taken and the ATSB has issued three recommendations and one safety advisory notice with the aim of addressing the identified safety issues.

1 FACTUAL INFORMATION

1.1 *Windeward Bound*

The Tasmanian registered sail training ship *Windeward Bound* (Figure 1) is a two masted brigantine-rigged[7] vessel built in Hobart, Tasmania. *Windeward Bound* is operated by The Windeward Bound Trust as a registered charity. It is owned by the master, one of the mates, both on board at the time of the incident, and three other persons, one of whom was also on board at the time of the incident. The trust operates sail training programs for financially disadvantaged young people, volunteers and Royal Australian Navy trainees.

Figure 1: ***Windeward Bound***

Windeward Bound has a measured length of 22.9 m and a sparred or overall length including the bowsprit of 33.0 m. The vessel's moulded breadth is 6 m, its moulded depth amidships is 2.95 m and, at its designed waterline draught of three metres, it has a displacement of 91.7 tonnes. It was launched in 1996 and commissioned in 1998 after a two year fit-out.

The vessel is named after Lewis Winde, the builder of an 1848 Boston schooner on which *Windeward Bound* was modelled. It is constructed almost entirely of Tasmanian eucalypt, huon pine and oregon pine, recycled from old boats and buildings. The hull is constructed of 5 cm hardwood strip planks, over epoxy-laminated douglas fir frames, spaced 38 cm (15 inches) apart. The stem, sternpost and keel are of epoxy-laminated Tasmanian blue gum and the decks are of huon and New Zealand kauri pines.

7 Sheets – rope or line attached to the bottom corners of a sail, used to release it or to change its position.

The vessel has a semi-balanced plate rudder that is operated mechanically from the helm and there is no automated steering system fitted to the vessel. At the time of the incident, the main engine was a Cummins diesel engine developing 198 hp and giving the vessel a service speed of 10 knots.

The box section keelson weighs about 11 tonnes and there are about 15.5 tonnes of lead ingots stowed in the bottom compartments for ballast.

The space below the weather deck is subdivided by three continuous and one stepped bulkheads (Figure 2). The collision bulkhead and the bulkheads forward and aft of the crew's accommodation are continuous. The bulkhead at the after end of the crew accommodation is also the forward bulkhead for the engine room. Located between the aft end of the engine room and the master's accommodation, is the aftermost bulkhead, which is stepped.

Windeward Bound is rigged with four square sails, three headsails, three staysails between the masts, a gaff mainsail and gaff topsail, totalling 12 sails in all (Figure 2). The sails are set, struck and adjusted manually, using tackles as necessary.

The total sail area is 402 m^2 and the windage lever of the sails from the centre of lateral resistance[8] is 9.87 m.

Navigation and communication equipment on board the vessel at the time of incident included an electronic chart system, a Global Positioning System (GPS), Furuno radar and a satellite communication (Inmarsat-C) system. The vessel was equipped with a speed log, which was inoperative at the time of the incident, and an anemometer that was fitted on the main mast.

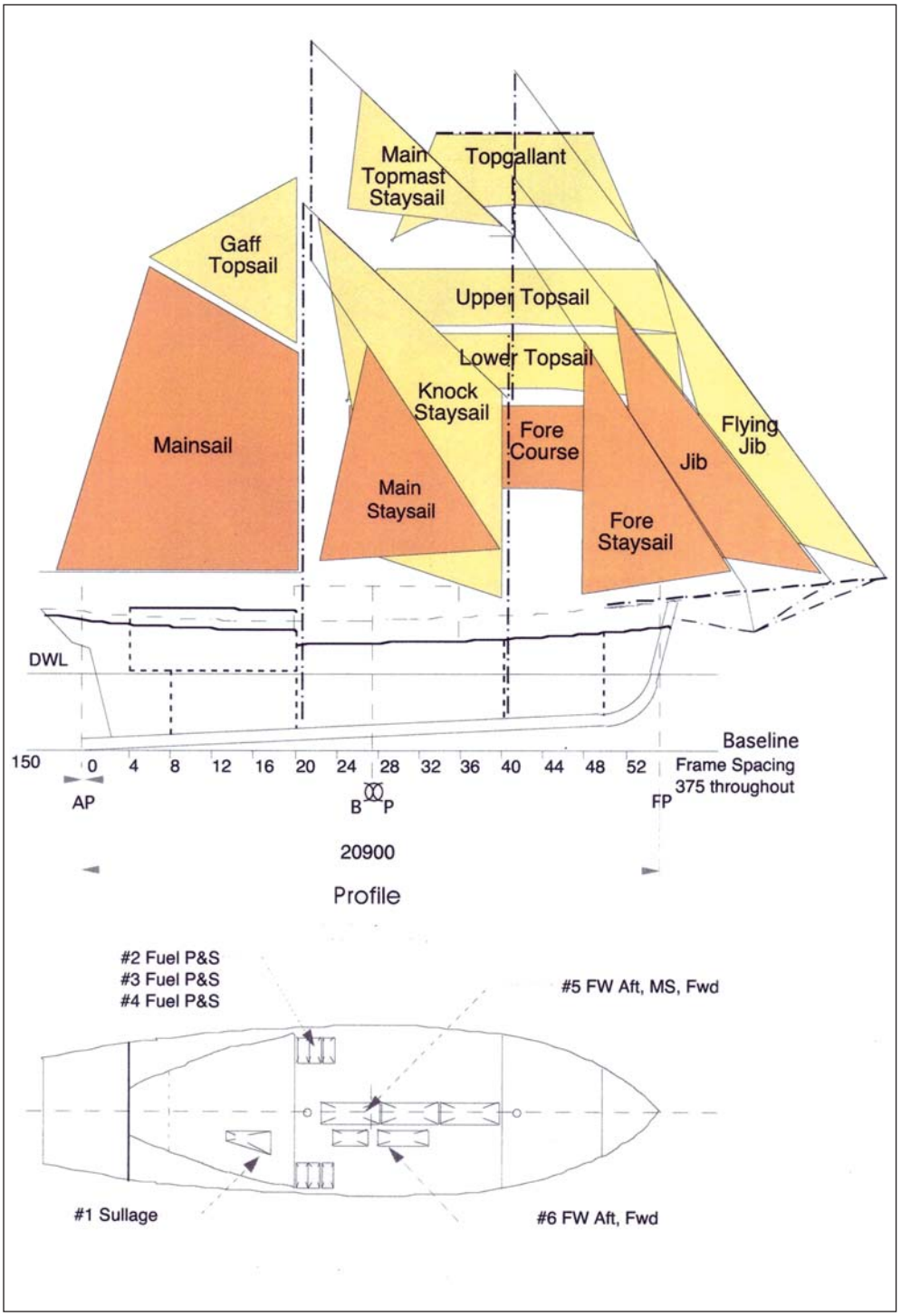
On interstate voyages, *Windeward Bound* participates in AUSREP (Australian Ship Reporting System) using Inmarsat-C polling for its position reports. Inmarsat-C polling allows short data messages to be sent automatically from a ship when a demand is received from a land earth station. The main advantage of Inmarsat-C polling is that it is not necessary for the master or any member of a ship's crew to manually report a ship's position. In *Windeward Bound*'s case, RCC 'interrogated' the vessel's Inmarsat-C system at twelve hour intervals to obtain automatic position reports, comprising latitude, longitude, course and speed.

Windeward Bound has dual classification, as a Class 2B trading vessel and as a Class 1D passenger vessel, with Marine and Safety Tasmania (MAST), the Tasmanian state marine regulatory authority. As a Class 2B vessel, *Windeward Bound* is licensed to carry 18 crew and 12 berthed passengers in all Tasmanian operational areas including offshore operations. As a Class 1D vessel, it is licensed to carry six crew and 65 passengers in smooth and partially smooth operational areas only.

At the time of the incident, *Windeward Bound* was on an interstate voyage, bringing it under the regulatory jurisdiction of the Australian Maritime Safety Authority (AMSA). Prior to the voyage, AMSA had issued the vessel with a 'determination' under section 194(6) of the Commonwealth *Navigation Act 1912*. This determination recognised that *Windeward Bound*'s certificates of survey (issued by MAST), were equivalent to certificates issued by AMSA. An exemption under section 421 of the Navigation Act was then issued. Thus, the vessel was permitted to proceed on interstate voyages.

8 Centre of the underwater profile of the hull, approximately half draught.

Figure 2: ***Windeward Bound*** **– Profile and tank location**



1.2 The crew

There were 16 crew members on board *Windeward Bound* at the time of the incident, most with square rig experience. In addition to the master, there were three watch officers, three watch leaders, two general purpose hands and a cook. There were also two naval cadets, two adults under sail training and two additional adults on board, one of whom was the chief executive officer of The Windeward Bound Trust.

Whilst at sea, the watch officers maintained a watch rotation of four hours on, eight hours off, while the watch leaders, general purpose hands and trainees rotated their watches at the 'dog' watches[9]. As the steering is manually operated, the tasks of the duty watch include steering the vessel, keeping a lookout, checking the decks and bilges and tending the sails.

The master had served in the Royal Australian Navy for seven years as a leading seaman, after which she sailed on various vessel types before undertaking the project to build *Windeward Bound*. The master then spent seven years, interspersed with voyages to sea, overseeing and assisting with the construction of the vessel and a further two years fitting it out. After the vessel was launched, the master completed the required sea time on board *Windeward Bound* and obtained a master class five certificate of competency in 2000. She then obtained a square sail endorsement and a marine engine driver grade three certificate of competency, after which she had sailed continuously on *Windeward Bound*, including the previous three years and seven months as master.

The watch officer, who was on watch during the incident, had six years of seagoing experience on sailing ships. He held a certificate as a general purpose hand and was completing examinations for a master class five certificate and a square sail endorsement.

The watch leader, who was also on watch at the time of the incident, had started her career at sea in 1996 on a sail training vessel. Since then, she had worked on a number of sailing vessels and power driven vessels, and had sailed on board *Windeward Bound* since 1 April 2004. She held master class five and mate class four certificates and was studying for a United Kingdom second mate's certificate of competency. She also held a Netherlands certificate as rating of a navigational watch.

The two general purpose hands on watch at the time of the incident had experience on sailing vessels. One had spent time sailing on yachts and the other had square rig experience.

1.3 The incident

At 2045 on Tuesday 1 June 2004, *Windeward Bound* sailed from Low Head, at the mouth of the Tamar River in northern Tasmania, bound for Sydney with draughts of 2.2 m forward and 3.2 m aft. The vessel's departure had been delayed by several days to allow a cold front to pass through Bass Strait. Another cold front was forecast to pass through Tasmania, Bass Strait and Victoria a couple of days after the vessel sailed.

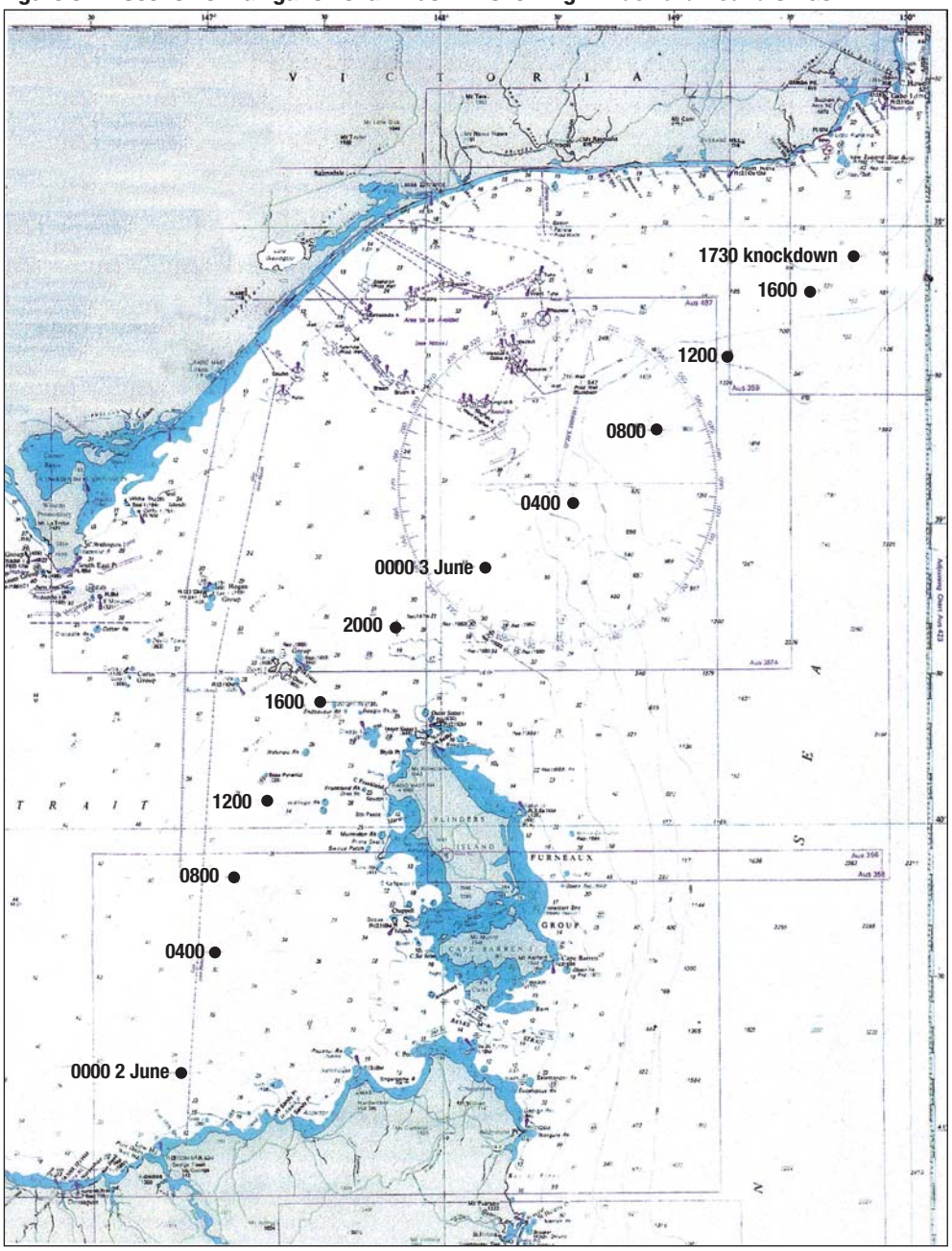
At 2130, after clearing the Tamar River, the vessel was steered on a course of 014°(T). At 2345, the wind speed was logged as 'steady' at 10 to 15 knots, but there

9 The first dog watch is from 1600-1800, the second from 1800-2000.

was no entry in the logbook to indicate the wind direction or the sail that had been set. By midnight, the vessel was on a course of 012°(T), making good a speed of 5.8 knots. The main engine was in use and the fore and main staysails and the lower topsail were set.

The ship's position at noon on 2 June was 39° 54.7'S, 147° 15.4'E (Figure 3). The vessel was making good a course of 025°(T) at a speed of 5.8 knots. At 1300, Bass Pyramid was abeam to port and, at 1650, the main engine was stopped.

Figure 3: Section of navigation chart Aus 422 showing *Windeward Bound*'s track



During the voyage, *Windeward Bound* was receiving regular weather forecasts on the vessel's Inmarsat-C system. At 0515 on 3 June, the Bureau of Meteorology issued a forecast containing a gale warning for all Bass Strait waters. The warning was associated with an approaching strong cold front which was predicted to move through the area during the day. Winds in eastern Bass Strait were forecast to shift

from the northwest to the west-southwest, increasing to between 30 and 40 knots. Seas were forecast to rise to four to six metres in the afternoon on a three to four metre swell later in the day.

At about 0900 on 3 June, the crew started bending on a new upper topsail as the vessel continued northward under sail. By 1000, *Windeward Bound* was in position 38° 32.8'S, 149° 05.27'E on a course of 039°(T).

At 1210, the Bureau of Meteorology issued another forecast for Bass Strait reiterating the previous gale warning.

By 1406, the upper topsail had been set and the vessel, steering 045°(T) at 5.5 knots, was approaching Gabo Island, off the Victorian coast. The fore and main staysails; and the upper and lower topsails were set.

At 1600, the two general purpose hands came on watch to assist the watch officer and the watch leader. *Windeward Bound* was on a course of 055°(T), heeled about 15 degrees to starboard, with the wind from the northwest at 15 to 20 knots.

At 1646, the Bureau of Meteorology issued another forecast which extended the gale warning to all Tasmanian waters and Victorian waters east of Cape Otway.

At about 1700, the wind backed to the southwest and increased in strength. The watch officer and watch leader discussed whether or not to strike the upper topsail. The watch officer then went to advise the master of the approaching bank of cloud from the southwest and to ask whether the upper top sail should be struck.

The master was of the opinion that the cloud, which appeared to be about two miles wide, was several miles away. To her, the cloud appeared to be similar to an average rainstorm on this part of the coast. She said 'to either side and for miles behind, the sky was clear and blue.'

The master instructed the watch officer to strike the upper topsail at the change of watch at 1800, when there would be additional hands on deck.

Patches of rain were now visible on the radar.

At 1715, one of the general purpose hands was sent below to call the next watch, while the other general purpose hand remained at the helm. *Windeward Bound* was now about 30 miles south of Gabo Island.

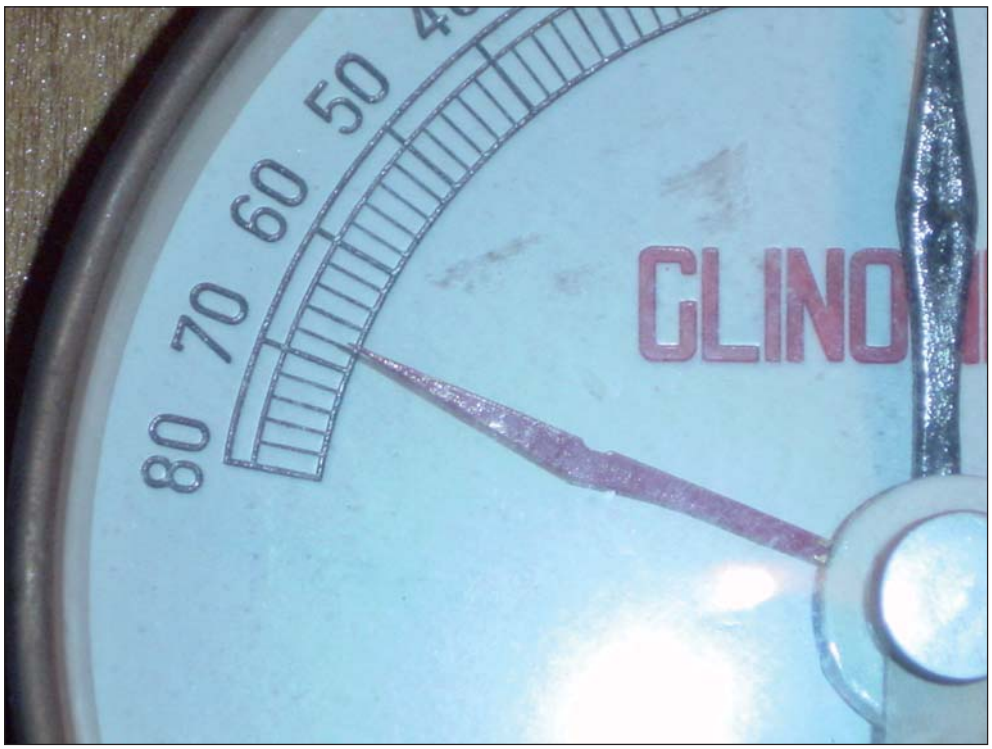
At about 1726, after several strong gusts of wind, the watch officer told the watch leader to run the vessel downwind, while he went to the chart room to consult with the master again. The master had observed the wind gauge in the chartroom indicate gusts of up to 38 knots and she instructed the watch officer to immediately strike the upper topsail and run the ship downwind.

While the watch officer was below, the general purpose hand at the helm was experiencing difficulty steering as *Windeward Bound* seemed, to the helmsman, to be trying to round up to port. She used hard-a-starboard rudder to bring the vessel off the wind and *Windeward Bound* ran downwind briefly before falling away to starboard.

At this point, the watch leader took the helm from the general purpose hand and attempted to bring the vessel's head round to port using 'a considerable amount' of port rudder. When the vessel was, again, heading almost downwind, the watch leader used starboard rudder, then hard-a-starboard rudder to try to steady the vessel on course. However, despite full starboard rudder, *Windeward Bound* continued swinging to port. It was at this point that a more severe gust of wind hit

the vessel and caused it to be 'knocked down[10]'. The vessel heeled to an angle of about 68 degrees (Figure 4), with the starboard side of its main deck submerged.

Figure 4: Inclinometer mounted on the aft bulkhead of the master's cabin



Water flooded through the starboard deckhouse door into the deckhouse area and from there down into the saloon which was one deck below. The water flowed aft in the main saloon until the crew hurriedly shut the deckhouse door and the other accommodation watertight doors.

The master left the deckhouse by the port deckhouse door, negotiating her way aft with difficulty on the steeply inclined deck. She called for the sheets to be let go and for the engine to be started. It was raining heavily and the watch officer, waist deep in water on the main deck, was barely able to keep his footing.

Once at the steering position, the master put the engine to full throttle ahead and ordered hard-a-starboard rudder. The sheets were eased and, a few minutes later, the vessel returned to upright. *Windeward Bound* had been 'knocked down' for several minutes.

The master took the helm and sent the watch leader forward to assist with reducing sail. The staysails were struck, the topsails were furled and *Windeward Bound* ran downwind under bare poles[11]. The master estimated that the wind speed had been about 40 to 45 knots with gusts of 60 to 80 knots (force 11 to in excess of force 12 on the Beaufort scale[12]).

The vessel's GPS position was now 38° 05.88'S, 149° 45.87'E and the knockdown had occurred immediately to the west of this position.

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10 See Analysis, section 2.2.

11 Bare poles: with all the sails struck or furled.

12 The Beaufort scale of wind force, developed in 1805 by Admiral Sir Francis Beaufort, enables sailors to estimate wind speeds through visual observations of sea states.

A muster of the ship's complement, held as soon as possible after the ship was upright, accounted for all on board. One of the watch leaders had dislocated a finger but there were no injuries to anyone else.

Damage to the vessel included the loss of a cover plate and lens from the starboard navigation light, three lifebuoys lost overboard, a torn lower topsail, which was soon repaired; and salt water damage in the main saloon and deckhouse area.

Of greater concern was the fact that seawater had entered the fuel tanks through the air pipes on the starboard side of the main deck. One of the tanks had been servicing both the generator and the main engine. During the period of time immediately after the knockdown, the main engine was unwittingly run on the contaminated fuel.

1.3.1 Damage to the main engine and generator

Prior to the knockdown on 3 June, at about 1530, one of the watch officers had noticed that the generator's temperature gauge was indicating 'high'.

The generator was shut down and, as the coolant level was found to be extremely low, the watch officer topped it up and restarted the generator. The generator ran for about 10 or 15 minutes before overheating again, so he shut it down. With one of the crew assisting him, the watch officer checked the generator again. There appeared to be nothing wrong with the generator and he was about to restart it when the knockdown occurred.

The watch officer, and the crew member assisting him, hurriedly climbed from the engine room into the saloon which was awash with water. They then heard the main engine start and run at full ahead as the master attempted to right the vessel.

When the vessel was upright, or nearly so, the watch officer informed the crew member who had assisted him with checking the generator, that the main engine was sounding odd.

The watch officer restarted the generator and again it ran for only a short while before stopping. The generator temperature was not in the high zone on the gauge so the watch officer bled the fuel injectors, hoping that this would be sufficient to enable him to start the generator again. However, while everything appeared to be in order, the generator still would not start.

At this stage, the master was not aware of any damage to the main engine and her intention was to divert to Eden to have the generator repaired. However, at about 2100, the main engine was stopped because it was running noisily.

At midnight on 3 June, the vessel's position was 37° 40.29'S, 150° 28.11'E and it was still running downwind under bare poles. The vessel's speed over the ground was 5.5 knots and the course made good was 037°(T). The last entry in the logbook for 3 June was that the wind speed was fluctuating between 25 and 45 knots.

The first deck log entry for 4 June read:

> 'Status –
>
> Generator is u.s., overheating and just won't start – was flooded with seawater (sump) by valves being left open.
>
> Main engine is running but won't respond to morse controls. Running/working our way towards Eden (hopefully). Will investigate morse controls in daylight.'

The master changed her mind about diverting the vessel to Eden, deciding, because of the prevailing weather conditions, that Jervis Bay was the preferred option. Accordingly, during the afternoon of 4 June, the course was altered for Jervis Bay.

1.3.2 The search for *Windeward Bound*

During the night of 3 June, after the knockdown, the master contacted a friend in Tasmania by satellite telephone to advise her of the vessel's situation. The friend then advised Eden Water Police that at 2300 on 3 June, *Windeward Bound* was 51 miles southeast of Eden, in some difficulty and making for Eden.

At 0005 on 4 June, the AUSREP Inmarsat-C poll of *Windeward Bound* returned the following information:

- Position – 37° 40'S, 150° 30'E,
- Course – 032°,
- Speed – 4.6 knots.

All subsequent 12 hourly AUSREP polls of *Windeward Bound* were unsuccessful.

At 1320 on 4 June, Eden Water Police advised the Rescue Coordination Centre (RCC), Canberra, of the information they had received from the master's friend regarding *Windeward Bound*.

About half an hour later, the RCC broadcast advice to shipping in the vicinity of *Windeward Bound*, requesting that a lookout be kept for the sailing vessel which was reportedly experiencing difficulty.

Responding to the broadcast, the yacht *Acropora* advised the RCC that it had sighted *Windeward Bound* when the latter was 'departing Eden'. However, the harbour master of the port of Eden confirmed that, while *Windeward Bound*'s estimated time of arrival at Eden had been 0600 on 4 June, the vessel had not yet arrived.

At 1646 on 4 June, the RCC coordinated an air search which located *Windeward Bound* in position 36° 29.64'S, 151° 18.78'E.

The aircraft confirmed with the vessel that it was safe and now bound for Jervis Bay.

Windeward Bound was granted permission to berth at HMAS Creswell, the navy base at Jervis Bay. At 2200 on 5 June, with assistance from a volunteer coastal patrol boat, the sailing vessel was secured alongside.

Arrangements were made to replace the main engine and the generator at Jervis Bay. Contaminated fuel was pumped from the fuel tanks, the fuel lines were drained and the fuel filters were renewed before the fuel was replenished.

After the main engine and generator were replaced, *Windeward Bound* sailed from Jervis Bay bound for Sydney, where it arrived safely.

2 ANALYSIS

2.1 Evidence

On 30 June 2004, the Australian Transport Safety Bureau (ATSB) was advised of the knockdown of *Windeward Bound*. On 5 July, the ATSB advised the master that it would be investigating the incident.

On 6 July 2004, while *Windeward Bound* was at Jervis Bay two investigators from the ATSB attended the vessel and interviewed the master, one of the watch officers and the watch leader who had the helm at the time of the knockdown. The trainee who had been at the helm just before the knockdown had left the ship. The other two watch officers, who had also left the vessel, were interviewed by the ATSB investigators on 12 July.

The Bureau of Meteorology provided weather forecasts for Bass Strait and Victorian coastal waters relevant to the incident as well as information relating to the weather and sea states in the area of the knockdown.

Copies of relevant documents were obtained, including log books, operating manuals, procedures, standing orders, safety management plan and statutory certificates. The master provided written statements from the watch officer and watch leader who had been on watch during the knockdown and from one of the other watch officers. The master also provided a photograph of the inclinometer in her cabin.

A copy of *Windeward Bound*'s stability booklet, approved by Marine and Safety Tasmania (MAST) on 2 November 1998, was provided to the ATSB.

The Rescue Coordination Centre (RCC) provided the ATSB with details of the events leading up to the search for *Windeward Bound* and of the successful air search. They also provided information relating to RCC's Inmarsat-C polling of the vessel after the knockdown.

Expert comment on the intact stability of *Windeward Bound* was received from Mr R J Herd, Hon FRINA, consultant naval architect.

2.1.1 Weather forecast

The weather forecast, promulgated by the Bureau of Meteorology, at 1034 local time on 3 June 2004, stated:

> Gale warning for Victorian coastal waters east of Wilsons Promontory, issued at 1033 on Thursday the 3rd of June 2004.
>
> PLEASE BE AWARE
>
> Wind gusts can be 40 percent stronger than the averages given here and maximum waves may be up to twice the height.
>
> Northwest winds reaching 20/30 knots in the south and west in the morning then to 25/35 knots early afternoon before a west to south westerly change at 30/40 knots becomes general during the afternoon and evening. Seas 2 to 4 metres in the west in the morning, rising to 4 to 6 metres throughout, later in the afternoon. West-south-westerly swell 1 to 2 metres, increasing to 2 to 4 metres late in the day.

2.2 Knockdown

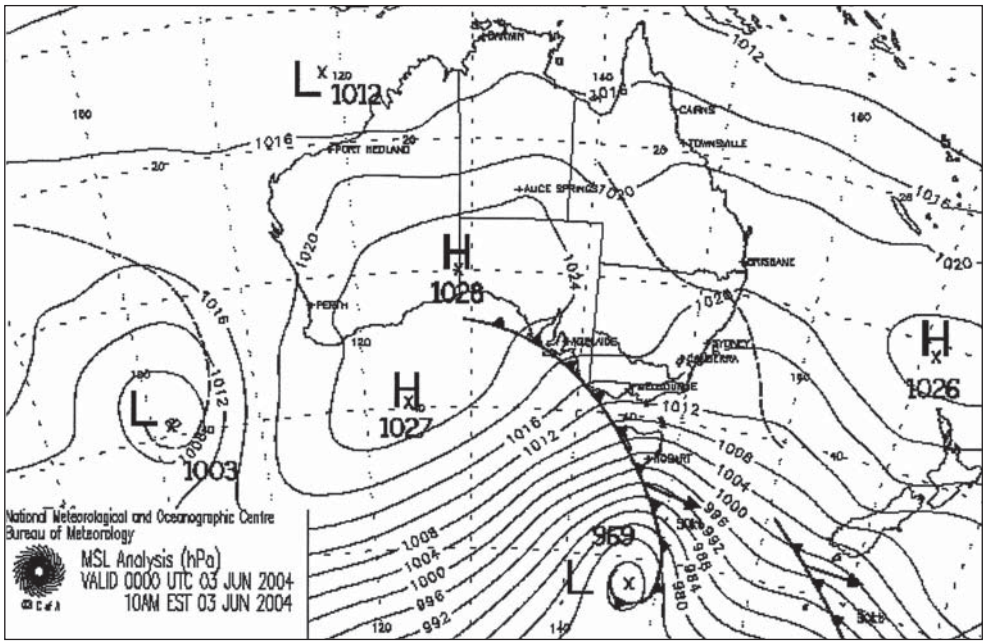
According to the Oxford Companion to Ships and the Sea, a knockdown is:

> The action of a small vessel which is rolled over with her masts and sails in the water by a sea breaking over her or by a violent squall.[13]

For this incident, the report uses the term 'knockdown' to describe what might be more precisely referred to as 'a broach leading to an extreme angle of heel'. The ATSB feels that the use of the term 'knockdown' is appropriate in this instance because this was the terminology used by the master and others in their reports, in the Windeward Bound company media releases and in the ship's log book entries. The term is also indicative of the commonly accepted terminology used within the sailing fraternity for this type of event.

At about 1700 on 3 June, *Windeward Bound* started to experience a change in wind speed and direction which preceded the forecast cold front passing through the area that afternoon (Figure 5). At the time, the vessel's heading was about 055°(T) and it was on the port tack on a broad reach[14]. The sails, including the upper and lower topsails, were trimmed to the wind. As the wind shifted from the northwest and became more westerly, the vessel's course was altered to maintain the wind just abaft the port beam. By 1713, the vessel's heading was 033°(T).

Figure 5: Synoptic chart at 1000 Eastern Standard Time 3 June 2004



When *Windeward Bound* was struck by several sudden strong gusts of wind from the southwest at about 1725, the watch officer ordered the watch leader to run the vessel downwind. At this point, perhaps due to the quarterly sea and swell, the vessel seemed, to the helmsman, to want to round up to port. The helmsman was having difficulty turning the vessel to starboard to run it downwind, so full starboard rudder was applied. Almost as soon as the vessel was running downwind, it started to fall away to starboard. The watch leader took the helm and she applied

13 The Oxford Companion to Ships and the Sea. Oxford University Press, 1998.

14 Point of sailing of a vessel with the wind reasonably 'free' and the sail full throughout. Broad reach is with wind on the beam or just abaft of the beam.

a considerable amount of port rudder. As the vessel started to swing to port, she used some starboard rudder, then full starboard rudder to arrest the swing to port. Despite the large amount of counter rudder, the vessel continued to swing to port before being 'knocked down'.

The large rudder angles used by the helmsmen are an indication that the crew were having difficulty maintaining the vessel's heading downwind. That the vessel appeared to be directionally unstable on this heading was possibly due to a combination of factors; mostly related to severe gusts of wind, the amount and trim of the sails and the manual steering system's physical arrangements. The wind, almost at right angles to the high aspect upper and lower topsails on the downwind heading, would also have caused some more stern down trim due to the lifting effect of square sails. In the steep following seas, the combination of these factors, and the vessel 'surfing' down the face of the swells, would have made steering a steady downwind course very difficult.

Windeward Bound has a large rudder and the three successive large rudder movements just before the knockdown would have caused the vessel to slow considerably. The failure of the vessel to respond to the final full starboard counter rudder is an indication that there was probably little water flow over the rudder at this point. By now, the near-stationary vessel was extremely vulnerable to the wind and sea conditions and it is likely that it broached when the sudden gust of stronger wind struck at about 1726. The strong wind acting on the sails, in particular on the upper topsail, would have caused much of the vessel's large heel to starboard.

It was extremely fortunate that none of the crew were seriously injured, or worse, when *Windeward Bound* was knocked down and that the prompt action on the part of the master and crew allowed the vessel to recover from its position of extreme vulnerability.

In the circumstances, the master took the most appropriate action which was to run the engine at full ahead to gain steerage way. She then turned the vessel downwind to bring it upright as the crew were releasing the topsail sheets and striking the other sails. Prompt action by the crew, in closing doors to the accommodation, had also stopped the flow of water into the saloon when *Windeward Bound* was lying heeled at an angle of about 68 degrees. If the flow of water into the saloon had not been quickly stopped, the vessel's stability would have been rapidly compromised.

In the past, several 'tall ships'[15] have been lost as a result of knockdowns, some with the loss of many lives. The auxiliary barque *Marques*, a square-rigged sailing ship, was lost together with 19 of its 28 crew. The vessel was about 80 miles north of Bermuda, 20 years earlier to the day of *Windeward Bound*'s knockdown.

Typically, the ships have been in light winds with sail set, when an extreme gust or squall has struck. Then, after being laid over onto one or the other beam end, seawater has entered interior spaces through open hatches, ventilators, portholes or other openings, resulting in the ships sinking in a matter of minutes. While *Windeward Bound* was not laid over onto its beam ends, the angle of heel of about 68 degrees was perilously close to the vessel's angle of down flooding (74.7 degrees).

2.2.1 Sail management and weather

The weather forecasts in the two days or so before *Windeward Bound*'s knockdown had predicted the passage of a strong cold front with associated strong winds through eastern Bass Strait in the afternoon of 3 June.

15 A sailing ship that has at least two masts and is square rigged – the American Sail Training Association.

The first gale warning for the area was issued by the Bureau of Meteorology at 1635 on 2 June and each forecast for the next 24 hours reiterated the warning. The master and crew were aware that a change was forecast and, although the master later stated that she was not aware of any gale warnings, the forecasts were available from the vessel's Inmarsat-C system. The master's night orders for 2 June contained advice about a change in the weather, including a shift in the wind direction to the southwest and an increase in wind speed. This advice was accompanied by an order to strike the fore staysail if the wind speed exceeded 30 knots.

In submission, the master stated:

> I was obviously aware of the original warnings…I was definitely unaware of the latest warning as I was off watch and asleep when it came in and it was not brought to my attention.

There was no procedure that required that the master be advised but the report was avaliable for her to review when she resumed duty.

The following day, despite the approach of the front and associated gale warnings, the master took no precautions to prepare the vessel for the onset of heavy weather. Indeed, the crew set about bending on a new upper topsail during much of the day. The upper topsail is a relatively large, high aspect, square sail which should only be used when expected maximum winds are less than 25 knots.

In submission, the master stated:

> *Windeward Bound* is prepared for heavy weather at all times…the sail being carried could be struck in a matter of a few minutes.

Statements from the master and crew suggest that *Windeward Bound* was subjected to wind gusts of 60 to 80 knots when it was knocked down. However, weather observations from Gabo Island, about 30 miles north of *Windeward Bound*'s position at the time of the knockdown, indicated that the maximum wind gust for the day, at the island, was 44 knots from the southwest at 1818.

Other advice from the Bureau of Meteorology indicated that conditions 80 miles upwind of the position of the knockdown, at *King Fish B* oil platform, would have been indicative of those experienced by *Windeward Bound*. At *King Fish B*, west-north-westerly winds had increased to about 35 knots (10 minute average) with gusts to 46 knots just prior to the change with an average of 41 knots and gusts of 53 knots with the change. Therefore, gusts of 60 knots (at *Windeward Bound*'s position) would be quite plausible but 80 knots not nearly as likely.

At 1700, the watch officer informed the master of the approach of an ominous looking band of cloud which marked the approach of the cold front. The master's response was to order that the upper topsail be struck about an hour later, at 1800, when more hands would be available. With the main staysail, the fore staysail and the upper and lower topsails set and, only the standard watch complement of four hands on deck, *Windeward Bound* was both unprepared and vulnerable when strong winds struck it at about 1726.

Windeward Bound had too much sail set for the forecast weather conditions which it experienced later that evening. The vessel's standing orders stated that the maximum wind speeds over the deck for the sails in use were:

- 40 knots for the main staysail.
- 30-35 knots for the fore staysail.
- 30 knots for the lower topsail.
- 25 knots for the upper topsail.

The weather forecast predicted winds of 30 to 40 knots, with gusts up to 40 percent higher and, had the standing orders been followed, some sail should have been struck well before the arrival of the front after 1700.

In response, the master stated:

> The standard issue by the Bureau of Meteorology always states 'please be aware that wind gusts may be a further 40% stronger that the average…
>
> This is given as a preamble to all weather forecasts and is only a preamble…'

Whilst this is a standard warning, its purpose is to remind mariners that the predicted values are for the average wind speed over a ten minute period not maximum values.

Windeward Bound's sails are set and furled manually; the square sails in particular require the crew to work high above the deck on the yards. It is, therefore, always desirable to send the crew aloft in the safest possible conditions. Sufficient time must also be allowed for working the sails, particularly when many of the crew are relatively inexperienced and are aloft in inclement weather. By the time the master and watch officer were discussing the approaching cloud bank just after 1700, it was probably too late. Had the crew attempted to furl the upper topsail at this time, it is possible that they would have been aloft when the vessel was knocked down at 1726. Had that been the case, their lives would almost certainly have been put at risk.

Windeward Bound's stability book contains pertinent advice for the vessel's master in respect of sail management:

> Stability considerations aside, the master shall at all times operate the vessel in a safe and seamanlike manner, paying due attention to weather and sea conditions.
>
> The master shall generally observe any vessel standing orders in respect of setting and furling sails.
>
> Notwithstanding this, the master shall take account of the prevailing wind strength and direction, the prevailing sea state and the point of sailing as well as likely or possible changes to these factors when deciding which sail combination to set. He (sic) shall also take account of the crew's ability at the time to manage sail in an emergency.

It would have been more difficult for any crew, no matter how experienced, to reduce sail under the conditions prevailing after the arrival of the front. Despite the advice in the stability book and the vessel's standing orders, the delay in reducing sail probably precipitated the events which culminated in the knockdown.

2.3 Vessel's area of operation and stability

2.3.1 Tasmanian voyages

All functions relating to the safe operation of recreational and commercial vessels in Tasmania are managed by MAST. Commercial vessels are certified under the provisions of the *Marine and Safety (Vessel Safety Standards) By-Laws 2000*. These by-laws contain various survey requirements for Tasmanian commercial vessels and also refer to the provisions for vessel construction, safety and equipment contained in the Uniform Shipping Laws Code (USL Code), promulgated by the Australian Transport Council of Ministers.

Windeward Bound was constructed under survey in Tasmania in accordance with the provisions of the USL Code, and at the time of the incident was registered in Tasmania as a Class 2B and 1D commercial vessel.

The USL Code contains various requirements for the stability[16] of sailing vessels depending on their size and area of operation. As a vessel with a measured length greater than 20 m, *Windeward Bound* is classified by the USL Code as a 'large sailing vessel' to which the following intact stability requirements apply:

> The vessel **should** have a range of positive stability, throughout her range of operating drafts, from the upright to at least 70° for service on smooth or partially smooth waters and 90° in open waters.

At the time of the incident, *Windeward Bound* had a range of positive stability of 77.5 degrees (Figure 7). Consequently, it did not meet the USL Code's requirement for 90 degrees of positive stability for a vessel operating in open waters. The vessel's 2B classification, however, allows it to trade in all operational areas up to and including offshore operations (up to 200 miles to seaward from the coast).

Advice received by the ATSB indicated that MAST had interpreted 'should' in the USL Code requirement as not meaning 'shall' when considering the vessel's range of stability and proposed area of operation. MAST had decided that a range of stability of 76 degrees, for certain conditions of loading, was an:

> …acceptable compromise, taking into account the sea kindly capabilities of the vessel especially a vessel relying on crew going aloft to set and retrieve sail.

They also noted that the buoyancy of sponsons, bulwarks and spars were not included in the stability assessment and could also be taken into account.

This is permitted under the USL Code.

When it was knocked down on the afternoon of 3 June, *Windeward Bound* was heeled to an angle of about 68 degrees to starboard. This was only about nine degrees less than the angle of vanishing stability[17] of 77.5 degrees, and only about seven degrees less than the vessel's first flooding angle of 74.7 degrees (through the engine room vent on deck). The engine room vent was not closed and secured at the time, and it was not automatically self-closing. Had the vessel heeled further and immersed the vent, or even further to its angle of vanishing stability, the likelihood of recovery would have been severely reduced.

In addition to its limited range of intact stability, *Windeward Bound* did not meet the wind heeling requirements for operations as a large sailing vessel. The USL Code contains a requirement that, with bare poles subjected to a wind of 450 Pascals (about 53 knots), the vessel will not heel more than the lowest of: the angle required to submerge half of the vessel's freeboard or, the angle of bilge immersion or, 14 degrees.

In *Windeward Bound*'s case, the applicable angle is that required to submerge half the freeboard (about nine degrees). *Windeward Bound* did not meet this criterion, as the vessel will theoretically heel to an angle of about 13 degrees when subjected to a wind of 450 Pascals under bare poles.

The decision by MAST to permit the vessel to operate in offshore areas was accompanied by certain inherent risks given the limitations in the vessel's range of stability. While MAST considered there were mitigating factors in the vessel's

16 Stability: the ability of a vessel to return to the upright after being heeled.

17 The angle at which the value of the righting lever, GZ returns to zero.

sea-keeping ability and construction, there were other factors that should have been carefully weighed when making a decision relating to the safe operation of the vessel. These include the fact that the vessel carries, at times, a significant number of passengers in addition to inexperienced sail trainees; and the likelihood that the vessel will encounter severe weather when operating on extended offshore voyages.

2.3.2 Interstate voyages

As *Windeward Bound* was on an interstate voyage at the time of the incident, the vessel was within the jurisdiction of the Australian Maritime Safety Authority (AMSA), the Australian Government marine regulator, and was required to comply with the relevant AMSA survey provisions. On 21 February 2003, the vessel was given a determination under Section 194 (6) of the Commonwealth *Navigation Act 1912*. In this process, AMSA recognises that if a commercial vessel meets the appropriate state survey requirements then its certification is equivalent to that issued by AMSA. This largely administrative process permits state and territory registered commercial vessels to operate under Commonwealth jurisdiction without the necessity to undergo a full AMSA survey.

When issuing a Section 194 (6) determination, AMSA carries out an inspection to ensure that the owner has maintained the vessel and its equipment as required by its state or territory survey authority. Following the inspection, AMSA may impose additional conditions, depending on the intended voyage or voyages. Additionally, AMSA will notify the state survey authority of its intention to issue a determination to ensure that the state or territory authority has no objection. At this time, AMSA also requires the state or territory authority to indicate if they have permitted any exemptions, such as, an exemption from complying with specific stability criteria.

When carrying out its inspection, AMSA assumes that the relevant state or territory authority has surveyed the vessel and issued it with certificates in accordance with the USL Code requirements applicable to the vessel. AMSA does not re-approve documentation such as the vessel's stability information. In *Windeward Bound*'s case, the inspection found the vessel to be in a satisfactory condition and MAST did not indicate to AMSA that they had exempted the vessel from any provisions of the USL Code. Nor was there any mention of the considerations taken into account in respect of the vessel's range of intact stability or any other stability requirements. Consequently, AMSA had no reason to reconsider the vessel's stability when issuing the determination.

Marine Orders (MO) Part 52, details the requirements for 'Sailing Ships' under AMSA's jurisdiction. With respect to intact stability, MO Part 52 refers to the provisions of the USL Code and, if a vessel meets the requirements of the USL Code, it is deemed also to meet the requirements of MO Part 52.

Windeward Bound's range of stability for the voyage from Low Head to Sydney (its original destination) fell short of the requirement of the USL Code by about 12.5 degrees. Consequently the vessel did not comply with the requirements of MO Part 52 and therefore AMSA should not have permitted it to conduct interstate voyages without the appropriate exemption from this provision.

2.3.3 Other stability considerations

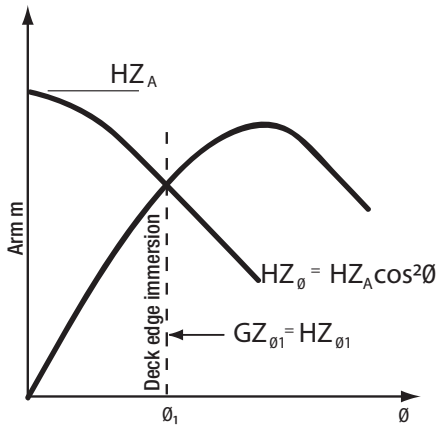
In determining the adequacy of a sailing vessel's stability, the USL Code details requirements with regard to assessing the vessel's angle of heel for various wind strengths with various sails set.

The USL Code requires that three curves be constructed showing wind heeling arms (HZ) and the vessel's righting lever (GZ) for a range of angles of heel for deck edge immersion, down flooding angle (or 60 degrees if the down flooding angle is greater than 60 degrees) and knockdown (90 degrees).

All the wind heeling curves take the form of $HZ_{\theta} = HZ_{A,\text{ or B or C}} \text{Cos}^2\theta$, where θ is the angle of heel, as the wind heeling moment is proportional to the wind pressure and to the cosine squared of the angle of heel. $HZ_{A,B \text{ and } C}$ are the values of the wind heeling arm at zero degrees which will result in the three conditions i.e., HZ_A for deck edge immersion, HZ_B for down flooding and HZ_C for knockdown.

The wind heeling arm (HZ) curve (Figure 6) should be plotted so that the point of intersection with the vessel's righting lever (GZ) curve is at the angle of deck edge immersion. The wind heeling arm curves for down flooding and knockdown should also be plotted so that for HZ_B, for example, the area under the righting arm curve equals the area under the heeling arm curve both taken to the down flooding angle.

Figure 6: Excerpt from USL Code showing wind heeling arm and righting lever curves for deck edge immersion



The purpose of performing these calculations and including the information in the vessel's stability book is to inform the master what margins are available in terms of wind strength and the sail set in the prevailing weather conditions before the vessel reaches the three conditions (deck edge immersion, down flooding or knockdown). For example, the master can look at the current wind conditions and the vessel's sail configuration, compare it with the sails used for the wind heel curve calculations and assess whether or not the strongest gust of wind the vessel is likely to experience will result in deck edge immersion.

The vessel must also meet certain minimum conditions in relation to the three conditions of heel due to wind strength. These are:

- a wind strength of 105 Pascals should not result in deck edge immersion;
- a wind strength of 115 Pascals should not heel the vessel more than 60 degrees and;
- a wind strength of 130 Pascals should not result in a knockdown.

The information presented in *Windeward Bound*'s stability book for various loaded conditions shows calculations and wind heeling arm curves for the limiting wind strengths of 105, 115 and 130 Pascals. The curves are labelled $HZ_{A,B \text{ and } C}$. However, the analysis as depicted in *Windeward Bound*'s approved stability booklet is not

what is required by the USL Code (Figure 7). While this may not have been a factor in the knockdown on 3 June, the information on wind heeling arm curves as presented in *Windeward Bound*'s stability book was inaccurate and of little use to the master in determining what sails should be in use in various wind strengths.

It is also worth noting that the wind heeling arm calculations in *Windeward Bound*'s stability book are based on a defined set of 'working sails' and not on the vessel's full set of sails. Using the full sail area of 402 m^2 and the lever arm of 9.87 m, it is found that the wind force for down flooding is only 75 Pascals (21 knots), well below the limit of 115 Pascals.

2.4 Watertight integrity

Figure 7: ***Windeward Bound*'s approved stability data**

Condition : 4 1-B and 2-B Operations - Depart Port

Hydrostatics			Trim and Drafts		
for trim =	0.40	metres	LBP =	20.900	metres
BL Draft at the LCF =	3.006	metres	Calculated Trim BP =	0.28	metres
LCB from midships =	-0.487	metres	BL Draft at the AP =	3.14	metres
LCF " "=	-0.180	metres	Base Line Correction Aft =	0.000	metres
MTC =	0.839	t-m	Draft Mark Aft =	3.14	metres
KMo =	4.157	metres	From page 3, P =	0.00	metres
GfMo = KMo - KGf =	0.83	metres	Draft Aft =	3.14	metres
plot 0.43 metres at	30	degrees	BL Draft at the FP =	2.86	metres
Immersion Angles			Rake of Keel Corr'n F'wd=	0.920	metres
Deck Edge =	17.7	degrees	Draft Mark F'wd =	1.94	metres
1st Potential Flooding =	51.2	degrees	From page 3, Q =	0.00	metres
1st Flooding =	74.7	degrees	Draft Forward =	1.94	metres

Righting levers GFZ = KN - KGf . SIN Ø

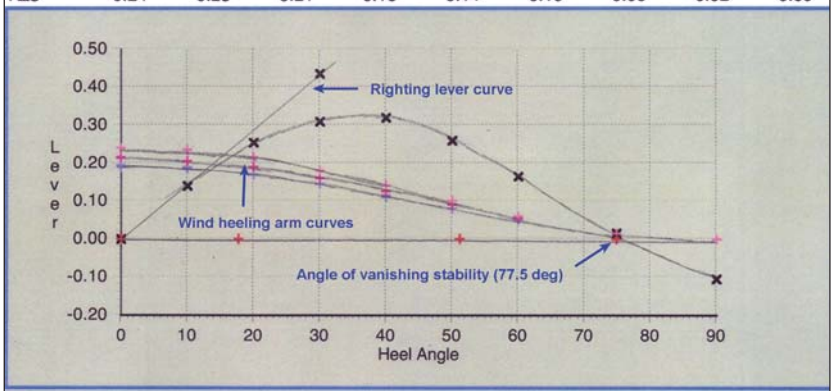
Heel Angle Ø	10	20	30	40	50	60	75	90
sin Ø	0.1736	0.3420	0.5000	0.6428	0.7660	0.8660	0.9659	1.0000
KN	0.72	1.39	1.97	2.46	2.81	3.05	3.23	3.22
KGf . sin Ø	0.58	1.14	1.66	2.14	2.55	2.88	3.21	3.33
GfZ	0.14	0.26	0.31	0.32	0.26	0.17	0.01	-0.10

Heeling Moments (See 4.3)

							Moment	
Stat Bal-Bare Poles	P =	460	A	77.7	h =	4.8	**17.6**	t-m
Stat Bal-Working Sail	P =	105	A	226.8	h =	7.4	**18.0**	t-m
Dyn Bal-Downflood	P =	115	A	226.8	h =	7.4	**19.7**	t-m
Dyn Bal-Capsize / 90	P =	130	A	226.8	h =	7.4	**22.3**	t-m

Heeling Levers (calculated for maximum single and combined moments)

cos Ø		0.9848	0.9397	0.8660	0.7660	0.6428	0.5000	0.2588	0.0000
BP	0.19	0.19	0.17	0.14	0.11	0.08	0.05	0.01	0.00
HZA	0.20	0.19	0.17	0.15	0.11	0.08	0.05	0.01	0.00
HZB	0.21	0.21	0.19	0.16	0.13	0.09	0.05	0.01	0.00
HZC	0.24	0.23	0.21	0.18	0.14	0.10	0.06	0.02	0.00



Status	Stability Criteria		Actual	Assessment
For Information	Area 0-30 deg >	3.15 m-deg	5.62	Complies
For Information	Area 0-40 deg or Øf >	5.16 m-deg	8.77	Complies
For Information	Ø at GfZ max >	35 degrees	37	Complies
For Information	GfZ at 30 deg >	0.20 metres	0.32	Complies
For Information	GfMo >	0.15 metres	0.83	Complies
Must Comply	Static Bal to Deck -Bare Poles	**17.7** degrees	**13**	**Complies**
Must Comply	Static Bal to Deck- Working Sail	**17.7** degrees	**13**	**Complies**
Must Comply	Dyn Balance to Downflooding	A> B	**yes**	**Complies**
Must Comply	Dyn Balance to Capsize or 90	A + C> B	**yes**	**Complies**

The watertight integrity of a vessel is crucial to its stability and therefore its safety while at sea. Watertight or weathertight[18] integrity is achieved by preventing the ingress of water into a vessel's floodable spaces. The vessel and its fittings are designed and constructed to achieve this aim. Furthermore, all openings to spaces such as hatches, doors and port holes are closed whenever a vessel puts to sea.

Openings are usually classed in three categories:

- Openings which cannot be kept closed and are therefore points of down flooding if immersed.
- Openings which are normally kept closed but which may be opened for passage during a voyage and immediately re-closed. These are points of potential down flooding.
- Small opening through which wires, chains, tackle etc. may be passed but which are not subject to down flooding and therefore may be neglected.

Windeward Bound has a number of openings leading to the spaces below deck. These openings include companionways, ventilators for the accommodation and engine room spaces, a ventilator for the battery locker and air pipes for the fuel tanks.

2.4.1 Ventilators

There are a number of concerns relating to the closing devices fitted to some of *Windeward Bound*'s ventilation openings. When the vessel was knocked down, the cowl ventilator for the engine room (Figure 8), the first point of down flooding, was only seven degrees away from immersion. While the ventilator was fitted with a butterfly valve operable from inside the accommodation, there was no way for the crew to quickly and effectively seal the ventilator from the deck. Furthermore, the arrangement did not comply with the applicable provisions in Tasmania's Marine and Safety (Vessel Safety Standards) By-Laws 2000 which state that:

> A ventilator for the space below deck is to be terminated in a fitting that prevents sea water from entering the ventilated space via the ventilator.

Figure 8: Weather deck showing vents open to down flooding

18 Weathertight, in relation to a fitting in a vessel, means that, in any sea conditions, water will not penetrate into the vessel through that fitting.

The engine room cowl ventilator should have been fitted with a closing device where it terminated, i.e. at deck level. A similar situation existed with the cowl ventilator forward for the crew accommodation.

In addition, the forced draft fan inlets for the engine room were not fitted with closing devices. While these ventilators do not represent a significant flooding risk, as they are close to the vessel's centreline and relatively high above the weather deck, they still require closing devices as there must be a means of isolating the engine room space in the event of a fire.

2.4.2 Air pipes

When *Windeward Bound* was knocked down, water entered the in-service fuel tank through the open air pipe. The water ingress into the fuel tank resulted in main engine and generator damage.

Windeward Bound's fuel tank air pipes were fitted with closing devices but, like the engine room cowl vent, they were ineffective because they were inside the accommodation spaces and were not easily operated by the crew (Figure 9). Furthermore, the arrangement was such that seawater could accumulate in the air pipe above the closed valve. Since there was no means of draining the air pipes into the bilge, the accumulated water would be dumped into the fuel tank when the valves were re-opened.

Figure 9: Shut off valves for air pipes

It is a requirement of the USL Code that air pipes to tanks and other spaces extend above the weather or superstructure deck, and that they are designed to prevent the back flow of seawater down the pipe. In addition, where the internal diameter of the pipe exceeds 30 mm, the pipe shall be provided with an efficient means of watertight closure that is permanently attached to the pipe or the adjacent structure.

Windeward Bound's fuel tank air pipes were less than 30 mm in diameter and they terminated in a 'gooseneck' to inhibit sea water from entering the pipes. However, their location on the weather deck made them prone to total submersion. Therefore, it would have been appropriate for the air pipes to be fitted with automatic closing devices.

A similar situation existed with the battery locker ventilator (Figure 10). The pipe terminated in a gooseneck but it was located outboard on the weather deck and was thus prone to total submersion. Given the hazards associated with the possible generation of chlorine gas when lead-acid batteries are submerged in seawater, it would have been highly desirable to terminate the vent pipe with a closing device.

Figure 10: Battery locker vent

2.5 AUSREP – reports and Inmarsat-C polling

A vessel participating in AUSREP is obliged to send in a deviation report if the vessel is more than two hours steaming from the position that is predicted from its sailing plan or last position report. During the night of 3 June, after the knockdown, the master of *Windeward Bound* advised a friend in Tasmania of the incident and that the vessel was making for Eden. The information was then forwarded by the friend to Eden Water Police and then to RCC.

When there was no sign of *Windeward Bound* at Eden and attempts at contacting the vessel had failed, an air search was conducted in the afternoon of 4 June. The search was successful and it was established that the vessel was safely en route to Jervis Bay. Considerable time and effort would have been saved if the vessel had been able to submit a deviation report to indicate that it was safe and was making for Jervis Bay instead of Eden.

In her report on the incident, the master stated that the vessel was unable to transmit an AUSREP deviation report after the change of course to Jervis Bay due to the fact that the generator was not operational and therefore the computer used to compile messages for the Inmarsat-C system was not functioning. However, a successful AUSREP poll at 0005 on 4 June indicates that, while the computer connected to the Inmarsat-C transceiver may have been inoperative, the transceiver itself was functioning at least until just after midnight.

Windeward Bound was required to have two sources of energy powering its radio installation. The vessel's generator was the main power supply and, in addition, the vessel was equipped with batteries as its reserve power supply. In the event that the main power supply failed, which it did in *Windeward Bound*'s case, the reserve power supply must be capable of operating the ship's radio installation for a period of six hours.

The successful Inmarsat-C poll about eight hours after the generator had shutdown indicates that the vessel's batteries still had sufficient power to supply the Inmarsat-C transceiver at this time. However, although the batteries were still operational when the ship arrived at Jervis Bay, the ship did not automatically respond to the next poll, twelve hours later, at about midday on 4 June.

By the time the master made the course change to divert to Jervis Bay in the afternoon of 4 June, there was no way that a deviation report could be sent using the vessel's radio installation due to the failed generator. Furthermore, the vessel was well outside mobile telephone range.

3 FINDINGS

3.1 Context

On 3 June 2004, the Australian sail training ship *Windeward Bound* was off the Victorian coast, heading northeast at about six knots. The wind was from the northwest and the vessel was heeled between 10 and 15 degrees to starboard.

At 1726, when the ship was about 30 miles south of Gabo Island, the wind speed increased. The helmsman was instructed to run the vessel downwind. Several large rudder movements were applied in an attempt to control the vessel, causing it to lose steerage way. A gust of near-hurricane force wind then heeled the vessel about 68 degrees to starboard.

From the evidence available, the following findings are made with respect to the knockdown of *Windeward Bound* on 3 June 2004 and should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors

1. The vessel did not meet the intact stability requirements with respect to its range of positive stability for operation in open waters. *[Safety Issue]*
2. The vessel did not meet the intact stability requirements with respect to wind heel with bare poles. *[Safety Issue]*
3. The vessel's approved stability book contained an incorrect assessment of the vessel's wind heel characteristics. *[Safety Issue]*
4. The master did not adequately obtain or assess the weather forecasts and take appropriate measures to prepare the vessel and the crew for the onset of heavy weather associated with the cold front which moved through eastern Bass Strait on the afternoon of 3 June 2004. *[Safety Issue]*
5. The vessel had too much sail set for the forecast weather conditions and the conditions which it later experienced when the cold front arrived.
6. The vessel probably experienced wind gusts exceeding 60 knots just after the arrival of the cold front.
7. The amount, type and trim of the sails which were set, the following seas and the three large rudder movements immediately prior to a sudden strong gust of wind at about 1726 resulted in the vessel being 'knocked down'.

3.3 Other safety factors

1. The considerations, with respect to the vessel meeting the intact stability requirements, taken by Marine and Safety Tasmania, should have been made available to the Australian Maritime Safety Authority before the vessel was permitted to undertake an interstate voyage. *[Safety Issue]*
2. The vessel's engine room and accommodation ventilation arrangements did not comply with the relevant requirements with respect to their closing arrangements. *[Safety Issue]*

3. The vessel's battery locker ventilator and fuel tank air pipes were not fitted with adequate closing arrangements. *[Safety Issue]*

4. The vessel was unable to transmit an AUSREP deviation report after the change of course to Jervis Bay during the afternoon of 4 June due to the fact that the generator was not operational and therefore the computer used to compile messages for the satellite communication system was not functioning. *[Safety Issue]*

3.4 Other key findings

1. The master and crew took the appropriate actions to right the vessel and quickly halt the flow of water into the saloon after the vessel was knocked down.

4 SAFETY ACTIONS

4.1 Safety actions taken by the Windeward Bound Trust

While *Windeward Bound* was berthed at Jervis Bay after the incident the master implemented several changes to the vessel's standing orders. These included instructions that:

- The vessel must be turned downwind before the onset of any squall or heavy wind.
- The officer of the watch is to act on his/her own initiative and order the reduction or removal of sail without reference to the commanding officer. Hands as required are to be called on deck for this process.
- The officer of the watch is to take the wheel as soon as any danger is imminent and the watch leader and all available hands are to go where required to attend to the sails.
- In the event of a potential blow from astern, the mainsail, if set, is to be the first sail struck.
- All high aspect sails (t'gallant, course, upper tops'l) and fore and aft sails are to be struck next.
- Yards are to be braced square to facilitate downwind running as soon as is possible.
- When under way at night, all watertight doors and hatches are to be closed and properly dogged regardless of weather conditions, except the main accommodation hatch and the watertight door to the commanding officer's cabin. The main accommodation escape hatch is to be closed at night at all times and, by day, is only to be opened with the permission of the master or the mate.
- While heavy weather is imminent or present, no personnel are to undertake work either in the engine room or confined spaces unless an emergency exists.
- When heavy weather is forecast or expected, storm covers are to be fitted to the after skylights.
- When tacking or wearing has taken place, ensure that the fuel tanks on the weather side are the open ones and that all fuel tanks on the lee side are closed and secured.

4.2 Safety actions taken by Marine and Safety Tasmania

After this incident Marine and Safety Tasmania (MAST) reviewed the stability information for *Windeward Bound*. The lightship displacement was found to have changed by more than 2 per cent since initial measurement and therefore the vessel was re-inclined. The vessel's Class 2B certificate was withdrawn pending results of the revised stability data.

In response MAST stated:

> Marine and Safety Tasmania (MAST) had considered a number of alternatives for ensuring that the *Windeward Bound* complied with the requirements of the

USL Code and the current draft National Standard for Commercial Vessels dealing with stability. The option of including the deck house superstructure was adopted after discussion with the owner of the vessel and her naval architect because other alternatives would have had an adverse effect on the ability to handle sail aloft.

Marine and Safety Tasmania (MAST) has now approved the new stability book dated 23/12/2005, submitted in respect to above named vessel, by Seward Maritime.

The Uniform Shipping Laws Code, Section 8, Sub-section A.4.1.10 provides criteria for taking into account superstructures located above the superstructure deck. MAST is satisfied that *Windeward Bound*'s deckhouse location, integrity and means of closure will contribute to the vessel's stability. The KN data contained in the stability book includes the deck house superstructure. Management and operating use of the deckhouse watertight openings and storm shutters are documented within the stability book. Importantly it is also included in the ship standing orders and safety management plan. Applicable visual signage is also posted within the deckhouse.

The safety management plan is a specific Tasmanian survey requirement under the Marine and Safety (Safe Operation) Regulations 2003 and the Plan and ship standing orders are managed both through the annual survey and a separate audit process. This audit process is designed to ensure that the vessel is operated in accordance with the approved safety management plan and that the crew are well aware of their specific responsibilities and understand their importance to the safety of the ship.

4.3 ATSB recommendations

MR20070019

The vessel's engine room and accommodation ventilation arrangements did not comply with the relevant requirements with respect to their closing arrangements.

The Australian Transport Safety Bureau recommends that Marine and Safety Tasmania takes action to address this safety issue.

MR20070020

The vessel's battery locker ventilator and fuel tank air pipes were not fitted with adequate closing arrangements.

The Australian Transport Safety Bureau recommends that the owners of *Windeward Bound* takes action to address this safety issue.

MR20070021

The considerations, with respect to the vessel meeting the intact stability requirements, taken by Marine and Safety Tasmania, should have been made available to the Australian Maritime Safety Authority before the vessel was permitted to undertake an interstate voyage.

The Australian Transport Safety Bureau recommends that the Australian Maritime Safety Authority takes action to address this safety issue.

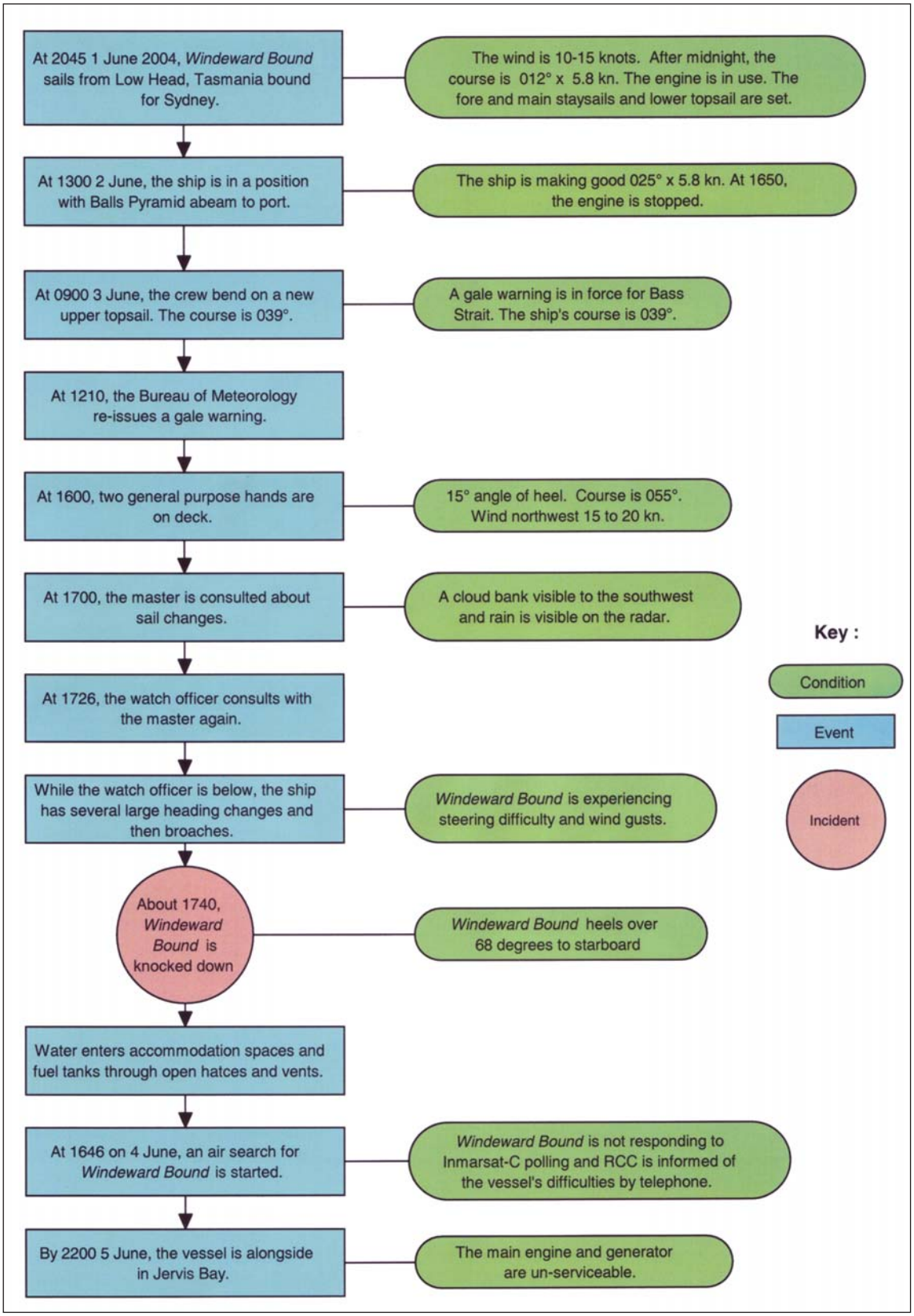
4.4 ATSB safety advisory notices

MS20070001

The vessel was unable to transmit an AUSREP deviation report after the change of course to Jervis Bay during the afternoon of 4 June due to the fact that the generator was not operational and so the computer used to compile messages for the satellite communication system was not functioning.

The Australian Transport Safety Bureau recommends that the ship owners, managers and masters should consider the implications of this safety issue and take action as appropriate.

5 APPENDIX A: EVENTS AND CONDITIONS



6 APPENDIX B: SHIP INFORMATION

6.1 *Windeward Bound*

Ship Type	Sail training vessel
Class	MAST, 1D and 2B
Flag	Australian
Builder	Brian Parry-Adams, Hobart, Tasmania
Year commissioned	1998
Owners	The Windeward Bound Trust, Hobart, Tasmania
Ship manager	Captain S Parry
Light displacement	84 tonnes
Designed WL draught	3 m
Displacement at design draft	91.7 tonnes
Length overall	33.0 m (including bowsprit)
Moulded breadth	6.00 m
Moulded depth	2.95 m
Engine	Cummins diesel
Total power	198 kW
Service speed	10 knots
Crew	10
Passengers	6

7 APPENDIX C: SOURCES AND SUBMISSIONS

7.1 Sources of information

The master and crew of *Windeward Bound*

Mr R J Herd, consultant naval architect, Hon FRINA

Mr M Seward, naval architect, Tasmania

Bureau of Meteorology

Marine and Safety Tasmania (MAST)

Australian Maritime Safety Authority (AMSA)

National Marine Safety Committee (NMSC)

7.2 References

Behaviour and Handling of Ships, Henry H Hooyer, Cornell Maritime Press,1994.

Marine Orders Part 52 'Sailing Ships', Australian Maritime Safety Authority.

Model stability information booklet for sail training ships between 15 metres and 24 metres in length, The Department of Transport, Marine Directorate, London, 1990.

The Nonlinear Dynamics of Ships in Broaching, Kostas J Spyrou, Dept of Naval Architecture and Marine Engineering, Ship Design Laboratory, National Technical University of Athens, Greece.

The Oxford Companion to 'Ships and the Sea', Oxford University Press, 1988.

Sail training vessels with particular reference to subdivision and stability, R.J. Herd and Associates, 2000.

Uniform Shipping Laws Code, Australian Transport Council, 1984.

7.3 Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the Executive Director may provide a draft report, on a confidential basis, to any person whom the Executive Director considers appropriate Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the Executive Director about the draft report.

The final draft of this report was sent to the master, two officers of the watch, the watch leader and helmsman of *Windeward Bound*. AMSA and MAST and two naval architects were also provided copies for comment.

Submissions were included and/or the text of the report was amended where appropriate.

8 APPENDIX D: MEDIA RELEASE

Sail training vessel knocked down in Bass Strait

According to the ATSB investigation, the 'knockdown' of the sail training vessel *Windeward Bound*, in Bass Strait, was the result of inadequate preparations by the ship's crew and the use of excessive rudder movements at the time that a forecast severe cold front passed over the vessel.

On 3 June 2004, *Windeward Bound* was off the Victorian coast, heading northeast at about six knots. The wind was from the northwest and the vessel was heeled between 10 and 15 degrees to starboard. The upper and lower topsails, the main and fore staysails were set. While a cold front was expected, the ship's master was unaware of the impending gale force winds repeatedly forecast.

At 1726 the helmsman was instructed to run the vessel downwind and shortly thereafter the vessel yawed to port and the helmsman put the rudder hard over to starboard. The watch leader then took the helm and, as the vessel was now swinging to starboard, applied a 'considerable amount' of port rudder. When the vessel had started to swing to port, the rudder was put hard over to starboard to arrest the swing. A gust of near-hurricane force wind then heeled the vessel about 68 degrees to starboard. The vessel was righted after several minutes using the main engine and the rudder and by letting the sheets go.

There was a minor injury to a crew member during the incident and the main engine had been damaged after being run with little or no lubricating oil pressure while the vessel was heeled.

During the next twenty four hours contact was lost with authorities ashore because of a failure of the ship's generator. An air search was initiated on the afternoon of 4 June and *Windeward Bound* was found safe and heading for Jervis Bay where it arrived late in the evening of 5 June.

The ATSB investigation found that the ship was not adequately prepared for the passage of the front and that the use of excessive rudder movements caused the vessel to slow sufficiently to broach and then be knocked down.

Significant safety action has already taken place and the ATSB has issued three safety recommendations and one safety advisory notice with the aim of preventing similar incidents.

Copies of the report can be downloaded from the ATSB's internet site at www.atsb.gov.au, or obtained from the ATSB by telephoning (02) 6274 6478 or 1800 020 616.

Independent investigation into the knockdown of the Australian sail training vessel *Windeward Bound* off Gabo Island, south-eastern Victoria
3 June 2004