



Australian Government
Australian Transport Safety Bureau



ATSB TRANSPORT SAFETY REPORT
Marine Occurrence Investigation No. 262
MO-2009-001
Final

Independent investigation into the grounding of the
Hong Kong registered products tanker

Atlantic Blue

at Kirkcaldie Reef, Torres Strait

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Abstract

At 2200 on 6 February 2009, a coastal pilot boarded the products tanker *Atlantic Blue* for its intended eastbound transit of the Torres Strait. The ship was nearly fully laden with a cargo of unleaded petrol and was bound for Townsville, Queensland.

The passage progressed normally and at 0130 on 7 February, *Atlantic Blue*'s heading was altered to 066° (T). However, no allowance was made for the 25 knot north-westerly wind abaft the port beam and the east-going tidal stream. Consequently, the ship made good a course of 070° (T) and by 0235, it was 1 mile south of the planned track.

At 0237, 0246 and 0256, the pilot made heading adjustments until the ship's heading was 059° (T). These small adjustments did not bring *Atlantic Blue* back on track as it progressed towards Kirkcaldie Reef. After 0307, as the ship closed on a shoal about 1 mile ahead, the pilot began altering the heading further to port. This course alteration was too little, too late and at 0312, *Atlantic Blue*'s bow grounded on a sandy shoal. The hull remained intact and there was no pollution. At 0700, the ship refloated on the flooding tide and was manoeuvred clear of the reef.

The investigation found that the ship grounded because its progress and position were not effectively monitored by the bridge team and inadequate action was taken to bring it back on track. Bridge resources were not managed effectively, off-track limits were not defined and the bridge team did not have a shared mental model of the passage. The report identifies safety issues in relation to the ship's passage planning procedures; the coastal pilotage check pilot regime and the coastal vessel traffic service's monitoring system. Safety actions to address all the issues have been taken or proposed by the relevant parties.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

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 identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, 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 initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

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, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, 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 in the interests of improved transport safety.

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.

Risk level: The ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

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

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

EXECUTIVE SUMMARY

At 2200¹ on 6 February 2009, a coastal pilot boarded the Hong Kong² registered products tanker *Atlantic Blue* for its intended eastbound transit of the Torres Strait. The ship was nearly fully laden with a cargo of unleaded petrol and was bound for Townsville, Queensland. The bridge team included the master, the mate on watch and two duty seamen.

The passage progressed normally and at 0130 on 7 February, *Atlantic Blue*'s heading was altered to 066° (T). No allowance was made for the 25 knot³ north-westerly wind abaft the port beam or the east-going tidal stream and the ship made good a course of 070° (T), moving away from the planned track. The second mate on watch thought that the pilot was aware of the ship's progress but the bridge team had not discussed or defined off-track limits.

At about 0230, the master left the bridge, telling the second mate that he would return in about 20 minutes after checking his emails.

By 0235, the ship was 1 mile⁴ south of the planned track and the second mate informed the pilot that it was outside the two-way route boundary. At 0237, 0246 and 0256, the pilot made small heading adjustments to port until the ship's heading was 059° (T). These small adjustments were not sufficient to bring the ship back on track as it progressed towards Kirkcaldie Reef, parallel to the planned track. The second mate thought that the pilot had the situation in control so he did not advise the master who had still not returned to the bridge.

After 0307, as *Atlantic Blue* closed on a shoal about 1 mile ahead, the pilot began altering the heading further to port. However, the course alteration was too little, too late and at 0312, the ship's bow grounded on a sandy shoal. The hull remained intact and there was no pollution. Water ballast was taken on board to prevent the ship from being pushed further onto the reef in the prevailing weather conditions.

At 0700, *Atlantic Blue* refloated on the flooding tide and was manoeuvred clear of the reef. The Australian Maritime Safety Authority (AMSA) detained the ship to assess its condition. The ship was safely anchored in the area and inspections by AMSA that evening did not detect any hull damage. The ship was permitted to continue its voyage to Townsville where an underwater hull inspection revealed that only some bow paintwork was damaged.

The investigation found that the ship had grounded because its progress and position were not effectively monitored by the bridge team and inadequate action was taken to bring it back on track. Bridge resource management was not used effectively, off-track limits were not defined and the bridge team did not have a shared mental model of the passage.

This report identifies safety issues in relation to: the shipboard safety management system procedures for passage planning; the assessment and audit system to check

¹ All times referred to in this report are local time, Coordinated Universal Time (UTC) + 10 hours.

² The Hong Kong Special Administrative Region (SAR), People's Republic of China.

³ One knot, or one nautical mile per hour, equals 1.852 kilometres per hour.

⁴ A nautical mile of 1852 m.

how coastal pilots carry out pilotages; and the traffic monitoring system of the coastal vessel traffic service. Safety actions to address all the issues have been taken or proposed by the relevant parties.

As a result of this investigation and further information that came to hand during it, the ATSB has decided to undertake a broader, systemic, safety issue investigation into Queensland's coastal pilotage operations, the outcome of which will be published in a separate safety report.

1 FACTUAL INFORMATION

1.1 *Atlantic Blue*

Atlantic Blue (Figure 1) is a tanker designed for carrying oil products or chemicals. At the time of the incident, the ship was owned by Heroic Hestia, Liberia and managed by Fleet Management, Hong Kong⁵. It was registered in Hong Kong and classed with the Korean Register of Shipping (KR).

The ship was built in 2007 by Hyundai Mipo Dockyard, Ulsan, Korea. It has an overall length of 183.21 m, a moulded breadth of 32.20 m and a depth of 18.80 m. At its summer draught of 12.216 m, the ship has a deadweight of 47,128 tonnes.

Figure 1: *Atlantic Blue*



Atlantic Blue is of double hull construction and has a total of 14 cargo tanks, including two slop tanks. All of the cargo tanks are located forward of the accommodation superstructure, seven on either side of the ship's centreline. The ship has a cargo carrying capacity of 51,897 m³ when the cargo tanks are filled to 98 per cent by volume. On either side of and under the cargo tanks, occupying the space between the inner and outer hulls, are segregated water ballast tanks, six on each side. The fore and the after peak tanks are also used for water ballast.

Propulsive power is provided by a single MAN B&W 6S50MC-C two stroke, single acting diesel engine that develops 9,480 kW at 127 rpm. The main engine drives a single, fixed-pitch propeller, which gives the ship a service speed of 14.5 knots⁶.

Atlantic Blue's navigation bridge is equipped with navigational equipment consistent with SOLAS⁷ requirements. The equipment includes two Furuno FAR series radars, both equipped with automatic radar plotting aids (ARPA) and global positioning system (GPS) input. A Furuno FM-8800D/S VHF radio and the main engine controls are situated in the middle of a centrally located main control console in the forward part of the bridge. The X-band radar is mounted on the port side of the console with a small chart table fitted outboard of the radar. The control

⁵ The Hong Kong Special Administrative Region (SAR), People's Republic of China.

⁶ One knot, or one nautical mile per hour, equals 1.852 kilometres per hour.

⁷ The International Convention for the Safety of Life at Sea, 1974, as amended.

panel for the Samsung SVDR-3000 voyage data recorder (VDR) is located on the starboard side of the console, outboard of the S-band radar. Situated immediately aft of the main console, along the ship's centreline, is the Tokimec TG-8000 gyro compass and steering stand.

The main chart table and a global maritime distress and safety system (GMDSS) communications station are located in the aft part of the bridge which is curtained off at night. The equipment mounted on the chart table includes two Furuno GP-150 GPS units, a Furuno FA-150 automatic identification system (AIS) unit and a Furuno FE-700 echo sounder. The GMDSS station includes a second identical VHF radio and a satellite communications (Inmarsat-C) terminal. Other bridge equipment includes a doppler speed log and a course recorder.

At the time of the incident, *Atlantic Blue* was on a single voyage charter to BP Australia. The ship's crew of 22 Indian nationals held appropriate qualifications and the necessary endorsements to sail on the Hong Kong registered tanker.

The master began his seagoing career as a cadet in 1996 after pre-sea training. He had sailed mainly on tankers, many of similar size and type as *Atlantic Blue*. In 2004, he obtained his Indian master's qualifications and in 2007, gained command. From 2008, between assignments at sea, he worked as a superintendent conducting ship audits, inspections and training. He had joined *Atlantic Blue* about a week before the grounding for his first assignment with the ship's managers. This was his fourth ship as a master and he had previously transited the Torres Strait.

The second mate, on watch at the time of the grounding, began his seagoing career with *Atlantic Blue*'s managers as a cadet in 2003 after a 3½ month pre-sea training course. In 2005, after obtaining his Indian second mate's qualifications, he began sailing as a third mate. In mid-2008, he was promoted to second mate. *Atlantic Blue* was his second ship as a second mate and the third tanker he had sailed on. He had been on board the ship for 2 months and this was his first transit of the Torres Strait.

1.2 The Torres Strait

The Torres Strait (Figure 2) lies to the north of Cape York, Queensland, and separates the Australian mainland from Papua New Guinea (PNG). The strait is an important waterway, linking the Arafura and Coral Seas. It extends about 150 miles⁸ in an east-west direction and, at its narrowest point, is about 90 miles wide.

The Torres Strait lies within the exclusive economic zones of Australia and PNG and includes some areas of the territorial sea and internal waters of both countries. The waters of the strait are shallow and strewn with small islets, reefs, shoals and several clusters of islands, collectively known as the Torres Strait Islands. There are more than 100 islands which are considered Australian territory.

The Torres Strait's unique positioning significantly influences its natural conditions. The diurnal tides (one high and low water per day) of the Indian Ocean and the semi-diurnal tides (two high and low waters per day) of the Pacific Ocean create marked differences in water level. Spring tides⁹ on one side can coincide

⁸ A nautical mile of 1852 m.

⁹ Spring tides produce the highest high waters and lowest low waters (greatest tidal range), whereas neap tides produce the lowest high waters and highest low waters (smallest tidal range).

with neap tides on the other and high water on one side with a low water on the other, resulting in tidal streams of up to 8 knots. Contrasting or similar tidal states on different sides of the strait, depending on the moon phase, result in significant variations in the direction and speed of the tidal streams in the area.

Figure 2: The Torres Strait



Tidal streams and currents in the Torres Strait are also affected by the prevailing winds, the size of the passages between islands and reefs and the underwater terrain. Water depths in the strait are generally no more than 13 m and much less in many areas. Sandwaves, a feature of the area, can reduce depths further. During summer, from December to February, the predominant wind is north-westerly. Heavy rain squalls are more common in summer months and can severely reduce visibility.

The Torres Strait's natural conditions can make navigation challenging. Each year, about 3,000 strait transits are made by ships of 50 m or more in length. Large ships can safely use only the shipping routes through the Prince of Wales Channel (PoWC) and the Great North East Channel (GNEC), which are just a few hundred metres wide in places. Deep draught ships utilise higher tides and/or reduce speed to achieve a safe under keel clearance. A draught of more than 9 m is generally considered deep and the recommended maximum draught is 12.2 m.

Many attributes of the Torres Strait are similar to those of the Great Barrier Reef (GBR), which extends south from the strait's southeast part. Essentially, they are part of the same region. As the world's largest coral reef ecosystem, the GBR has long been recognised as an environmentally sensitive area and since 1975, measures to protect the area have been progressively implemented. In 1990, when the World Heritage listed GBR was declared a particularly sensitive sea area (PSSA)¹⁰, its northern limit extended only as far as Cape York and excluded the Torres Strait.

In 2003, the governments of Australia and PNG made a submission¹¹ to the International Maritime Organization (IMO) to extend the GBR PSSA to include the Torres Strait. Two protective measures associated with ship routing and pilotage were also proposed for the area. With regard to pilotage, it was submitted that 'the carriage of a properly qualified, skilled person with local knowledge as a pilot considerably reduces the risk of a shipping incident throughout Torres Strait'¹².

In July 2005, the IMO extended¹³ the GBR PSSA to include the Torres Strait and approved both of the proposed protective measures. A new two-way shipping route was established in the GNEC and, in October 2006, the existing system of compulsory coastal pilotage in parts of the GBR was extended to include routes in the strait between Booby Island in the west and Dalrymple Island in the east.

1.2.1 Compulsory coastal pilotage

Since 1991, coastal pilotage has been compulsory for all ships of 70 m or more in length and all types of loaded tankers, irrespective of size, when transiting certain defined areas in the GBR. The Australian Maritime Safety Authority (AMSA) has the responsibility for regulating coastal pilotage. To carry out this function, AMSA

¹⁰ An area of the marine environment that needs special protection through action by the International Maritime Organization because of its significance for recognised ecological, socio-economic or scientific attributes where such attributes may be vulnerable to damage by international shipping activities.

¹¹ IMO, Marine Environment Protection Committee-49th session-Agenda item 8 (MEPC 49/8), *Extension of the Existing Great Barrier Reef PSSA to include the Torres Strait Region*, 2003.

¹² *ibid.* p.18, 5.11.

¹³ IMO, Resolution MEPC.133(53), *Designation of the Torres Strait as an extension of the Great Barrier Reef PSSA*, 2005.

has implemented marine orders (legislated regulations) for coastal pilotage¹⁴ which were revised following the inclusion of the Torres Strait in the GBR PSSA and re-issued in 2006.

Provisions in the coastal pilotage marine orders include pilot licensing, the manner in which they carry out their duties and the operations of pilotage providers. These marine orders incorporate a safety management code 'to facilitate the effective, efficient and safe management of pilotage services'. The code includes a system to maintain and continuously improve pilotage procedures, under which all pilots are regularly assessed, in each pilotage area for which they are licensed, by a check pilot¹⁵.

Due to the nature of coastal pilotage with long voyages and the type of work, pilot fatigue is recognised as a significant issue. A fatigue management plan¹⁶ has been agreed with pilots and pilotage providers. The plan specifies minimum mandatory rest periods for pilots between pilotages, between time and voyage based tours of duty and between consecutive work periods without defined leave breaks.

Pilotage services in the Torres Strait are provided by two private companies and there are about 60 pilots licensed for routes within the strait. Each pilotage provider company manages the logistics of providing services with an approximately equal number of pilots. The companies have different structures but neither employs the pilots. In most cases, they act as the agents and managers of individual pilots. Pilot transfers in the strait are done by pilot boats and each company has its own boats.

Pilots usually board eastbound ships transiting the Torres Strait off Booby Island and disembark off Dalrymple Island, where westbound ships embark a pilot (Figure 2). The distance between these pilot boarding grounds, along the shipping routes, is about 125 miles. The transit time, excluding periods a deep draught ship might wait for tide, is usually between 7 and 10 hours. The minimum mandatory rest period for pilots undertaking successive pilotages in this area, excluding travel time, is 12 consecutive hours.

Atlantic Blue's coastal pilot at the time of the incident began piloting in the GBR in 2001, following a 30 year seagoing career. After more than a year as a trainee or piloting with a licence restricted by ship type or draught, he obtained an unrestricted licence for the three commonly used coastal pilotage areas; the GNEC, the Inner Route and the Hydrographers Passage to the south (Figures 2 and 3). In February 2008, he also obtained a check pilot's licence. In addition to attending prescribed professional development courses every 4 years, the pilot maintained the validity of his Australian master's qualifications, which he first obtained in 1988. His seagoing experience included 18 years as a mate or master on different types of ships in Australia and overseas.

¹⁴ AMSA, *Marine Orders Part 54, Coastal Pilotage*.

¹⁵ Experienced pilots who are licensed by AMSA to perform check pilot functions.

¹⁶ *Queensland Coastal Pilotage Fatigue Management Plan*, Version 1.0, March 2007.

1.2.2 Coastal vessel traffic service

The Great Barrier Reef and Torres Strait Vessel Traffic Service (REEFVTS) is a coastal VTS¹⁷ jointly operated by AMSA and Maritime Safety Queensland (MSQ). Each agency is responsible for different operational functions of the service. Its declared objectives are to enhance navigational safety in the area by interacting with shipping, to minimise the risk of a ship related incident, environmental damage and pollution and to provide the ability for a quicker response to an incident.

The two major components of REEFVTS are a ship reporting system, REEFREP¹⁸, and monitoring and surveillance systems, including AIS, radar, automated position reporting via Inmarsat-C polling and VHF radio reports. These systems and various databases are integrated into a traffic information module (TIM). The TIM display uses electronic navigational charts (ENCs) and ship position and track information is displayed using data from AIS, radar or Inmarsat-C polling. This makes real or near real time monitoring possible and automated alarms are used to monitor ships in the large area covered by REEFVTS (Figure 3).

At the time of the incident, the service's operational centre, REEFCENTRE, was located at Hay Point near Mackay. The centre was also used by Hay Point VTS for local vessel traffic. To enhance coordination and communication, the centre is electronically linked to the AMSA-operated Australian Rescue Coordination Centre (RCC) in Canberra.

The REEFCENTRE operates 24 hours a day and is manned by MSQ personnel. All REEFVTS officers (VTSOs) have completed at least the minimum international competency standard of Certificate III-VTS operations. Two VTSOs are on duty at all times, one attending to REEFVTS and the other to Hay Point VTS operations.

The services provided by REEFVTS to shipping include navigational assistance (information to assist shipboard decision making), ship traffic information (STI) and maritime safety information (MSI). The STI consists of TIM-generated ship encounter predictions which include ship's names and encounter times for the next 6 hours and any changes to earlier predictions. The MSI includes navigational warnings and information. Ships receive STI and MSI when entering the area and then at least every 5 hours, normally via Inmarsat-C.

Navigational assistance is usually provided via VHF radio. Ships are required to keep a listening watch on the appropriate REEFVTS VHF channel (channel 19 in the Torres Strait) and channel 16. Reports when a ship enters or exits the area and when a pilot boards or disembarks a ship are also made via VHF radio. Documented safe operating procedures describe how VTSOs should communicate with ships.

The duty VTSO attending to REEFVTS duties at the time of the incident had a background navigating small vessels in Queensland and New Zealand. He had then worked as a ships' agent in Mackay and Hay Point before joining MSQ. In addition to obtaining his Certificate III-VTS operations, he had maintained his small vessel

¹⁷ IMO Resolution A.857 (20) defines a VTS as a service implemented by a Competent Authority, designed to improve the safety of vessel traffic and to protect the environment. The service should have the capability to interact with the traffic and respond to traffic situations in the VTS area.

¹⁸ The Great Barrier Reef and Torres Strait Ship Reporting System (REEFREP) is a mandatory ship reporting system applicable to all ships 50 m or more in length, all types and sizes of tankers and other ships that present a higher risk, which are defined in the system's regulations.

marine qualifications and held a GMDSS general operator's certificate. He had worked at REEFCENTRE for 16 months.

Figure 3: Area covered by REEFVTS at the time of the incident



1.3 The incident

On 30 January 2009, *Atlantic Blue* sailed from Singapore bound for Australia after loading a cargo of about 35,000 tonnes of unleaded petrol. All the cargo tanks, except the two small slop tanks which had not been loaded, were nearly full. The ship was on an even keel with a draught of 10.40 m. Its intended destination, after passing to the west and south of Australia en route, was Melbourne, Victoria.

On 31 January, the ship's destination was changed to Brisbane, Queensland. The change meant that the ship would need to pass to the north of Australia and transit the Torres Strait before sailing to Brisbane via the GBR Outer Route, a requirement of the charterer, BP Australia (BP), for laden tankers. The unexpected change of destination also meant that two navigational charts, necessary for the Torres Strait transit, would need to be supplied with the coastal pilot.

Atlantic Blue's estimated time of arrival (ETA) at Booby Island pilot boarding ground was 2200¹⁹ on 6 February. Its maximum intended draught for the Torres Strait transit was 10.30 m. With this ETA, draught and the tidal predictions, water depths during the transit would allow the ship to maintain more than the required minimum 1 m static under keel clearance.

The master, however, had concerns about the under keel clearance available to the ship at its berth in Brisbane and exchanged a number of communications with BP. Although advice from the port did not indicate a problem, BP decided to address the master's concerns by arranging for the ship to first discharge part of its cargo in Townsville, Queensland, thus reducing its arrival draught for Brisbane.

At 1730 on 6 February, the master was advised of the change of the destination to Townsville. He then tried, unsuccessfully, to have charts for the approaches to Townsville included with the charts being supplied with the coastal pilot.

At 2000, the coastal pilot left Thursday Island in a pilot boat to board *Atlantic Blue*. The pilot had spent a little over 21 hours on the island after a westbound GNEC pilotage. By 2130, the ship's ETA and pilot boarding requirements had been confirmed with the master. The north-westerly wind was about 15 knots with moderate seas of up to 1.5 m. The sky was partly cloudy and visibility was good.

At 2200, the pilot boarded *Atlantic Blue* off Booby Island (Figure 4). On the bridge, he met the master and checked necessary information, including the ship's draught, expected speed, cargo and readiness of its navigational equipment and machinery. The third mate was on watch and two seamen were on duty, one manually steering the ship and the other posted as a lookout. The second mate, responsible for passage plan preparation, was also on the bridge and began marking the planned courses on the large scale chart that the pilot had brought so that it could be used immediately.

The pilot contacted REEFVTS using the aft VHF radio on channel 19 and reported *Atlantic Blue*'s draught, transit speed, cargo, intended route and other necessary information. He did not report any ship defects and was provided with details of two westbound ship encounters that were expected during the next few hours. The aft VHF radio was left on channel 19 and the forward one on channel 16.

By 2208, the pilot had taken over the conduct of the ship. He gave the helmsman a heading to steer and asked for the main engine rpm to be increased to its full manoeuvring speed of about 12 knots. He then completed exchanging information with the master and provided details of his passage plan. Documents in the pilot's plan included a route plan, under keel clearance calculations, tidal information and voyage notes for the master and mates.

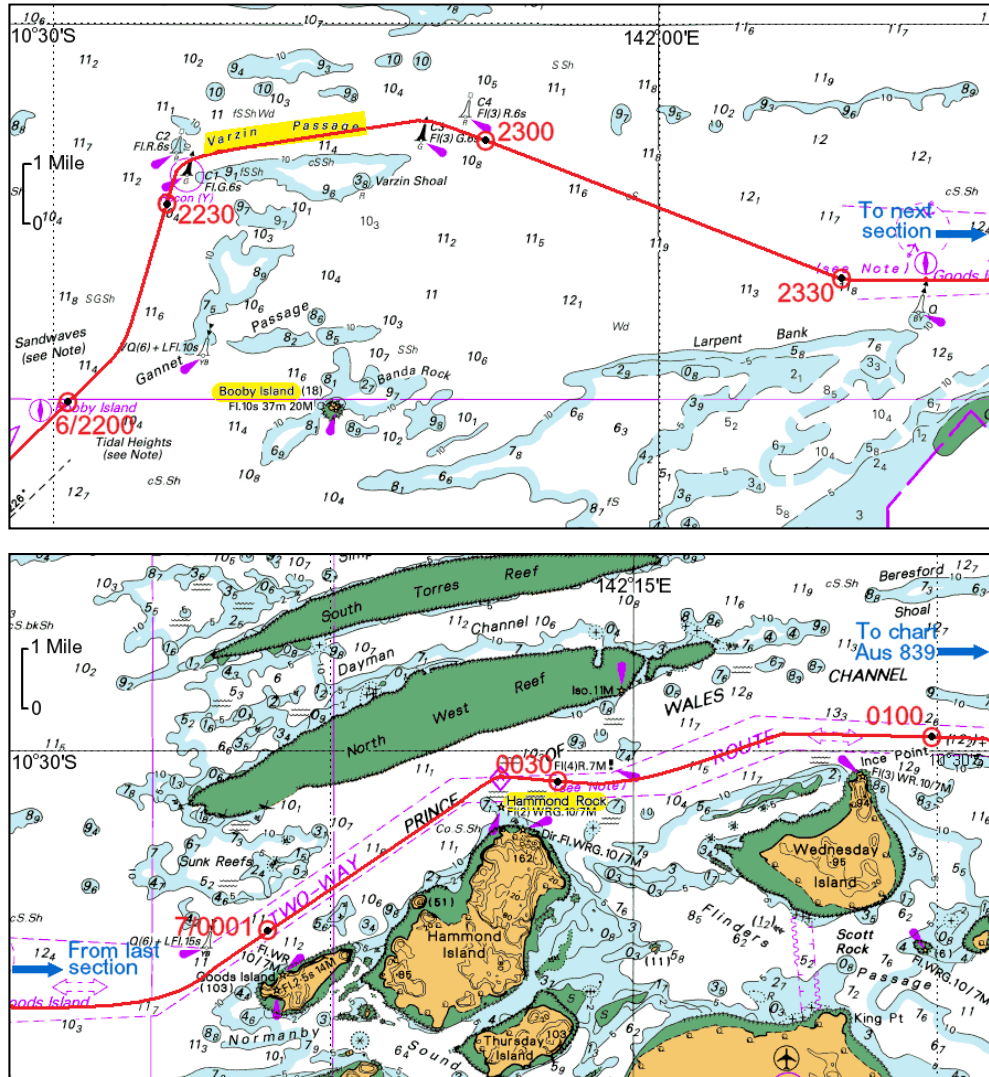
The pilot discussed his passage plan with the master who agreed to use the route suggested by the pilot, who expected the 123 mile transit to take 9½ hours. The master told the second mate that they would follow the pilot's plan. The second mate found that the pilot's plan was similar to the ship's passage plan but noted that the pilot intended to use of the western, instead of the eastern, two-way route in the GNEC (Figure 2).

The pilot used visual cues and the starboard radar for piloting. The third mate plotted *Atlantic Blue*'s position on the chart at 5 minute intervals using visual

¹⁹ All times referred to in this report are local time, Coordinated Universal Time (UTC) + 10 hours.

bearings, radar and, from to time, cross checked with the GPS. The helmsman and the lookout exchanged roles periodically.

Figure 4: Sections of navigational chart Aus 700 showing *Atlantic Blue's* track (AIS/GPS data recorded by REEFVTS) between about 2200 on 6 February and about 0100 on 7 February



Shortly after 2300, the master left the bridge to check his email messages. It was a Friday and he wanted to respond to any urgent messages before offices ashore closed for the weekend. He returned to the bridge at about 2330 just before passing the first expected westbound ship.

At 2355, the ship entered the PoWC and its speed²⁰ was 11 knots in the opposing south-westerly tidal stream of about 1 knot. By midnight, the routine change of watch for the duty seamen was completed. The second mate finished making changes to the passage plan to follow the western two-way route in the GNEC, then arranged to relieve the third mate after an hour and left the bridge to rest.

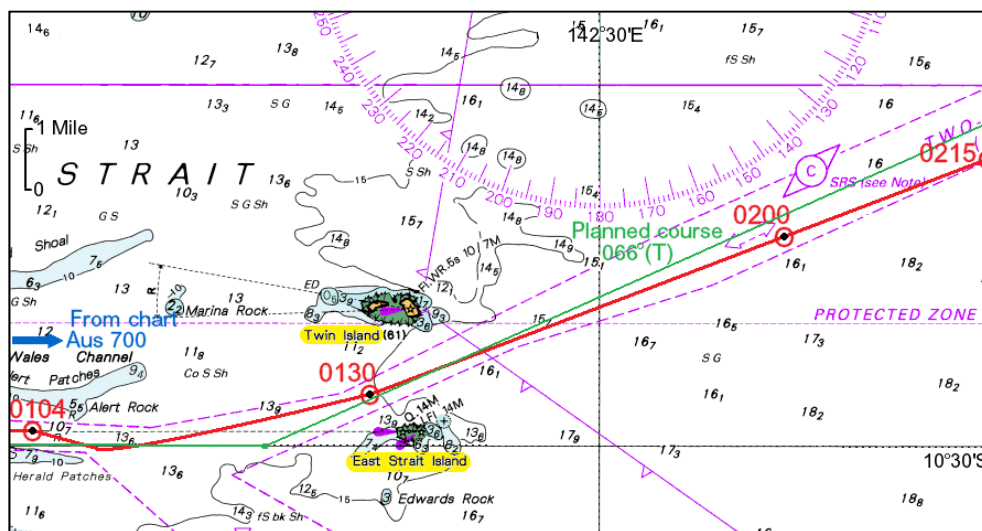
At about 0100 on 7 February, the REEFVTS duty VTSO noted that *Atlantic Blue* had nearly exited the PoWC. The ship's position was being automatically polled via

²⁰ All speeds referred to in this report are 'made good/over the ground'.

Inmarsat-C and he expected the next VHF communication with it would be at about 0730 before the pilot disembarked.

At 0104, the ship's heading²¹ was 090° when the pilot ordered 105° to pass between two charted buoys near the eastern entrance of the PoWC. The third mate was handing over the watch to the second mate who had just returned to the bridge. The East Strait Island leading lights right ahead indicated the ship was on the 090° (T) leading line but north of the charted 090° (T) course-line (green line in Figure 5). Both the mates challenged the pilot's heading order and he explained that the 105° course was as per his passage plan. The 105° (T) course-line was then marked on the chart indicating how the ship was passing to the north of a submerged rock and between the buoys (shown on the large scale chart Aus 293 being used). The master and the mates acknowledged their understanding of the course alteration and the pilot's response.

Figure 5: Section of navigational chart Aus 839 with *Atlantic Blue's* track between about 0100 and 0215 on 7 February



Shortly after 0110, *Atlantic Blue's* heading was altered to 078°, towards the GNEC. The north-westerly wind, which had earlier dropped to a gentle breeze in the PoWC, had strengthened to 20 knots. The tide was now ebbing and, with the stream setting in an easterly direction, the ship's speed had increased to 13 knots.

With the ship in deeper, more open waters, the pilot asked for the auto-pilot to be engaged and the main engine rpm to be increased to sea speed. The heading could not be steadied in auto-pilot so hand steering was continued²². The limited under keel clearance resulted in excessive load on the engine, preventing an increase to its usual sea speed of 123 rpm, so it was set at 110 rpm to avoid excessive vibrations.

At 0130, *Atlantic Blue's* heading was altered to 066° to follow the charted 066° (T) course-line in the two-way route towards Kirkcaldie Reef. The ship was about 1 mile south of Twin Island, close to the charted course-line, i.e. the planned track. Its speed was now 14.1 knots, about 1 knot more than the speed that could be expected without the favourable tidal stream and wind.

²¹ All ship's headings in the report are in degrees by gyro compass with negligible error.

²² Some auto-pilots are not able to maintain a sufficiently steady course when water depths are less than twice the ship's draught because larger rudder angles are necessary in shallower water.

During the ship's intended GNEC transit, the tide would be ebbing until about 0400. Tidal stream predictions along the planned route were based on high water at Twin Island, predicted to occur at 2245 on 6 February with a low water expected about 6 hours later, at 0439 on 7 February. The tidal levels were approaching those predicted for the next spring tides in a couple of days.

Tidal stream information in the pilot's passage plan indicated that the rate of the east-going stream would increase on the passage leg towards Kirkcaldie Reef. The plan indicated that by about 0300, the stream would be setting in an approximately 105° (T) direction at about 0.8 knots in a position 3 miles west-northwest of the reef. The pilot also told the master about seasonal variations to tidal streams in the months of January and February due to the inflow of water into the sea after heavy rainfall in the area to the north which is common during summer.

By 0135, *Atlantic Blue* had cleared East Strait and Twin Islands. The pilot intended to sit in the pilot chair and before doing so, he marked the chart where he was to be called, as per his notes for the crew, in case he inadvertently dozed off. He marked a long line with the notation PCP (please call pilot) next to it across the charted course-line about 2.8 miles west of Kirkcaldie Reef as shown (Figure 6).

Atlantic Blue was expected to arrive at the PCP line in about 1½ hours and the pilot sat in the pilot chair on the port side of the bridge to have his second mug of coffee that night.

The master remained on the bridge and continued conversing with the pilot who was aware that the ship did not have charts for approaching Townsville. The pilot advised the master that later on he would provide electronic copies of the relevant charts from his electronic charting system (ECS) and GPS-equipped laptop computer which he was not using for piloting.

By 0200, *Atlantic Blue*'s speed had increased to 14.4 knots. On the 066° heading since the course alteration, the ship had made good a course of 070° (T) and was now about 3 cables²³ south of the planned track. The second mate was plotting the ship's position on the chart at 5 minute intervals using the port radar next to the small chart table where the chart was placed. From time to time, the pilot left the pilot chair to check the starboard radar display and the heading being steered by the helmsman. He saw that the second mate was plotting positions with the chart table light dimmed but did not look at the chart to check what those positions were indicating.

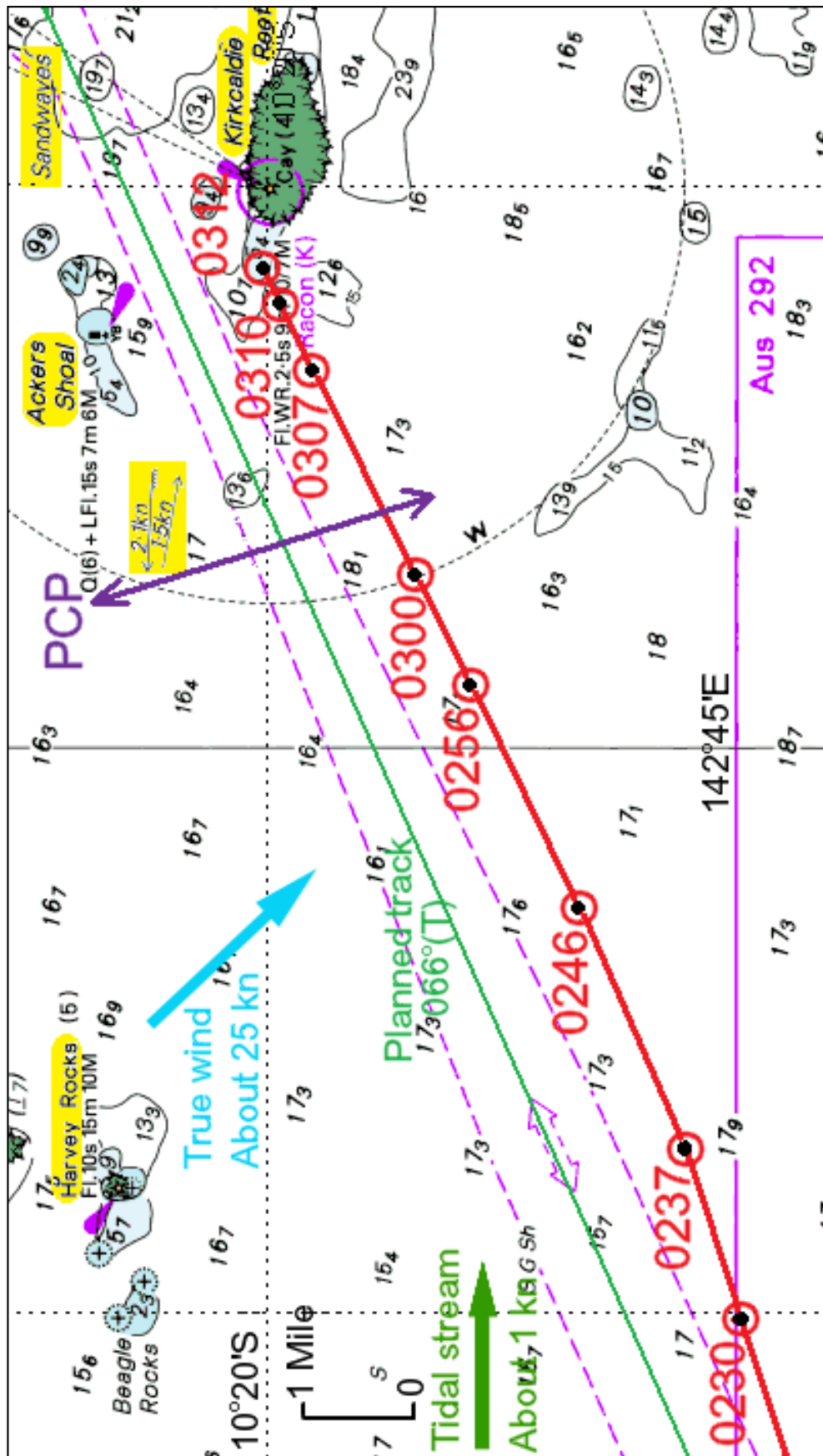
At some time during this stage of the passage, the pilot started his laptop computer and copied the screen displays of the electronic charts covering the approaches to Townsville onto the master's USB flash drive.

Atlantic Blue continued to make good 070° (T) at about 14.5 knots. The ship's recorded GPS data indicates that at 0215, it was at the southern boundary of the two-way route, about 6 cables south of the planned track (Figure 5). The position plotted on the chart using Kirkcaldie Reef light and racon²⁴, however, indicated that the ship was about 2 cables south of the planned track.

²³ One cable equals one tenth of a nautical mile or 185.2 m.

²⁴ A radar beacon fitted to a navigational mark or charted feature to make it conspicuous. When triggered by an incoming radar pulse, it transmits a coded signal on the same frequency.

Figure 6: *Atlantic Blue's* track in the period immediately before grounding



At about 0230, the master again left the bridge telling the second mate that he would return in about 20 minutes after checking his emails. There was no traffic nearby and the westbound *MSC Antwerp* was expected to pass in about 1 hour.

Atlantic Blue's 0235 position, as plotted on the chart using radar, indicated the ship was outside and south of the two-way route. To confirm this, the second mate plotted a GPS position which placed the ship even further south, about 1 mile to starboard of the planned track. He advised the pilot the ship was south of the track and outside the two-way route (Figure 6). The pilot checked the parallel index²⁵ (PI) he had set up on the starboard radar using Harvey Rocks and at 0237, ordered a heading of 062°.

On its 062° heading, the ship made good 067° (T). The north-westerly wind had increased to about 25 knots and the ship's speed was 14.5 knots. At 0246, the pilot ordered a heading of 060° and at 0256, he ordered 059°.

Atlantic Blue was now making good 065° (T) at 14.7 knots, almost parallel to, and nearly 1 mile to starboard of, the planned track. The second mate continued fixing positions every 5 minutes and after the 0300 fix, noted the ship was near the PCP line which he had also electronically marked on the port radar. He informed the pilot the ship was at the PCP line and the pilot acknowledged the information.

With the ship approaching Ackers Shoal and Kirkcaldie Reef, the pilot reduced the starboard radar's display range to 6 miles. He set up a PI to pass 6.5 cables from Ackers Shoal beacon and noted the ship was well south of the planned track. The second mate heard the pilot order a heading of 050° and thought that the pilot had started altering towards the next charted course-line of 040° (T). It was just after 0307 and as the ship's head swung to port, the helmsman applied starboard helm to steady the ship. The pilot ordered 'nothing to starboard'. By 0310, the heading was 055° and, again, turning to port.

At this time, the VTSO at REEFCENTRE was communicating on the VHF radio with a ship exiting the REEFREP area at its southern limit. At 0310, the TIM generated a 'shallow water alert'²⁶. The VTSO acknowledged the alarm and saw that *Atlantic Blue* had triggered the alert. The TIM display showed the ship closing on the 5.4 m shoal about 3 cables (550 m) directly ahead of it. At 0310½, the VTSO began calling *Atlantic Blue* on VHF channel 19, the REEFVTS working channel.

As *Atlantic Blue*'s bow closed on the shallow water, the ship's rate of turn to port increased²⁷. At 0311, when the bow entered the 10 m depth contour its heading was 048° and swinging more rapidly to port with the 5.4 m shoal ahead.

By this stage, the VTSO had made two unsuccessful attempts to contact *Atlantic Blue* on channel 19. He decided to try channel 16 instead and began calling the ship.

At 0312, *Atlantic Blue*'s heading was 040° and still swinging to port as the bow grounded. The ship's GPS position was 10°20.0'S 142°49.2'E and its speed rapidly decreased. The sea-bed in the general area consists of sand and shells and there

²⁵ Parallel indexing is a real-time radar monitoring technique used to verify that the vessel is maintaining its intended track and will therefore pass a radar mark at a predetermined range.

²⁶ An audio-visual alarm that is triggered when a ship enters a TIM-defined area of shallow water.

²⁷ A moving ship's bow has a tendency to be repelled by a nearby shoal or bank as a result of interaction between the shallow area and the positive pressure zone around the bow.

were no sounds or vibrations. In less than half a minute, the ship stopped and the main engine rpm reduced. The second mate saw the speed displayed by the GPS was less than a knot and the engine rpm was 85. He called the master.

Just as the ship was grounding, the VTSO called the ship on channel 16 twice and again received no response. At 0313, he called *MSC Antwerp*, which was approaching Kirkcaldie Reef from the north. The VTSO briefly explained the situation to its pilot, who agreed to assist. *MSC Antwerp*'s pilot immediately called *Atlantic Blue*'s pilot on the VHF radio and asked him to contact REEFVTS.

Soon after *Atlantic Blue*'s master arrived on the bridge, he noted the ship's speed and main engine rpm and saw the telegraph was at full ahead. He called the engine room to ask if there was a problem and the engineer said that he did not know and asked for the rpm to be reduced. The master saw the GPS position was almost constant and the speed was nearly zero. The echo sounder display was alternating between 3.5 m and 7 m below the aft transducer. The master then noticed that Kirkcaldie Reef light was in the same relative position as when he had arrived on the bridge. Its flashing light appeared very close and he thought that the ship was probably aground.

At 0315, *Atlantic Blue*'s pilot called REEFVTS on channel 19 using the forward VHF radio. The VTSO advised him that AIS indicated the ship was 'amongst the reef' and asked if everything was alright. The pilot replied that the ship was 'just above it' but did not indicate any problems. These communications confirmed to the master that the ship was aground and he stopped the main engine.

The VTSO again called *MSC Antwerp*'s pilot to confirm the situation at Kirkcaldie Reef. At 0320, *MSC Antwerp*'s pilot confirmed that his ship's AIS and radar indicated that *Atlantic Blue* was stationary in the shallow water near the reef.

After 0322, the VTSO had a number of conversations with *Atlantic Blue*'s pilot but the pilot did not confirm the grounding. The VTSO then informed REEFVTS managers at AMSA and MSQ that the ship may have grounded.

At 0331, after a couple of brief attempts to refloat *Atlantic Blue* by running the main engine half astern, the pilot informed REEFVTS that the ship was aground. He requested that AMSA and Torres Pilots, his pilotage provider company, be informed of the incident. He also advised that checks overside with the ship's deck lights on did not indicate any oil pollution in the water.

At 0332, the master mustered the crew and ordered water depths around the ship to be checked and tanks to be sounded to check for damage. He then started making notifications to the ship's managers, AMSA and others.

At 0333, the VTSO confirmed *Atlantic Blue*'s grounding to AMSA. He also advised that AMSA's emergency towing vessel, *Pacific Responder*, was approximately 20 miles south of Kirkcaldie Reef. *Pacific Responder* was directed by AMSA to proceed to *Atlantic Blue*'s location, where it was expected at 0700. The VTSO remained in contact with the pilot to obtain more information, including the type and quantity of cargo on board, and updates of the ship's situation.

At about 0345, *MSC Antwerp* safely passed the grounded *Atlantic Blue*.

By 0400, water depths around *Atlantic Blue* had been checked. The minimum depth was 8.8 m off the starboard bow with depths of more than 14 m midships and aft. The ship's draught was 10.3 m and only its forefoot (the underside of the bow)

appeared aground. Cargo tank levels were unchanged and ballast tank soundings revealed no water or cargo ingress, indicating that the double hull was intact.

Atlantic Blue's heading had settled on 025° with the strong wind and waves nearly on the port beam. The predicted low water at Poll Island, about 4 miles north of the ship, had been at 0345 and a high water of 3.8 m was expected at 1031. The master was concerned that the ship might be pushed sideways on to Kirkcaldie Reef on the rising tide. To avoid this and reduce the forward draught to assist in refloating, he ordered that number six wing water ballast tanks be filled.

At 0405, the master put the main engine full astern in an attempt to refloat *Atlantic Blue*. The attempt was unsuccessful and the engine was stopped after 10 minutes. When another similar attempt from 0428 to 0438 failed, the master and the pilot agreed to wait for a further rise in the height of tide.

At 0620, a further attempt to refloat the ship was also unsuccessful. The predicted height of tide at Poll Island was 1.5 m and expected to rise to 2 m by 0700 and to 2.8 m by 0800. A few minutes later, the master felt the ship move and noted a slight change of heading. He advised the pilot that he intended to make another attempt.

At 0652, the main engine was started astern and as the rpm built up to full astern, *Atlantic Blue* developed sternway. At 0700, the ship was afloat and manoeuvred astern to clear the reef. The master informed AMSA that the ship had been refloated and was advised that it was now detained and had to be safely anchored in the area to wait for inspections by AMSA and KR (its classification society) surveyors. *Pacific Responder* had arrived in the area and stood by. Torres Pilots, in consultation with AMSA, had dispatched another pilot from Thursday Island to relieve the pilot on the ship.

At 0818, *Atlantic Blue*'s starboard anchor was let go in a position 4.5 miles east-northeast of Kirkcaldie Reef light, well clear of the two-way route. While at anchor, the crew inspected the forepeak and empty ballast tanks and found no damage. At about 1030, the relieving pilot boarded the ship and took over from the pilot who left the ship a few minutes later. *Pacific Responder* continued to stand by.

At 1900, an AMSA surveyor boarded *Atlantic Blue* and carried out an internal hull inspection. No damage was found and at 2120, the surveyor left the ship. Later that evening, AMSA released the ship from detention to allow it to sail to Townsville where an underwater hull inspection was to be carried out with KR in attendance.

Shortly before midnight, the anchor was weighed and the ship resumed its voyage to Townsville. At 0625 on 8 February, the master reported exiting the Torres Strait to REEFVTS.

In the early hours of 10 February, *Atlantic Blue* anchored off Townsville. At 1006, a harbour pilot boarded the ship and by 1224, it was berthed at the oil tanker berth. The ship was attended by AMSA and KR surveyors and an underwater hull inspection revealed an intact hull with no shell plate defects. Some paint loss was the only indication that the ship had grounded with up to 90 per cent paint loss in the bow section where the bow had pushed aside sand at the 5.4 m shoal. There was little paint damage elsewhere and the propeller and rudder were undamaged.

On 11 February, *Atlantic Blue* completed its cargo operations and sailed from Townsville. The ship continued its voyage without incident, calling at Brisbane followed by Adelaide, South Australia. On 23 February, it sailed from Adelaide bound for Sikka, India.

2.1 Evidence

On 10 February 2009, two investigators from the Australian Transport Safety Bureau (ATSB) interviewed *Atlantic Blue*'s pilot in Brisbane. The pilot provided copies of his passage plan, diary, record of events and other relevant documents.

Later on 10 February, the ATSB investigators attended *Atlantic Blue* in Townsville. The master and second mate were interviewed and copies of relevant documents and records were taken. The evidence included copies of the navigational charts used, log and bell books, course recorder and echo sounder charts, passage plans, master's standing orders, bridge check lists and various procedures. The removable hard drive from the ship's voyage data recorder (VDR) was also taken.

The investigators found the ship's navigational equipment, including the gyro compass, course recorder, automatic identification system (AIS) and global positioning system (GPS) units to be in good working order.

On 11 February, the investigators attended the regional harbour master's office in Mackay and held discussions with him and REEFVTS managers. They took copies of relevant documents and interviewed the vessel traffic service officer (VTSO) on duty at the time of the incident. Relevant traffic information module (TIM) video and audio data was also obtained.

During the course of the investigation further information was obtained from *Atlantic Blue*'s master, the Australian Maritime Safety Authority (AMSA), Samsung Heavy Industries, Korea (Samsung), the VDR manufacturer and Torres Pilots, the pilotage provider.

2.1.1 Samsung SVDR-3000 voyage data recorder

The ATSB technical analysis team found that *Atlantic Blue*'s VDR removable hard drive contained no incident data. The relevant folder on the drive, created 2 hours after the grounding, comprised empty directories. The ATSB sought Samsung's assistance but no solutions to retrieving the missing data emerged.

The master advised that when he had pressed the save button on the VDR touch screen display after the grounding, progress bars appeared on it, indicating to him that data was being saved. He also thought a message confirming the save was displayed. The equipment's last annual survey report indicated that, on 1 July 2008, the necessary inspections, checks and tests had been completed satisfactorily.

The ATSB decided to check if data had been saved to another drive in the VDR system and hence, on 22 February, an investigator attended the ship in Adelaide. There was no data on other drives and a check of the system after reinstalling the removable hard drive confirmed that no data could be saved to it. The VDR was not functioning as designed but did not indicate, as required by international standards, that data was not saved or display an error, fault or warning to indicate a defect.

On 16 March, a service technician attended *Atlantic Blue* in Sikka. He too found the VDR could not save any data. After reinstalling system files and replacing the

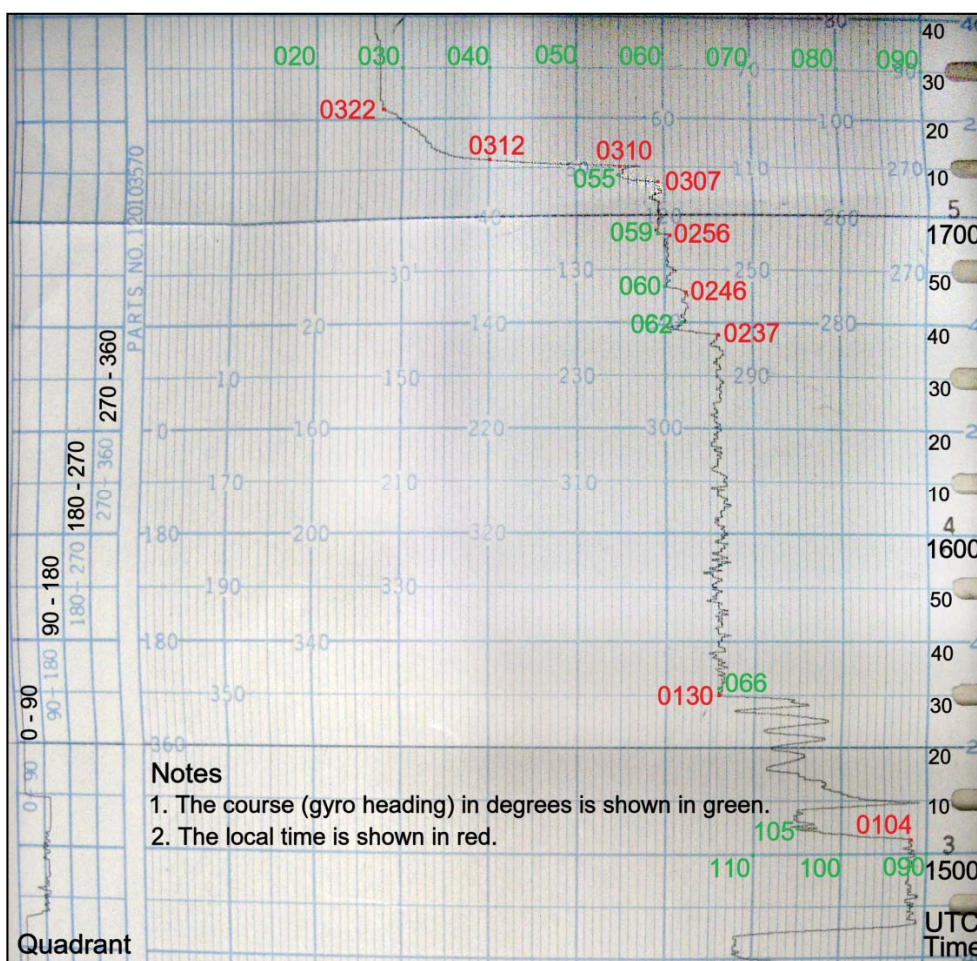
removable hard drive, data could be saved. He concluded that corrupted files due to a software or hardware problem had caused the equipment to malfunction.

At the time of the incident, *Atlantic Blue*'s VDR was not functional and did not provide a failure indication as required by the relevant equipment standards.

2.1.2 Course recorder, AIS/GPS and other recorded data

Although VDR data was not saved, other automatically recorded data allowed an accurate reconstruction of *Atlantic Blue*'s track and of the sequence of events. The ship's course recorder chart provided an accurate, clear and continuous record of its heading and the times that it was altered (Figure 7). This information was consistent with the ship's AIS/GPS data recorded by REEFVTS which, together with recorded VHF communications, was particularly useful.

Figure 7: Annotated copy of *Atlantic Blue*'s course recorder chart



Evidence from the course recorder was consistent with REEFVTS data and manually recorded information on the navigational charts and various log books. This information was supported by accounts of the incident. Any discrepancies in those accounts, particularly in the timing of events leading up to the grounding, were resolved by comparing them with the automatically recorded data.

2.2 The grounding

At 0312 on 7 February, *Atlantic Blue* grounded in position 10°20.0'S 142°49.2'E, on a shoal at Kirkcaldie Reef, nearly 1 mile south of its planned track (Figure 6). For at least the previous 1½ hours, the ship had been steered on headings that, in the prevailing wind and tide conditions, were inappropriate to follow the planned track.

The navigational chart (chart) provided information to estimate the tidal stream in the area of the grounding. The maximum mean spring tide ebb stream velocity about 3 miles west-northwest of Kirkcaldie Reef is east-southeast at 1.5 knots. Based on the charted information, the stream velocity along the two-way route between Twin Island and Kirkcaldie Reef from 0130 to 0330 was expected to be easterly at up to 1 knot. Moreover, the 25 knot north-westerly wind abaft the ship's port beam was augmenting the tidal stream, thereby pushing the ship to starboard.

At 0130, *Atlantic Blue* was close to the planned track, when its heading (true and gyro) was altered to 066° (Figure 7). By 0235, the ship was 1 mile to starboard of the track. It had made good 070° (T), which indicates a combined set and leeway of 4° to starboard.

The PCP (please call pilot) line marked across the course-line was about 2.8 miles west of Kirkcaldie Reef. A PCP mark in the approaches to a critical area is intended to allow the pilot enough time to assess the situation and take action necessary for the ship's continued safe progress. Notwithstanding this, the ship should remain within defined safe limits of its planned track and arrive at the PCP mark on or close to the track so that it is possible for the ship to safely progress.

At 0235, the point where the PCP line intersected the planned track was bearing 057° (T) from *Atlantic Blue*'s position. The course to steer to the intersection point, allowing for set and leeway experienced, was 053° (T). However, at 0237, the heading was altered to 062° and 9 minutes later, to 060°. By 0256, the intersection point was bearing 035° (T) at 2.1 miles and a large heading change was required. Instead, it was adjusted by 1°, to 059°.

By the time the ship crossed the southern extension of the PCP line, it was still nearly a mile off-track with the reef ahead. At this stage, emergency action, comprising a large change of course and/or speed, was required. In deep water, the ship was capable of turning within 4 cables and in shallow water (depth less than twice the ship's draught), its turning circle would probably double. However, further heading changes were not made until after 0307 and these actions were too little and too late to avert the grounding.

Atlantic Blue grounded as a result of deviating from its planned track in the prevailing wind and tide conditions. Between 0237, when the ship was 1 mile off-track, and when it grounded at 0312, the series of small heading changes only resulted in a course made good of 065° (T), nearly parallel to the planned track. Had available bridge resources been effectively used to follow the passage plan or adequate action taken to return to the track, the grounding could have been avoided.

2.3 Bridge resource management

Bridge resource management (BRM) can be defined as the effective management and utilisation of all resources, human and technical, available to the bridge team to

ensure the safe completion of the vessel's voyage²⁸. A key safety aspect of BRM is the implementation of defences against single-person errors with the aim of avoiding serious incidents.

A ship is exposed to higher risks in pilotage areas because of the smaller margins of safety due to factors which often include reduced depth and width of fairways, increased traffic, tidal variations and stronger currents. A pilot's local knowledge and practised piloting techniques are intended to, and should, reduce the risks to an acceptable level; making the pilot a valuable addition to the bridge team's resources.

However, a pilot is not a replacement for any bridge team member/s and it is necessary that the ship's crew works with the pilot by observing good BRM practice in executing the agreed passage plan. A number of ATSB investigation reports highlight the importance of BRM. An AMSA marine notice²⁹ indicates that many serious incidents during a pilotage have been attributed to ineffective BRM. To reiterate the importance of effective BRM from lessons learned, the notice states that 'in many cases, when the pilot boarded the ship, the master and deck officers ceased to monitor the navigation and the position of the ship'.

Atlantic Blue's bridge team comprised an adequate number of appropriately qualified members who carried out a number of necessary tasks. However, one of the team's primary tasks was monitoring the ship's progress to ensure it followed the planned track. All team members, including the pilot, had the necessary training, experience and guidance to carry out this task. The failure to adequately allow for the prevailing wind and the tidal stream was essentially a single-person error that could have been detected and corrected through effective BRM.

2.3.1 Monitoring the ship's progress

The publications library on *Atlantic Blue's* bridge included internationally recognised best practice guides to supplement the ship's standard procedures for navigation. With regard to monitoring a ship's progress, the bridge team management guide³⁰ states:

Monitoring is ensuring that the ship is following the pre-determined passage plan and is a primary function of the Officer of the Watch. ...

Monitoring consists of following a series of functions, analysing the results and taking action based upon such analysis.

After 0130 on 7 February, *Atlantic Blue's* progress along the 066° (T) planned track could have been effectively monitored using a number of different methods. A basic requirement was to accurately establish the ship's position at appropriate intervals. However, what was more important was how this positional information was used to keep the ship on, or within safe limits of, the planned track and clear of navigational hazards in the prevailing wind and tide conditions.

²⁸ *Focus on Bridge Resource Management*. Washington State Department of Ecology, 2007.

²⁹ AMSA, *Working with Australian pilots*, Marine Notice 9/2006.

³⁰ *Bridge Team Management, A practical guide*, Second Edition, p. 41, The Nautical Institute, 2004.

Position and track monitoring methods

Atlantic Blue's planned tracks were marked on the charts. The ship's passage plan required its position to be plotted at intervals not exceeding 5 minutes. Visual bearings were the planned primary position fixing method and radar or GPS the secondary methods. Parallel indexing (PI) information was marked on the charts.

The ship's track could also be monitored by setting course alteration positions (waypoints) in the GPS unit. The unit would then indicate the bearing and distance to the next waypoint and the off-track or cross track error³¹. Audio-visual alarms could be set to provide a warning if the defined off-track limit was exceeded. In addition, the radars would automatically display the planned track and the off-track limits set in the GPS unit. However, waypoints for the ship's transit of the Torres Strait were not set in the GPS unit.

In *Atlantic Blue*'s master's experience, pilots usually objected to track and limit lines cluttering radar displays. He also felt that, due to their local knowledge, pilots often followed tracks slightly different to the ship's passage plan. Therefore, it was his usual practice to not utilise the track monitoring functions of the GPS unit and radar during a pilotage. Hence, he instructed the second mate not to set the Torres Strait pilotage waypoints in the GPS unit, telling him that track and limit lines on the radar display 'might confuse the pilot'. The second mate did not find this unusual since the ship's previous master had also followed the same practice. However, not setting waypoints in the GPS unit circumvented a useful defence against grounding by disabling automated alerts for deviations from planned tracks.

The ship was not fitted with an electronic chart system (ECS) or an electronic chart display and information system (ECDIS) for continuous real-time track monitoring using its GPS position because an ECDIS was not mandatory. However, the GPS course and speed made good could be compared with the heading and expected speed through the water to estimate the combined effect of wind and current. Since the GPS data was displayed by radars, this potentially useful monitoring information was also readily available.

At interview, *Atlantic Blue*'s pilot said he did not use his ECS and GPS-equipped laptop computer for Torres Strait transits because their duration was 'only 9 hours'. In this area, unlike many coastal pilots who use laptop computers as additional aids as standard practice, the pilot normally used only visual and/or radar monitoring techniques. His passage plan included PI information and in the GNEC he relied mainly on PI.

Therefore, track monitoring on 7 February relied on visual, radar or GPS positions plotted on the chart and the pilot's visual and/or radar monitoring techniques. The pilot was not using his ECS and GPS-equipped computer and the automatic track monitoring functions available on the ship's equipment were also not being used.

Limits for track monitoring

Defining clear and unambiguous maximum off-track limits allows bridge team members responsible for monitoring a ship's progress to take necessary action when

³¹ The distance that a ship is to the right or left of the planned track, i.e. off-track, is displayed on many GPS units as the cross track error or XTE.

limits are exceeded. The bridge procedures guide³², another recognised reference on board *Atlantic Blue*, states that a passage plan should incorporate the ‘maximum allowable off-track margins for each leg, where appropriate’.

The passage plan prepared by the ship’s crew did not include maximum allowable off-track margins. The pilot’s passage plan also did not specify any off-track limits. His voyage notes for the master and mates provided the following guidance for track monitoring:

Check position frequently and keep vessel on course line.

Actual courses and A/C [alter course] positions may differ slightly from Waypoint File depending on traffic, tide, weather etc.

If you do not understand or are unsure of any of my orders or instructions please ask me to explain.

Please alert me if you consider the vessel is sufficiently off course so as to run into danger.

At interview, the pilot confirmed that an allowable off-track distance or limit was not specified for any track. He stated that he expected the bridge team to inform him if the ship was ‘sufficiently off course so as to run into danger’ as per his notes.

The PCP line, the only limit defined during the passage, provided no indication of an allowable off-track limit. The line extended more than a mile on either side of the 066° (T) track with arrow heads at its ends, suggesting a position line (Figure 6). In the absence of specific off-track limits, this could suggest that it was acceptable for the ship to be anywhere on the PCP line.

In summary, allowable off-track limits for any stage of *Atlantic Blue*’s Torres Strait transit were not defined. Consequently, members of the bridge team did not know exactly when they should alert the pilot if the ship was ‘off course’.

Executing the plan

At 0130, when *Atlantic Blue*’s heading was altered to 066° (T), the fix plotted by the second mate using a visual bearing of Twin Island lighthouse and the island’s radar range indicated that the ship was near the charted track. The pilot had used his PI to pass the island 8 cables off. No allowance was made for the east-going ebb tidal stream and the strong wind just abaft the port beam.

The pilot was using the radar on its north-up relative motion display (own ship’s position stationary) and he set up a PI to pass Harvey Rocks 3.6 miles to port of the planned 066° (T) track. He used an offset electronic bearing line (EBL) as an index line because he found the radar’s index line function³³ cluttered its display with ‘too many lines’. However, the offset EBL index line that the pilot had set up tended to drift from its set position and he needed to adjust it whenever he checked the radar.

As *Atlantic Blue*’s passage progressed, the second mate continued to fix its position every 5 minutes. The 0140 GPS and radar fix was slightly south of the planned track, indicating the ship was being set to starboard of its heading. The trend

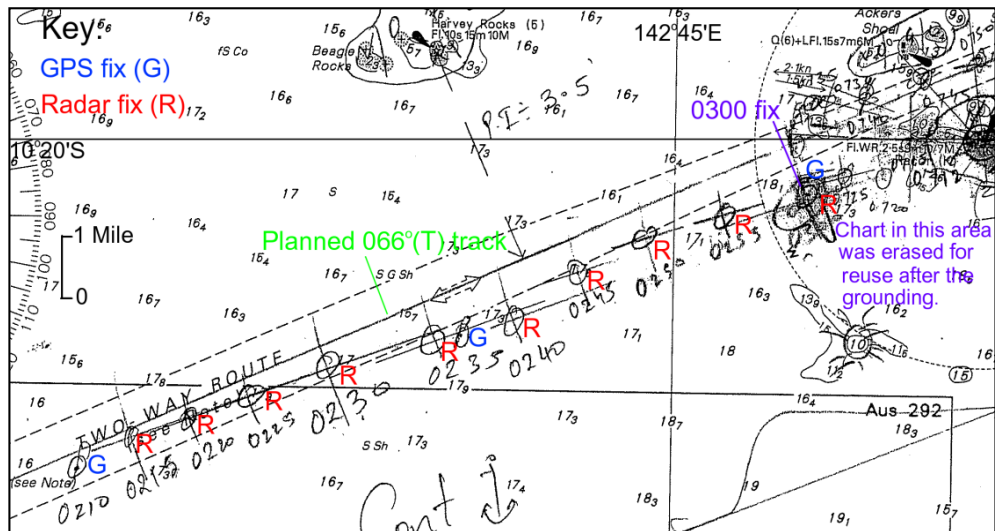
³² *Bridge Procedures Guide*, Fourth Edition, p. 24, International Chamber of Shipping, 2007.

³³ This function automatically creates multiple, parallel, equidistant index lines on either side of the EBL. The EBL and the variable range marker (VRM) controls are used to set or adjust the lines.

continued and the 0205 fix, plotted using the radar bearing and range of an island about 10 miles off the starboard beam, indicated the ship was about 4 cables south of the planned track. The 0210 GPS fix indicated a similar off-track distance. The second mate did not bring this information to the pilot's attention because he thought that the pilot was aware that the ship was moving south of and away from the charted track.

At this stage, the second mate took out the next chart and plotted the 0210 fix on it (Figure 8). He identified Kirkcaldie racon and decided to use it for fixes since it was conspicuous. At 0215, he found the racon's bearing and range to be 070° (T) x 14.5 miles and the fix indicated the ship was about 1 cable south of the planned track. This off-track distance was not consistent with the last two fixes but the second mate did not resolve this inconsistency by cross checking the GPS position or using other radar targets. The GPS position would have indicated that the racon's bearing at the time was actually 068.5° (T) and that there was a 1.5° (west) error in the bearing that had been used.

Figure 8: Annotated copy of the navigational chart used



Atlantic Blue's gyro error had been verified as less than 0.5°. Hence, the most likely reason for the bearing error was the racon signal's arc width on the radar display. The arc, 14.5 miles distant, may have been a couple of degrees wide and, as a result, the bearing taken was probably inaccurate. Despite a bearing error, using at least three position lines from objects well separated in azimuth³⁴ would have resulted in more accurate fixes and parallel indexing could also have been used. Moreover, the GPS provided an independent and reliable position fixing and verification method.

A radar target off the ship's beam is recognised as being more effective for off-track distance monitoring than one fine that is on its bow or quarter. A bearing error for a target fine on the bow or quarter can translate, particularly at long ranges, to a large distance error across the track. Furthermore, radar ranges are generally more accurate than radar bearings. Using only Kirkcaldie racon, then about 4° on *Atlantic Blue*'s starboard bow was, therefore, an unreliable off-track distance monitoring method.

³⁴ In this case, the horizontal angle between objects in the same plane.

At 0220, 0225 and 0230, Kirkcaldie racon's bearing was recorded to be 070° (T). However, at 0235, the bearing was found to be 068° (T) and the 0235 fix was outside the two-way route. The second mate verified the ship's position with the GPS and then informed the pilot that the ship was outside the two-way route.

At 0237, the pilot checked the radar and ordered a new heading of 062° to be steered. Since VDR data was not saved, it is impossible to ascertain what his PI for Harvey Rocks was indicating. However, at interview, the pilot stated he had thought *Atlantic Blue* was north of the track but could not explain why he had then adjusted the heading further to the north. He did not check the position on the chart and expected REEFVTS would have made contact had the ship been outside the two-way route. He could not recall the ship's actual passing distance (4.5 miles) off Harvey Rocks.

It is possible the pilot's PI may have given him misleading indications. A correctly set up index line is aligned to the planned true course and tangential to the variable range marker (VRM) set at the intended passing distance from the selected target. Therefore, the pilot's index line for Harvey Rocks should have been aligned along a 066° (T) direction at a range of 3.6 miles to port. However, it may have drifted off and not been properly re-adjusted or it may have been incorrectly set up in the first place.

In any case, 'parallel indexing does not replace the need to fix the ship's position on the chart at regular intervals'³⁵. While *Atlantic Blue*'s position after 0235 continued to be fixed every 5 minutes, using Kirkcaldie racon's bearing resulted in inaccurate, inconsistent and unreliable off-track indications. After 0240, the off-track distance appeared to decrease suggesting that the heading adjustments made had been effective. Although the 0255 fix indicated the ship was further off-track, the pilot adjusted the heading again at 0256. Had specific off-track limits been in place, the second mate may have been sufficiently concerned to again alert the pilot.

At about 0300, *Atlantic Blue* was near the PCP line and after plotting the 0300 fix using the radar and GPS, the second mate informed the pilot that the ship was at the line and directed the pilot's attention to the charted fix. The pilot reduced the radar display range to 6 miles, set up a PI for Ackers Shoal beacon and then could 'really see' that the ship was well south of the track. The 0305 fix indicated the reef was about 1 mile ahead but now there was little, if any, time to take action. The small heading changes made after 0307 could not prevent the ship from grounding about 5 minutes later.

Monitoring *Atlantic Blue*'s progress and position should have consisted of a series of functions to ensure the ship remained on or near the planned 066° (T) track. This task should have included determining the set and leeway and making appropriate allowances by steering headings to follow the planned track and remain within defined off-track limits. However, such allowances were not made, there were no set limits and the headings steered did not bring the ship back to, or near, the track.

2.3.2 Shared mental model

A bridge team's shared mental model of the passage plan is central to effective BRM. A mutual understanding of individual roles and responsibilities in executing the agreed plan makes it more likely that single-person errors are detected early.

³⁵ *Bridge Procedures Guide*, Fourth Edition, p. 48, International Chamber of Shipping, 2007.

This is particularly important in pilotage because many of the critical navigational decisions are, in practice, made by one person, the pilot.

The concept of a shared mental model helps explain how teams, regardless of the environment in which they operate, are able to cope with difficult and changing task conditions. Shared mental models serve three critical purposes: they help people to describe, explain and predict events in a common environment. Any team that must adapt quickly to changing tasks might draw on shared or common mental models for those tasks. In order to adapt effectively, team members must be able to predict what their team mates are going to do, and what they are going to need to be able to do it³⁶.

Passage plan

An agreed passage plan allows bridge team members to have the same mental model of the tracks to be followed. Although it would be ideal, ships transiting the GBR usually do not have the pilot's passage or route plan in advance of the pilot boarding. Hence, passage planning is often discussed after the pilot boards. In many cases, the courses, in accordance with the pilot's passage plan, are laid on the charts by the pilot because of his familiarity with them and the planned waypoints are set in the GPS unit by the ship's crew. Carrying out tasks most familiar to each team member in these circumstances is an efficient way to utilise resources in implementing the agreed plan and it encourages teamwork.

The passage plan prepared by *Atlantic Blue*'s crew was similar to but not the same as the pilot's plan. The master agreed to the pilot's plan and the second mate made amendments to the charted courses. The main change was to the courses northeast of Kirkcaldie Reef to use the western, instead of the eastern, two-way route in the GNEC (Figure 2). However, most other courses were left unchanged and, as instructed by the master, the waypoints were not set in the GPS unit. No one advised the pilot that this had not been done and he did not ask if it had.

While the pilot's route plan indicated the use of the deeper eastern route in the GNEC, another part of his passage plan appeared to be contrary to this. The route plan contained a table of waypoints for the eastern route immediately above a table for the western route waypoints. The pilot had put a tick above the upper table and a cross on the lower table, thus indicating the route that he intended to follow. However, a chart section in his passage plan indicated tracks (marked in blue) along the western route only. The chart section's intended purpose was probably to provide tidal information with tidal stream rates and directions marked (in red). The result of this was that when the second mate looked at the passage plan, he saw the chart section and changed the charted courses to follow the western route.

Although *Atlantic Blue* grounded before it reached the area where the courses described above were changed, what is important is that not all of the charted course-lines were the same as the ones that the pilot intended to follow. The tracks followed between 0104 and 0130 (Figure 5) represent a readily apparent difference. This should also have indicated to the pilot that the charted courses were not the same as the ones he was following as per his plan.

³⁶ Cannon-Bowers, J A, Salas, E, & Converse, SA (1993). Shared mental models in expert team decision making. In Mathieu, J, Heffner, T, Goodwin, G, Salas, E, and Cannon-Bowers, J, (2000). *The influence of Shared Mental Models on Team Process and Performance*. Journal of Applied Psychology 2000, Vol 85, No. 2 (pp. 273-283), American Psychological Association Inc, 2000.

In submission, the pilot stated that his passage plan was detailed, comprehensive and clear and that had the master and crew followed his plan, the grounding would not have occurred. He stated that 'irrespective of the fact that specific off-track limits were not specified, it was readily ascertainable for the second mate and master to determine whether the ship was off track'. Torres Pilots submitted that the grounding would have been avoided if the second mate had complied with the pilot's voyage notes (listed in section 2.3.1).

However, the pilot had conduct of *Atlantic Blue* throughout the passage and the crew reasonably believed that he was piloting the ship based on his local knowledge and normal practice. The pilot's monitoring of the ship's progress during the hour before its grounding should have indicated to him that the ship was outside the two-way route. In any case, he was informed that the ship was outside the two-way route about 37 minutes before the grounding. It was at this time that substantial action should have been taken to bring the ship back to the track, well before the ship closed on Kirkcaldie Reef.

Not all of the bridge team members clearly understood the agreed passage plan and, despite the charted 066° (T) track, they did not have the same mental model of the track to be followed. Consequently, team members thought they were following a plan but in fact none of them followed any plan in the time leading up to the grounding.

Communications

Good, interactive, closed-loop communication is essential to develop and sustain a shared mental model. Such communication promotes team work and encourages challenge and response, a key BRM tool and defence against single-person errors. The master-pilot information exchange and/or team briefings should include reiterating the limits defined in the passage plan and clarifying team member roles and responsibilities. This makes it more likely that critical decisions/actions will be checked and, where necessary, challenged to elicit appropriate responses.

According to *Atlantic Blue*'s second mate, his tasks included advising the pilot if the ship was off-track and when it arrived at the PCP line. He spoke to the pilot only in relation to these tasks. He said that the pilot conversed with the master at length until the master left the bridge and, in his experience, pilots interacted mainly with masters. In submission, the second mate also advised that, had the master remained on the bridge, he would have found it easier to communicate and inform the master about the ship's position. This suggests that he might have been more inclined to interact with the pilot at the pilot's initiation, when following a clearly defined instruction or through the master when he was present.

At interview, the pilot described the second mate as quiet. The pilot did not discuss roles or responsibilities because he assumed that he and the crew were working as 'just one team'. He expected the crew, as part of the bridge team, to tell him if the ship was sufficiently off course or running into danger, as per his notes. However, without specific off-track limits, a deviation being brought to his attention relied on a crew member's interpretation of his notes or independently deciding to do so. This is precisely what the second mate did.

Nevertheless, the crew should also have sought clarification regarding limits along the planned tracks, and the pilot's expectations, at the time of the master/pilot

information exchange or at another appropriate time, for instance after the second mate had taken over the watch from the third mate.

Challenge and response

At 0104, the second and the third mates challenged the pilot's 105° heading order because their mental model of *Atlantic Blue*'s passage plan indicated the course there should have been 090° (T). The pilot's response, including that he was following his passage plan, satisfied them. However, this indicates that the bridge team was not aware of the pilot's mental model of this part of the passage.

Between 0130 and 0230, the second mate's position fixing indicated that the ship had deviated from the planned 066° (T) track. He considered the off-track limit on this track should have been 2 cables but, with no defined off-track limits, he did not bring the deviation to the pilot's attention. However, he should have because the ship had moved much more than 2 cables off-track and, hence, was of concern.

During this period, the second mate saw the pilot checking the radar from time to time and he thought the pilot was aware of *Atlantic Blue*'s progress. When the pilot started his laptop computer to copy the electronic charts, the second mate noted a ship vector and a track with red and green lines to either side on the computer's screen. He assumed the pilot was using the computer to check the ship's progress.

In submission, the pilot stated that it was unusual that the second mate made such an assumption because he had used his computer only briefly to copy the electronic charts and had then put it away.

The statements of the pilot, master and second mate at interview and in submission are conflicting with regard to when, and for how long, the computer was used. What is more important in this respect is that the ECS and GPS-equipped computer was a navigational aid that could have been used for monitoring the ship's passage. It is also important to recognise that an assumption like that made by the second mate is possible and probably not unreasonable in the circumstances, and that appropriate communication can prevent such a misunderstanding.

In any case, given that the pilot was using the radar, his PI was probably indicating that *Atlantic Blue* was closer to the track than it was because the 066° heading was maintained. Although the fixes on the chart indicated that the ship was off-track, the pilot stated he did not see them in the dim light. In submission, he stated that it had been physically impossible for him to see the fixes since the chart was placed under a dim light in a small console that could fit only one person at a time instead of the designated chart table in the aft part of the bridge.

However, the small chart table located at the end of the console in the front of the bridge was about 1 m wide and 1.5 m deep and two map lights with dimmers and adjustable flexi-arms were mounted above it. Other than marking the PCP line, the pilot made no move to approach the chart table or ask the second mate to stand aside so he could look at the chart. Alternatively, he could have asked for the chart to be moved to the large table in the curtained-off area aft. It is normal to resolve difficulties accessing charts or radars via communication.

Consequently, the pilot remained unaware of the fixes on the chart. However, after fixing the 0235 position, the second mate advised the pilot that *Atlantic Blue* was

outside the two-way route. He probably did so because the charted note³⁷ indicated, to him, that two-way route boundaries were limits that should not be breached. This also means that this challenge could have been made as early as 0215 had his position fixes been more accurate.

At interview, the pilot stated that he was informed that the ship was outside the two-way route but his perception was that the time was 0250. He advised that he then started to 'correct', i.e. make heading changes. However, the course recorder chart and other evidence indicate that he started to correct at 0237 (Figure 7).

The pilot's heading order of 062° at 0237 and his earlier response satisfied the second mate. It appeared to him that the pilot had the situation in hand. Consequently, he did not determine a course to steer to safely return to the track or call the master, who had only just left the bridge.

The 0245 fix indicated that the ship was still outside the two-way route but it was getting closer to the planned track. At 0246, when the pilot adjusted the heading to 060°, the second mate was further reassured that the pilot had the situation in control and that heading adjustments made were having the desired effect, thus making a challenge unlikely.

The second mate, probably affected by confirmation bias³⁸, could also see that the pilot was using the starboard radar and did not appear to be alarmed. Consequently, the second mate did not independently verify the radar fixes or query the pilot again about the ship's position and the pilot's actions. He appears to have primarily relied on the pilot ordering headings that would ensure the ship's safe progress. Instead of making the number of assumptions that he did, the second mate should have used some of those opportunities to seek clarification and challenge the pilot.

At 0256, the pilot again adjusted the heading to port and at 0300 acknowledged that *Atlantic Blue* was at the PCP line. The second mate saw the pilot checking the radar and still thought that he had the situation in hand. However, the ship was about a mile off-track and its proximity to the reef should have indicated that the ship was 'sufficiently off course so as to run into danger', necessitating a challenge. By this time at the latest, he also should have called the master since it was 10 minutes past the time that he should have returned to the bridge.

A little later, when the pilot ordered 050°, the second mate assumed the course was being altered to join the next charted course-line. He thought that the pilot was again deviating from the charted course-line just as he had done at 0104 and did not challenge the pilot who he described as 'cool and not panicked' at that time.

Although there were some examples of challenge and response between *Atlantic Blue*'s bridge team, they proved ineffective in preventing the grounding. The main reason for this was probably the absence of defined off-track limits and a clear understanding of bridge team member roles and responsibilities in accordance with an agreed plan and a shared mental model.

³⁷ The notes states: The two-way route shown on this chart is a ships routing measure. Its use is not mandatory, however, it does indicate the best and safest route for all vessels having regard to charted depths and dangers.

³⁸ Confirmation bias, in human factor terms, involves a person seeking information to confirm an expectation or assumption and rejecting that information which conflicts with an expectation.

2.3.3 State of the bridge and situational awareness

State of the bridge is a term used to describe the bridge team's condition in relation to its ability to effectively perform necessary tasks. The concept encompasses all the factors that can influence the team's ability. The factors include the workload, capability, experience, fatigue, health and motivation of team members, the type and condition of navigational equipment and external conditions such as weather. These factors also influence individual team members' situational awareness³⁹ which is, therefore, often associated with the state of the bridge.

An optimum state of the bridge describes the condition when the bridge team is effectively managing the workload. Undesirable states of the bridge are associated with alarm or inattention due to a combination of influencing factors. A sufficient number of appropriate team members can effectively manage workload, recognise undesirable states and take steps to return to an optimum state. A poor state of the bridge at a critical phase of the passage has often led to a serious incident.

As *Atlantic Blue* closed on the reef and grounded, the bridge team expressed little, if any, concern. It was only after the ship had stopped that the second mate thought something was wrong. The pilot did not realise that the ship was aground for a few minutes. No team member had comprehended the increasingly serious situation while it was developing or had suspected what was about to happen. The state of the bridge could be described as being inattentive at a critical phase.

The degraded state of the bridge just before the ship grounded developed gradually over a 1½ hour period. The state of the bridge probably started to decline shortly after 0130 when the ship's heading was altered to 066° (T). By this stage, most critical areas of the passage with small margins of safety had been passed. Greater margins existed along the two-way route until *Atlantic Blue* approached Kirkcaldie Reef more than 1½ hours later. Hence, the pilot reduced his workload to occasional checks of the radar. The second mate continued fixing the ship's position every 5 minutes and the master conversed with the pilot. In submission, the master advised he was aware that the ship's position was being regularly fixed.

Shortly before the master left the bridge at 0230, he noted that *Atlantic Blue* was in 'a comparatively open passage'. The 0225 fix, the most recent one he is likely to have seen, probably did not alarm him since it indicated, incorrectly, that the ship was inside the two-way route (Figure 8). Moreover, the pilot and the second mate were performing tasks that indicated they were adequately monitoring the ship's progress.

By the time the master left the bridge, the state of the bridge had declined but there were no navigational hazards nearby. The second mate knew the ship was off-track but assumed the pilot was aware of this. At interview, he stated that had the pilot not been on the bridge, he would have kept the ship within 2 cables of the planned track. In any case, had the inconsistency between the 0210 and 0215 fixes been resolved, his understanding of the situation would have improved.

The pilot maintains that he should have been informed that *Atlantic Blue* was off-track earlier than he initially was. However, at about 0235 and some 37 minutes before the ship grounded, he was advised that the ship was outside the two-way

³⁹ Situational awareness has been variously defined, including simply as knowing what is going on around you. In relation to a ship's passage, it includes knowing what has recently happened, what is happening and, based on where the ship is, what is about to happen.

route, 15 minutes earlier than his perception of being informed at 0250. Nevertheless, he stated that temporarily leaving the bridge when his workload reduced may have been better because the heading may then have been adjusted earlier than it first was. It is necessary to note here that a pilot's presence on the bridge is often, wrongly, taken as meaning the pilot is in charge and aware of every aspect of the ship's progress.

Indicating the tidal stream on the chart and taking into account the relative wind direction and its increased strength may also have been helpful to the bridge team. It would also have been useful to estimate the effect of the wind and tide on the ship's progress by checking the GPS course and speed made good on the radar displays. In any case, the set and leeway being experienced should have been determined and would have provided a proper understanding of the effect of the prevailing conditions. The pilot's PI did not prompt him to make an allowance for these conditions earlier probably because it was inaccurate. Moreover, he expected the second mate to inform him if the ship was sufficiently off-track. The second mate did do so at about 0235 but neither individual knew the other's intentions since they had not communicated these.

After the second mate informed him that *Atlantic Blue* was outside the two-way route, the pilot was unconvinced because his situational awareness was inadequate. An expectation that REEFVTS would make contact if the ship was outside the two-way route, his understanding of the ship's progress and expectations in this respect may have led to confirmation bias and he did not verify the position fixed on the chart. Subsequently, the pilot's actions and their apparent success based on radar fixes probably resulted in the second mate being similarly biased and not verifying the fixes.

In his cabin, the master remained unaware of the developing situation. While the number of bridge team members at that time was adequate, the master's presence could have improved the state of the bridge. When the second mate advised the pilot that the ship was outside the two-way route, the master would probably have checked the chart and verified the ship's position. It is also likely that he would have remained on the bridge and actively monitored the situation. Furthermore, because of their similar levels of authority, the master was much more likely to challenge the pilot early and strongly repeat a challenge.

At interview, the master advised that he left the bridge because he felt compelled to attend to email messages. He said that he would have otherwise stayed on the bridge and challenged the pilot when he saw that the ship was so far off-track whilst approaching Kirkcaldie Reef.

However, the master's earlier checks of the chart should have prompted him to advise the pilot that the ship was off-track, clarify if the charted course-line was being followed and the allowances for wind and current that were necessary to do so. While his leaving the bridge, in itself, was not a violation, confirming that it was safe to do so by verifying the ship's position and checking its progress was the absolute minimum necessary to ensure that navigation remained the first priority. It was also important to have defined a specific time or a position where he was to be called. Not only would this have better ensured that he was on the bridge for parts of the passage he intended to personally oversee but clarified any doubts that the second mate or pilot may have had.

In submission, *Atlantic Blue*'s managers, Fleet Management, advised that the master was never compelled by it or any other party to attend to email messages.

The ship's managers also advised that this was prohibited by its procedures for critical navigation but noted that the ship was in reasonably clear waters and that the pilot was on the bridge.

It was not until the pilot set up a PI for Ackers Shoal to clear the 5.4 m shoal, a few minutes after 0300 that he realised just how far south of the track the ship was. However, he still thought that the ship would safely pass between Ackers Shoal and Kirkcaldie Reef. His perception was probably based on the visual disposition of the lights on those hazards. For example, at 0307, the lights were about 44° and 23° to port and starboard, respectively, of the ship's head. The aspect of the lights may have given the impression that the ship would clear the hazards which they marked.

The unsuccessful attempts by REEFVTS between 0310½ and 0313 to contact *Atlantic Blue* on VHF channels 19 and 16 indicate that the bridge team was probably focused on the ship's changing heading. It is also possible the initial calls on channel 19 may have not been heard because the VHF radio set to this channel was in the aft part of the bridge and bridge team members were in the forward part.

At 0315, when the grounded *Atlantic Blue*'s heading was 033°, it appeared to the pilot to be in the middle of the area between the lights. This visual perception may explain why he did not confirm the grounding to REEFVTS until much later. By then, the master who had recently returned to the bridge was certain that the ship was aground. Kirkcaldie light's constant relative bearing, the nearly constant GPS position, almost zero speed and calls by REEFVTS left little doubt. This indicates that the state of the bridge had degraded to the extent that team members had not related all those cues to the grounding before the master did. As the situation had developed, their perception of each other's actions, their own situational awareness and understanding of the ship's progress had given them a false sense of security.

At interview, the pilot advised that to avoid such an incident in the future he would probably use his ECS and GPS-equipped laptop computer to monitor a ship's progress. His voyage notes stated that the 'pilot's electronic charts enhance the vessel's safety and the computer is not to be operated by the vessel's crew'. The use of laptop computer-based ECSs is widespread among coastal pilots and a number of AMSA documents⁴⁰ provide guidance on the appropriate use of these aids.

In any case, the pilot's ECS, if reliable and accurate, could have improved track monitoring and provided an additional defence, particularly as the ship was not fitted with an ECS or ECDIS, recognised as useful aids that improve situational awareness. Although the ship's equipment was adequate for monitoring, available defences in the form of the GPS off-track alarms and radar track and limit display functions had been circumvented.

While a number of factors influenced the state of the *Atlantic Blue*'s bridge, the main reason for its decline was ineffective monitoring, the disparity in the mental models of team members and their inadequate situational awareness. Had the degraded state of the bridge been recognised and corrected as early as possible after the first heading adjustment at 0237, the grounding probably would not have occurred.

⁴⁰ Including, AMSA *Pilot Advisory Notes 14/07 & 13/08* and the AMSA *Queensland Coastal Pilotage Training Program, Study Guide, Version 1, 2004*.

2.3.4 Human performance

There was probably a decline in the performance of *Atlantic Blue*'s bridge team members that also influenced the state of the bridge. The main reasons for this included their recent rest and work hours, workload during the pilotage and the time of the day during which the situation that led to the grounding developed.

The Australian House of Representatives (2000) enquiry⁴¹ highlighted a decline in task performance that reduces for each hour between 10 and 16 hours that a person is awake. In addition, the human wake-sleep cycle follows a daily circadian rhythm that varies with body temperature in a 24-hour cycle of alertness/sleepiness that affects performance.

Performance tends to peak in the early evening when body temperature is at its highest. A trough in performance is associated with the reduction of body temperature between 0200 and 0600⁴². Such performance patterns across the time of day occur for tasks involving manual dexterity, simple recognition and reaction time⁴³. The chance of being involved in a work-place accident or driving accident has also been shown to be significantly higher between 0200 and 0600 in comparison to other times of the day.

Inadequate sleep before working throughout the night further affects performance. The combination of the night, especially the very early morning circadian rhythm, and sleep deprivation can reduce performance more than each variable alone.

The 21 hour period at Thursday Island before piloting *Atlantic Blue* provided the pilot much more than the minimum 12 hours of rest required. Before boarding the ship, he had slept for a couple of hours during the afternoon in addition to 8 hours sleep the previous night which should have provided adequate rest. At interview, he stated that he felt well rested when he boarded the ship. After passing Twin Island at 0130, he felt a little tired but expected this after piloting for 3½ hours at that time of the day. He did not want to remain standing so, from time to time, he sat in the pilot chair having marked the PCP line in case he inadvertently dozed off.

At this stage, navigation did not require as high a level of the pilot's attention than it had in the preceding 3½ hours. Now with less stimulation after the long period of nearly continuous concentration, his level of arousal probably reduced. A moderate arousal level is associated with optimal performance and too high or too low arousal levels with a decline in performance. The relationship between performance and arousal, known as the Yerkes-Dodson⁴⁴ law, probably contributed to a decline in the pilot's performance after the ship entered the more open waters of the GNEC.

The second mate's performance could also have been affected due to less sleep than was normal for him. On 6 February, he kept the 0000-0400 watch and then slept for

⁴¹ House of Representatives Standing Committee on Communication, Transport and the Arts (2000). *Beyond the Midnight Oil: An inquiry into managing fatigue in transport*. Commonwealth of Australia, Canberra.

⁴² Campbell, SS 1992. Effects of sleep and circadian rhythms on performance. In AP Smith & D M Jones (Ed.s) *Handbook of Human Performance*, vol 3, 196-216.

⁴³ United States Congress, Office of Technology Assessment, (1991) *Biological Rhythms: Implications for the Worker*. (OTA-BA-463) Washington, DC: US Government Printing Office.

⁴⁴ Yerkes RM, Dodson JD 1908. The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology* 18: 459-482.

7 hours, as usual, before his 1200-1600 watch. After the afternoon watch, he attended routine lifeboat and other drills and then to some passage plan-related paperwork before leaving the bridge at 1730 for dinner. He returned to the bridge at 1830 to relieve the chief mate for his dinner. At 1900, the second mate left the bridge to rest but did not sleep. At about 2200, he again came to the bridge to mark courses on the newly received charts. At midnight, after amending the passage plan, he left the bridge after arranging with the third mate to take over the bridge watch after an hour. Again, he did not sleep but rested until 0100 on 7 February, when he returned to the bridge and took over the watch.

By 0312, when *Atlantic Blue* grounded, the second mate had been awake for the previous 16 hours, over 10 of which he had spent working on the bridge or at drills. In addition, he did not get his usual 3 hours of sleep before his morning watch. In submission, he advised that he was tired due to the additional work and less sleep and that this affected his response which was not optimal. Although self assessment of fatigue is unreliable, and is usually associated with under-reporting, it is possible his reduced sleep and increased work hours led to a decline in his task performance as identified by the 2000 Australian inquiry referred to earlier in this section.

In general, the decline in the performance of the bridge team was probably the result of a combination of factors including the time of the day, reduced stimulation from navigation when the ship moved into relatively open waters and, in the case of the second mate, possibly a longer period of being awake.

2.4 Safety management systems

There were systems in place that were intended to ensure *Atlantic Blue*'s crew and the pilot safely navigated the ship. The ship's safety management system (SMS) documented procedures that the crew were required to follow. Furthermore, a number of AMSA requirements and guidelines for coastal pilots covered pilotage procedures and practices.

2.4.1 *Atlantic Blue*'s SMS

Atlantic Blue's bridge procedures manual⁴⁵ contained the ship's SMS procedures for navigation. The procedures aimed to provide guidance consistent with good practice and the manual acknowledged recognised publications, including the bridge team management and the bridge procedures guides that had been consulted.

The ship's bridge procedures summarised a number of key BRM elements. This included single person errors, error chains, monitoring the ship's progress, situational awareness, preoccupations, dangerous situations, delegation and managing workload. The procedures required a pilot to be accepted as a 'valuable addition' to the bridge team.

The bridge resource or bridge team management training of *Atlantic Blue*'s master and mates and their seagoing experience should have allowed them to follow the ship's procedures. During the pilotage, the ship's bridge team used some BRM tools. However, the absence of defined off-track limits was an impediment that, to a significant degree, contributed to the BRM being ineffective.

⁴⁵ Fleet Management, *Bridge Procedures Manual*, Revision 0, 1 Dec 2008.

The ship's procedures did not specifically require off-track limits to be defined. The procedures required margins of safety for various sections of the passage to be 'agreed and understood by all concerned' but did not describe how these margins were to be used to monitor the passage plan. The standard passage plan format did not include defined off-track limits.

The master's standing orders required position fixing consistent with the passage plan but off-track limits were not mentioned. At sea, the normal practice was to set a 1 mile off-track limit. However, in pilotage waters it was usual to not use the track monitoring functions of the GPS unit and the radar. As a result, the procedures and practices on board the ship did not ensure that off-track limits were defined and used at all times.

The ship's passage plan did not indicate any margins of safety and off-track limits for the Torres Strait transit were neither defined nor set in the GPS unit. Although the pilot's passage plan and notes did not specify such limits either, none were discussed or agreed for any leg of the pilotage passage as per the ship's procedures. This indicates an assumption by the crew that, during the pilotage, the ship would remain within safe limits, which there was no need to define.

Atlantic Blue's SMS procedures did not require specific off-track error limits to be included in the passage plan or otherwise ensure that limits for effective track monitoring were always defined. Had the ship's passage plan for the Torres Strait included off-track limits or limits had otherwise been agreed and used by the bridge team, the grounding may have been prevented.

2.4.2 Pilotage procedures and practices

In general, pilotage systems in Australia and overseas have, for over a decade, moved towards standardised procedures and practices. Many ports and pilotage areas have used existing piloting methods, the collective knowledge and experience of pilots, recommended navigational practice, advice from consultants and other methods to develop a pilotage SMS. All pilots in these systems follow the same accepted best practice procedures and passage plans for their ports/pilotage area. Over time, these standard systems are reviewed and refined to reduce risk.

In the GBR pilotage areas, AMSA has used the pilot licensing process and the coastal pilotage marine orders to progressively implement safety measures. These measures include a pilot training program for suitably qualified masters or mates and a staged pilot licensing process before an unrestricted licence is issued. Other safety initiatives include BRM training, regular professional development courses and fatigue management measures. A number of these initiatives have taken into account the findings of various safety reviews, fatigue studies and incident reports. The Queensland Coastal Pilotage Safety Management Code⁴⁶ (QCPSM Code) encompasses all of the existing safety measures and initiatives.

The QCPSM Code

Introduced in 2001, the QCPSM Code is designed to facilitate the effective, efficient and safe management of coastal pilotage services in Queensland. The

⁴⁶ AMSA, *Marine Orders Part 54, Coastal Pilotage*, Issue 4, 2006, Appendix 1, *Queensland Coastal Pilotage Safety Management Code*.

code's stated objectives are to promote safety at sea, prevent injury or loss of life and avoid damage to the marine environment and to property by ensuring that all pilotage operations are covered by an approved SMS. The code includes requirements for pilotage providers, their SMSs, the responsibilities of pilots and providers and standards for pilot transfers.

Requirements of the QCPSM Code and provisions in the marine orders have resulted in systems that, in some respects, are similar to those required by the ISM (International Safety Management) Code for the safe operation of ships. One such similarity is the issuance of a document of compliance (DOC) to a pilotage provider whose SMS meets the requirements of the QCPSM Code.

The QCPSM Code requires pilots to comply with their pilotage provider's SMS. However, the pilotage providers' SMS do not include standard procedures for piloting, navigation or passage planning. The SMS of *Atlantic Blue's* pilotage provider, Torres Pilots, mainly contained guidance about the provider's operations, of which only some areas like pilot rosters, pilot transfers, fatigue management and emergency response were related to the activities of individual pilots managed by the provider. The provider companies assign ships to pilots; they do not employ, or provide, them with an SMS for piloting those ships.

To meet the requirements of the QCPSM Code, each pilot has to develop his own individual documented systems for piloting. Pilots use their own piloting methods with their own passage plans, checklists, forms and guidance notes for ships' crews. There is no common system applied by every pilot conducting the same pilotage operation. To assure a level of safety, AMSA has put in place the check pilot regime⁴⁷ to assess the adequacy of these numerous individual systems.

Check pilot regime

Implemented in 2003⁴⁸, the check pilot regime was intended to continuously improve pilotage procedures and techniques. Under this regime, all pilots are assessed in each area for which they are licensed, at least once every 2 years. The assessments are carried out by a licensed check pilot and include an audit and check process of the pilot's systems, procedures and practices. The AMSA approved check pilot assessment checklist⁴⁹ comprises 14 broadly defined performance criteria, including effective communication, BRM, passage planning and monitoring. The checklist provides a number of specific checks to assess each criterion.

Over the years, *Atlantic Blue's* pilot had undergone six assessments with three different check pilots. At the time of the incident, he was using his usual practices, passage plan and guidance notes for the crew. He was also a check pilot. Therefore, his pilotage system should have met all the check pilot performance criteria and been consistent with every critical item in the assessment checklist.

⁴⁷ *ibid.* Appendix 1, Annex B, *Check Pilot Regime*.

⁴⁸ AMSA Pilot Advisory Note 10/03 announced that the check pilot system was in full operation and Pilot Advisory Note 01/04 noted the completion of a significant number of check pilot voyages.

⁴⁹ AMSA, *Check Pilot Assessment checklist*, March 2007. The previous version of this checklist was issued in August 2004 and was similar in most respects, including the performance criteria.

However, serious non-conformities existed in the pilot's system in relation to the 'successful passage planning' and 'effective BRM' performance criteria. A specific item in the check pilot assessment checklist requires confirming the passage plan contains 'the allowable cross track error for each track' and that this is discussed with the ship's crew. *Atlantic Blue*'s pilot's passage plan did not specify the allowable cross track error for any track nor did he discuss any off-track limits. In this respect, his notes for the crew were ambiguous and inadequate.

Check pilot assessments include checking that pilots demonstrate open, interactive and closed loop communication, challenge and response, briefings and delegation. While AMSA required the pilot to promote and practice these BRM principles, he did not adequately do so on board *Atlantic Blue*. He did not consider it necessary to define, discuss or delegate bridge team roles and responsibilities. This led to lesser communication and the reduced effectiveness of the challenge and response tool. The pilot's belief that the bridge team could just work as a team without defining any limits, roles or responsibilities was inconsistent with recognised BRM practice, the QCPSM Code and relevant pilot advisory notes⁵⁰.

The above indicates that the check pilot regime and the pilot licensing process had not ensured that *Atlantic Blue*'s pilot's systems were adequate. It is also indicative of the drawbacks of check pilots assessing the numerous systems of their peers without any standard pilotage procedures and passage plans. Although the same assessment criteria may encourage some uniformity in pilots' systems, it does not make them the same nor does it make all of them best practice. A pilotage area should have one pilotage system developed as best practice with standard passage plans as a minimum base or reference.

The ready availability of an appropriate standard passage plan to a ship's crew in advance of its Torres Strait and GBR transit would also be a significant advantage. This would improve BRM and encourage acceptance of the pilot as a valuable addition to the bridge team. This could prevent an undesirable state where the ship's crew become inattentive during a pilotage, effectively making the pilot the only active member of the bridge team.

Under the QCPSM Code, individual pilots are responsible for the preparation of comprehensive passage plans. This task could be done most effectively if it were collectively tackled by pilots, providers and AMSA and standard passage plans developed just as they have been in many contemporary port or harbour pilotage systems.

In summary, had *Atlantic Blue*'s pilot's system included specific off-track limits and following BRM methods consistent with recognised practice, the grounding may have been avoided. However, several assessments of his system under the check pilot regime had not ensured that his piloting procedures and practices complied with the requirements of the QCPSM Code. This suggests potential deficiencies may exist in certain areas of the systems of pilots and check pilots and some aspects of the check pilot regime. Furthermore, the code has not resulted in the development of a standard coastal pilotage system aimed at best practice.

In submission, the pilot stated that the check pilot regime had clearly failed because several assessments of his system had not ensured its compliance with the QCPSM

⁵⁰ AMSA Pilot Advisory Notes 03/99 and 03/03 current at the time of the incident (later superseded by 07/09) provided guidance with respect to passage planning and BRM.

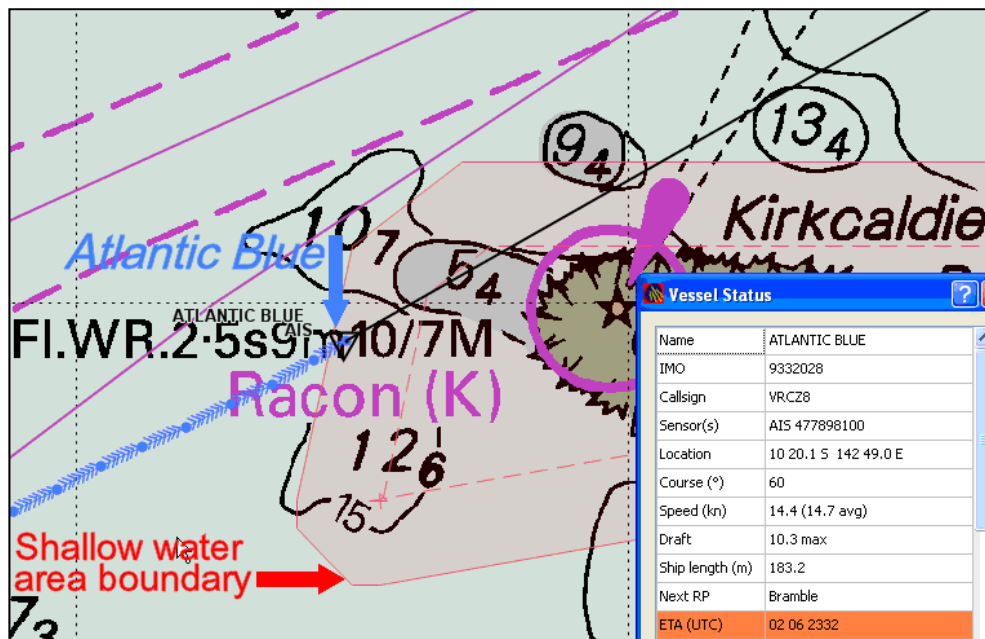
Code. Those assessments indicated to him that his system had been approved by the appropriate authority and, hence, he had no knowledge or reason to believe it was deficient in any manner. However, as a result of the incident, he undertook further BRM training and has amended his system. The amendments include specific off-track limits in his passage plan and detailed BRM guidance in his voyage notes with respect to monitoring the ship's progress and the role of the pilot. In addition, he has made recommendations to Torres Pilots in relation to passage plans.

2.5 REEFVTS monitoring

To effectively monitor shipping in the REEFVTS area and to facilitate the provision of navigational assistance to ships, the traffic information module (TIM) is set up to generate automatic alarms. The alarms are intended to provide the duty VTSO with an early warning of a ship standing into shallow water, deviating from its normal route or approaching a critical course alteration point so that a hazardous situation can be avoided. When a ship breaches limits defined in the TIM, the corresponding alarm (shallow water alert, exiting corridor⁵¹ alarm or critical turn alarm) is triggered.

At 0310 on 7 February, the shallow water alert was triggered when *Atlantic Blue* crossed the shallow water area boundary defined in the TIM (Figure 9). Despite the duty VTSO taking immediate action in accordance with REEFVTS procedures, the ship grounded 2 minutes later. The shallow water alert, the first and only automatic alarm generated for the ship, was ineffective because the boundary of the shallow water area was too close to the danger.

Figure 9: Section of the TIM display at 0310 on 7 February



⁵¹ Electronic corridors defined in the TIM are described as 'intelligent' lines and areas to represent key navigation areas used by transiting ships in the VTS area.

According to REEFVTS procedures⁵², automatic alarms are intended to enhance the duty VTSOs situational awareness and enable interaction with a ship if necessary. Therefore, it is important that the alarms, where possible, provide an early warning to allow timely action to be initiated. Only then can such alarms enhance situational awareness and form effective defences against serious incidents. It is also recognised that where some reliance is placed on automatic alarms, the absence of an alarm suggests a safe or normal condition and an overall perception of safety. It is important to consider this known risk when developing such automated systems.

On 7 February, had the two-way route being transited by *Atlantic Blue* been a TIM corridor, an exiting corridor alarm would have been generated at 0215 (about 1 hour before the shallow water alert was triggered). However, without the corridor alarm facility, early detection of the ship exiting the two-way route was only possible by continuously observing its progress with the TIM display set to a larger scale. Alternatively, regular and frequent checks of the ship's progress on the display may have indicated that a hazardous situation was developing. However, although traffic is not heavy, closely monitoring the passage of every ship would be a difficult task for a single VTSO to perform effectively because the REEFVTS area is geographically very large.

Two-way routes in the GBR are based on tracks that ships have safely transited for many years. Charts refer to these routes as the best and safest routes. Therefore, two-way routes can be described as established navigation corridors. It is seldom necessary for a ship to be taken outside these routes although this may be warranted sometimes. Examples include two ships meeting in a very narrow section of a two-way route, a ship exiting a route to wait for high tide before continuing its passage or exiting a route due to a breakdown or emergency. In such cases, it is usual for the pilot to advise REEFVTS in advance of the deviation or as soon as practicable. This avoids the necessity for the VTSO to initiate interaction with a ship to query its deviation, whether an automatic alarm has been triggered or not.

Given the above, it follows that two-way routes should be defined as TIM corridors. This would better utilise available resources to enhance traffic monitoring and complement a ship's bridge resources. On 7 February, an exiting corridor alarm for *Atlantic Blue* would have led to the duty VTSO initiating early action. Potentially, the state of the bridge could have improved and changed the sequence of events sufficiently to prevent the grounding.

Defining two-way routes as TIM corridors would also be consistent with AMSA's layered approach to navigation safety in the GBR in which pilotage is the final layer. The other layers in this system are REEFVTS, a network of navigation aids and existing ship routing measures. Moreover, the definition⁵³ of an exiting corridor situation (i.e. a ship has deviated significantly from a recommended or standard route, particularly where areas of shallow water are in close proximity) accurately describes *Atlantic Blue*'s situation in the time leading up to the grounding.

Therefore, defining shallow water areas appropriately and charted two-way routes as corridors in the TIM can provide timely and effective warnings. This may have prevented *Atlantic Blue*'s grounding and can assist REEFVTS in achieving its objectives of enhancing navigational safety and minimising the risk of an incident.

⁵² AMSA & MSQ, *REEFVTS Safe Operating Procedures Manual*, Version 2.0, 1 November 2007.

⁵³ *ibid.* Section 4, subsection 6, p. 14, SOP E-15: Exiting Corridor Alarm.

2.6 Incident response

The consequences of a ship grounding in the GBR PSSA can be very severe, especially when they involve oil or other pollution. All involved parties need to have effective measures in place to manage such emergencies and mitigate the consequences. This makes it possible for them to work with each other and make optimal use of available resources for the safest possible outcome. An appropriate incident response is, therefore, necessary and is a main objective of REEFVTS.

Fortunately, a soft grounding resulted in *Atlantic Blue*'s double hull remaining intact and there was no immediate pollution risk from a cargo or fuel oil spill. It was also fortunate that it was nearly low water, preventing the hull grounding further and the flooding tide allowed the ship to refloat fairly soon. While those conditions were favourable, the response from the involved parties was also positive.

The REEFVTS duty VTSO took immediate action to confirm the grounding. The VTSOs communication to obtain and provide information and make notifications, allowed the situation to be effectively managed from the beginning. He identified that AMSA's emergency towing vessel (ETV) *Pacific Responder* was in the general area and this assisted the early decision to direct it towards *Atlantic Blue*'s location.

Pacific Responder is a useful resource stationed in the northern part of the GBR and was capable of assisting *Atlantic Blue*. The ETV stood by the ship while AMSA and MSQ coordinated their resources and efforts to manage the situation and monitor it.

When *Atlantic Blue*'s master realised that the ship was aground, he stopped the main engine and took action in accordance with the ship's emergency procedures. He made timely notifications to AMSA, the ship's managers and other parties ashore. He then provided them with initial and regular updates of damage assessments and related information.

Earlier in the voyage, the master had simulated a notification exercise with AMSA and felt this experience enhanced his response to the grounding. He also thought a number of routine emergency drills conducted on 6 February may have improved the emergency response on board in general.

While it took some time for *Atlantic Blue*'s pilot to confirm the grounding to REEFVTS, he then asked for AMSA and Torres Pilots to be notified. Subsequently, he communicated with REEFVTS as required and offered the master advice and provided tidal information.

Since *Atlantic Blue* grounded at nearly low water, the laden ship would tend to refloat on the flooding tide and action to prevent it being pushed further on to the reef in the prevailing weather conditions was necessary. The master anticipated this and his actions, in consultation with the pilot, to move the ship away from the reef without tug assistance as soon as it refloats were timely and proved effective.

The ship was detained by AMSA and anchored in a safe location to allow an assessment of its condition. In accordance with standard practice, and prudently, the pilot was relieved as soon as possible by an adequately rested pilot. Once initial assessments indicated that the ship was not seriously damaged, AMSA permitted it to continue its voyage to Townsville, where further assessments would be possible. This avoided unnecessary delays to the ship.

The actions taken in response to *Atlantic Blue*'s grounding, both on board the ship and ashore were timely and appropriately managed.

3.1 Context

At 2200 on 6 February 2009, a coastal pilot boarded the tanker *Atlantic Blue* for its intended eastbound transit of the Torres Strait. The ship was nearly fully laden with a cargo of petrol and was bound for Townsville.

The passage progressed normally and at 0130 on 7 February, *Atlantic Blue*'s heading was altered to 066° (T). The ship made good 070° (T) in the prevailing wind and tide conditions and by 0235 it was 1 mile south of the planned track.

A number of small heading adjustments were made but none were effective. At 0312, *Atlantic Blue*'s bow grounded on a sandy shoal near Kirkcaldie Reef. The hull remained intact and there was no pollution. At 0700, the ship refloated on the flooding tide and was manoeuvred clear of the reef.

From the evidence available, the following findings are made with respect to the grounding. They should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors

- At 0130 on 7 February 2009, *Atlantic Blue*'s heading was altered to 066° (T) and, for more than 1 hour, no allowance was made for the strong wind abaft the port beam or the east-going tidal stream. As a result, the ship moved outside the boundary of the charted two-way route that it was transiting.
- The heading adjustments at 0237, 0246 and 0256, a total of 7 degrees to port, were too small to bring the ship back on track and it progressed about 1 mile south of, and parallel to, its planned track towards Kirkcaldie Reef.
- The alteration of course to port after 0307 was neither early enough nor large enough to avert the grounding.
- The passage plan did not define any off-track limits and the bridge team did not discuss these limits, define roles and responsibilities for track monitoring or use available automatic track monitoring functions to support a shared mental model.
- The position fixing and track monitoring methods used by the bridge team were not consistently accurate. This was a result of not making the most effective and appropriate use of the radar and global positioning system equipment.
- Bridge resource management was ineffective and the state of the bridge progressively declined in the absence of a shared mental model and adequate communication between members of the bridge team.
- At about 0230, the master left the bridge without checking if it was safe to do so by verifying *Atlantic Blue*'s position. If he had determined that the ship was a mile off-track and outside the two-way route, he probably would have initiated some corrective action and remained on the bridge to monitor the effectiveness of the action taken. As a result, the state of the bridge would not have continued to decline and the ship may have moved closer to the track.

- By not using the pilot's electronic charting system equipped laptop computer, an available aid to monitor *Atlantic Blue*'s progress and the additional defence it provided against a grounding was removed.
- *Atlantic Blue*'s safety management system procedures did not require specific off-track limits to be included in the passage plan or otherwise ensure that limits for effective track monitoring were always defined. *[Significant safety issue]*
- The pilotage system used by *Atlantic Blue*'s pilot did not define off-track limits or make effective use of recognised bridge resource management tools in accordance with the Queensland Coastal Pilotage Safety Management Code and regular assessments of his procedures and practices under the code's check pilot regime conducted over a number of years had not resolved these inconsistencies. *[Significant safety issue]*
- The 'shallow water alert' generated by the Great Barrier Reef and Torres Strait Vessel Traffic Service's (REEFVTS) monitoring system did not provide adequate warning of *Atlantic Blue* entering shallow water because the boundary of the defined shallow water alert area was too close to dangers off Kirkcaldie Reef. *[Significant safety issue]*
- The REEFVTS monitoring system did not provide an 'exiting corridor alarm' when *Atlantic Blue* exited the two-way route that it was transiting because the route had not been defined as a navigational corridor. *[Significant safety issue]*

3.3 Other safety factors

- In the period leading up to the grounding, the performance of *Atlantic Blue*'s bridge team members could have been affected by the normal decline at that time of the day due to the body's circadian rhythm. A decrease in the pilot's performance may also have resulted from reduced stimulation after the ship moved into relatively open and navigationally less challenging waters. The second mate's reduced sleep and increased working hours may have led to a decline in his task performance.

3.4 Other key findings

- *Atlantic Blue*'s voyage data recorder did not save incident data to any storage drive of its system because, at the time of the grounding, it was not functional. The equipment did not provide a failure indication, as required by international standards, that data had not been saved or backed up nor did it display any error, fault or warning to indicate a defect.
- The actions taken in response to *Atlantic Blue*'s grounding, both on board the ship and ashore were timely and appropriately managed.

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisations. In addressing those issues, the ATSB prefers to encourage relevant organisations to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

4.1 Fleet Management, Hong Kong

4.1.1 Passage planning procedures

Significant safety issue

Atlantic Blue's safety management system procedures did not require specific off-track limits to be included in the passage plan or otherwise ensure that limits for effective track monitoring were always defined.

Action taken by Fleet Management, Hong Kong MO-2009-001-NSA-017

Fleet Management has advised the ATSB that as a result of the incident a number of corrective measures have been, or will be, implemented on board ships managed by the company. These measures comprise action to directly address the safety issue and other action to support these direct measures and to avoid similar incidents.

The company has decided to revise its shipboard safety management system (SMS) procedures to include off-track limits. The passage plan will specify these limits for each leg of the passage. Procedures will require the officer of the watch (OOW) to call the master to the bridge if the OOW is unable to keep the ship within those defined limits.

Fleet Management has circulated a safety alert to managed ships highlighting *Atlantic Blue's* grounding to emphasise the importance of bridge team management and measures to avoid a similar incident. The measures include a mandatory risk assessment before the master leaves the ship's bridge during a passage.

The master-pilot information exchange checklist in the company's SMS has been revised. For a pilotage passage of long duration, the checklist includes identifying critical areas, marking master and pilot call points on charts and briefing the OOW for critical areas and required actions during the passage.

Training to support the measures above has been extended to include a process whereby masters and mates undertake a mandatory, 2 day 'navigational safety

course' before they join a Fleet Management managed ship. In addition, the company has implemented 'SAFER+', a behaviour based safety training tool, for its staff. *Atlantic Blue*'s second mate at the time of the grounding is to undertake another bridge team management course at the next opportunity.

ATSB assessment of action

The ATSB is satisfied that the action taken by Fleet Management will adequately address the safety issue.

4.2 Australian Maritime Safety Authority

4.2.1 Check pilot regime

Significant safety issue

The pilotage system used by *Atlantic Blue*'s pilot did not define off-track limits or make effective use of recognised bridge resource management tools in accordance with the Queensland Coastal Pilotage Safety Management Code and regular assessments of his procedures and practices under the code's check pilot regime conducted over a number of years had not resolved these inconsistencies.

Response from the Australian Maritime Safety Authority MO-2009-001-NSA-025

The Australian Maritime Safety Authority (AMSA) has advised the ATSB that a review of the coastal pilotage marine orders is being finalised. Changes will include an upgrade of check pilot procedures to promote more rigour and independence within the check pilot system. It is also intended to enhance pilot training and licence renewal requirements through the use of bridge simulators and additional testing and training requirements for trainee pilot licences. This training will focus on bridge team management, human factors and piloting to a passage plan. The marine orders will require standard passage plans to be employed and a consultative process to develop plans which are acceptable to all pilots is being progressed.

The review into Coastal Pilotage Services in the Torres Strait and Great Barrier Reef by AMSA and the Department of Infrastructure, Transport, Regional Development and Local Government, commenced in July 2008, is being progressed. An independent, full review of the fatigue management plan is also to be completed.

In its response, AMSA also advised that it has concerns that there may be systemic issues that could impact upon the safe operation of coastal pilots and the ability to fully develop a 'safety culture'. These concerns are based upon reports from pilots raising various issues about safety and certain aspects of pilotage operations.

ATSB assessment of response

The ATSB is not satisfied that the action proposed by the Australian Maritime Safety Authority will, by itself, adequately address the safety issue because specific information obtained from AMSA in relation to its concerns about the operations of

coastal pilots indicates that wider, significant safety issues may exist. Therefore, the ATSB will undertake a systemic, safety issue investigation into coastal pilotage which it aims to complete by the end of 2011.

4.3 Great Barrier Reef and Torres Strait Vessel Traffic Service (REEFVTS)

4.3.1 Shallow water alert

Significant safety issue

The 'shallow water alert' generated by the Great Barrier Reef and Torres Strait Vessel Traffic Service's (REEFVTS) monitoring system did not provide adequate warning of *Atlantic Blue* entering shallow water because the boundary of the defined shallow water alert area was too close to dangers off Kirkcaldie Reef.

Action taken by REEFVTS MO-2009-001-NSA-026

The Australian Maritime Safety Authority (AMSA), joint competent authority of REEFVTS, has advised the ATSB that a review of shallow water areas had already been started in late 2008. The review was conducted by REEFVTS staff from AMSA and Maritime Safety Queensland (MSQ). The joint review resulted in a decision to extend shallow water areas so that their boundaries are at least 2.5 miles, where possible, from the nearest shallow water or danger adjacent to a shipping track. These changes were implemented in March 2009, following *Atlantic Blue*'s grounding, and included enlarging the shallow water area off Kirkcaldie Reef. A process to annually review shallow water areas was introduced after the grounding.

ATSB assessment of action

The ATSB is satisfied that the action taken by REEFVTS adequately addresses the safety issue.

4.3.2 Exiting corridor alarm

Significant safety issue

The REEFVTS monitoring system did not provide an 'exiting corridor alarm' when *Atlantic Blue* exited the two-way route that it was transiting because the route had not been defined as a navigational corridor.

Action taken by REEFVTS MO-2009-001-NSA-027

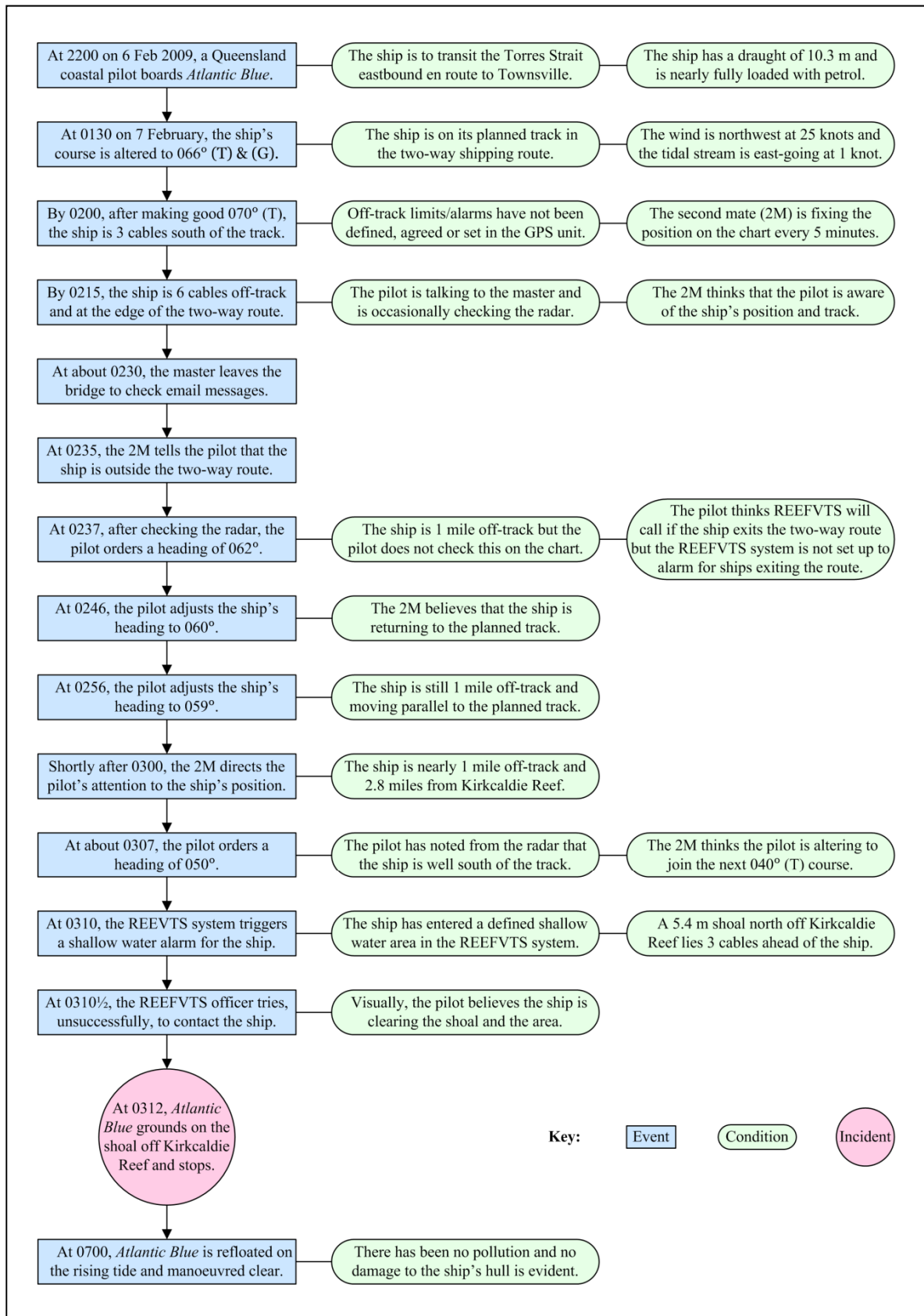
The Australian Maritime Safety Authority (AMSA), joint competent authority of REEFVTS, has advised the ATSB that following *Atlantic Blue*'s grounding a process to annually review electronic navigational corridors was introduced. Reviews are to be conducted by REEFVTS staff from AMSA and Maritime Safety Queensland (MSQ). The joint reviews completed have taken into account REEFVTS records of past tracks and positions of ships to define electronic

corridors that closely follow two-way routes. Two-way routes in the Torres Strait, including the route between Twin Island and Kirkcaldie Reef, have been defined as electronic corridors.

ATSB assessment of action

The ATSB is satisfied that the action taken by REEFVTS adequately addresses the safety issue.

APPENDIX A: EVENTS AND CONDITIONS CHART



APPENDIX B: SHIP INFORMATION

Atlantic Blue

IMO Number	9332028
Call sign	VRCZ8
Flag	Hong Kong, China
Port of Registry	Hong Kong
Classification society	Korean Register of Shipping (KR)
Ship Type	Chemical/products tanker
Builder	Hyundai Mipo Dockyard, Ulsan, Korea
Year built	2007
Owners	Heroic Hestia, Hong Kong
Ship managers	Fleet Management, Hong Kong
Gross tonnage	29,266
Net tonnage	12,023
Deadweight (summer)	47,128 tonnes
Summer draught	12.216 m
Length overall	183.21 m
Length between perpendiculars	174.00 m
Moulded breadth	32.20 m
Moulded depth	18.80 m
Engine	1 x MAN B&W 6S50MC-C
Total power	9,480 kW
Speed	14.4 knots
Crew	22

APPENDIX C: SOURCES AND SUBMISSIONS

Sources of Information

Master and crew of *Atlantic Blue*

Atlantic Blue's coastal pilot

Australian Maritime Safety Authority

Maritime Safety Queensland

Great Barrier Reef and Torres Strait Vessel Traffic Service (REEFVTS)

The duty REEFVTS vessel traffic service officer

Fleet Management, Hong Kong

Torres Pilots, Brisbane

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Submissions

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

A draft of this report was provided to *Atlantic Blue*'s master, second mate and coastal pilot, Fleet Management, Hong Kong, Torres Pilots, the pilotage provider company, the Great Barrier Reef and Torres Strait Vessel Traffic Service (REEFVTS), the duty REEFVTS vessel traffic service officer, the Australian Maritime Safety Authority (AMSA), Maritime Safety Queensland (MSQ), Samsung Heavy Industries, Korea (Samsung), the Korean Register of Shipping (KR), BP Australia (BP) and the Marine Department of Hong Kong (MARDEP).

Submissions were received from *Atlantic Blue*'s master, second mate and coastal pilot, Fleet Management, Torres Pilots, AMSA, MSQ, REEFVTS, Samsung, KR, BP and MARDEP. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Independent investigation into the grounding of the Hong Kong registered products tanker *Atlantic Blue* at Kirkcaldie Reef, Torres Strait on 7 February 2009.