Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT
Aviation Occurrence Investigation
AO-2009-068
Final

Operational event
132 km west of Horn Island Aerodrome
Queensland
9 November 2009
VH-EMZ
Bell Helicopter 412

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Figures 1 and 8: Chris Howell, Southern Shipping Services Limited, New Zealand
Figure 2: Geoscience Australia (inset map: *http://www.clker.com/* website)
Figure 6: Master and crew of *Maersk Duffield*
Figures 15 and 22: Wire Rope Users Manual (Fourth Edition), Wire Rope Technical Board
Figure 21: Australian Maritime Safety Authority

Abstract

At about 1500 Eastern Standard Time on 9 November 2009, a Bell Helicopter Company 412 helicopter, registered VH-EMZ and operating as call sign ‘Rescue 700’, departed Horn Island Aerodrome, Queensland to rendezvous with a container ship located about 132 km to the west of Horn Island. The purpose of the flight was to evacuate an ill crew member and transfer him to hospital.

Prior to arrival, the flight crew had been advised that the patient would need to be recovered via rescue winch from the ship’s forecastle. Approaching overhead the winching area, with the rescue crew officer (RCO) and paramedic being lowered by the winch and about 6 m above the deck, the pilot lost sight of the ship. Shortly after, the helicopter began drifting back towards a mast that was located on the forecastle. Despite assistance from the winch operator to re-establish the hover, the pilot was unable to arrest the helicopter’s movement and the winch cable became fouled on the foremast while the helicopter continued to drift rearwards. The winch cable separated and the paramedic and RCO fell about 10 m to the ship’s deck, seriously injuring both personnel.

The investigation identified that the requirement to confirm adequate hover reference existed overhead an intended winch area, before deploying personnel on the winch, was left to the pilot’s discretion. In this instance the pilot, despite his extensive experience, did not identify the possibility of losing sight of the ship, and therefore the necessary hover reference.

Following the occurrence, the helicopter operator issued an instruction to aircrew emphasising the importance of ensuring that adequate hover reference exists during winching operations. The helicopter operator also commenced a review of its operations manual to ensure that it provides sufficient procedural guidance for winching operations and commenced the development of company-wide aviation risk management training that will commence in early 2011.

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.

FACTUAL INFORMATION

History of the flight

On 5 November 2009, the container ship *Maersk Duffield* (Figure 1) departed Singapore on a voyage to Australia and New Zealand via the Torres Strait and the inner route of the Great Barrier Reef. At about 1100 Eastern Standard Time[1] on 9 November 2009, the ship's master contacted the Australian Rescue Coordination Centre (RCC) via satellite telephone and requested medical assistance in relation to an ill crew member. The RCC organised for a doctor to contact the vessel and, following discussion with the master, the doctor assessed that the crew member should be transferred to hospital at the earliest opportunity.

Figure 1: Container ship *Maersk Duffield*

At about 1500[2], a Bell Helicopter Company 412 helicopter, registered VH-EMZ and operating as call sign 'Rescue 700' departed Horn Island Aerodrome, Queensland, to rendezvous with the ship about 132 km to the west of Horn Island (Figure 2) and transfer the crew member to hospital. On board the helicopter were the pilot, who was seated in the front right seat; an air crew officer (ACO), who was seated in the front left seat[3]; and a rescue crew officer (RCO)[4] and paramedic, who were seated in the rear cabin.

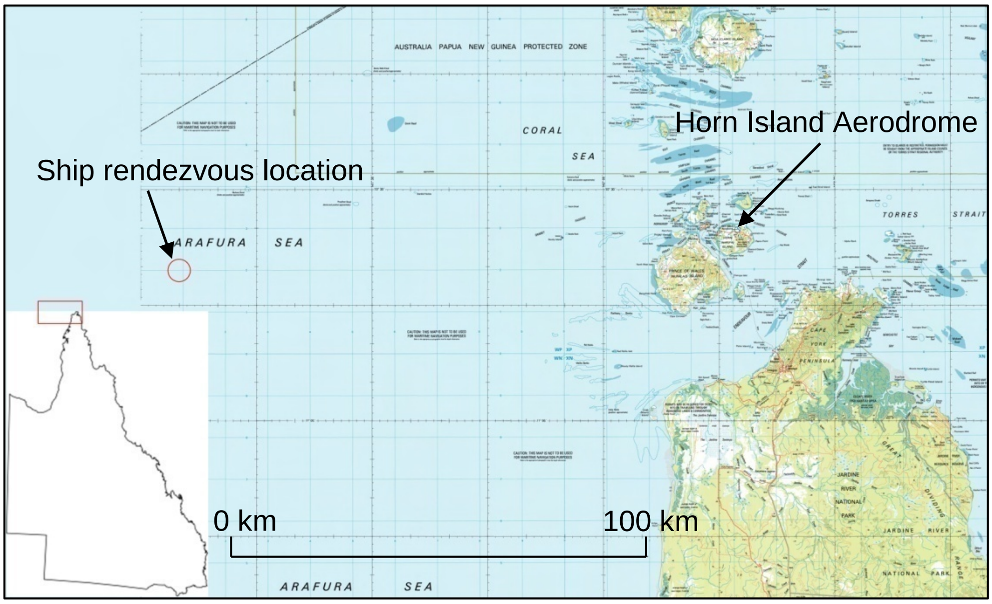
1 The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred. Eastern Standard Time was Coordinated Universal Time (UTC) + 10 hours.

2 The helicopter's departure was delayed until the ship was within the helicopter's effective range.

3 The ACO generally occupied the front left seat and relocated into the rear cabin when required to operate the rescue winch.

4 The RCO's role was to accompany the paramedic on the rescue winch.

Figure 2: Area map



Prior to departure from Horn Island, the crew were informed by the RCC that the ship's crew were not familiar with helicopter operations and that there was no area on the ship suitable for the helicopter to land. The RCC further advised that only the forecastle area (Figure 3) was suitable for winching operations, and the following details of the intended winching area were provided:

> winch area: forecastle of the ship, dropping area is located ahead from forward mast [foremast] (16.2 m high), horizontal clearance from mast on deck is about 8-9 meters, in this area there are no obstructions higher than 1.5 meters.

Figure 3: *Maersk Duffield* forecastle, as seen from the radar scanner platform[5]

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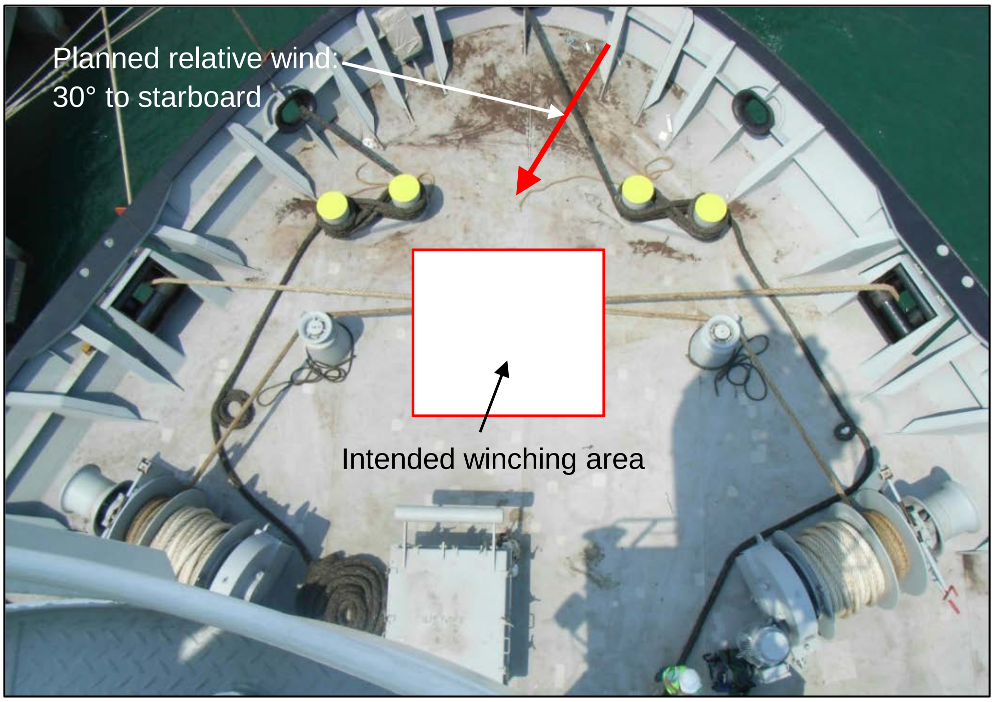
5 This image was taken while the ship was berthed. At the time of the accident, the forecastle was clear of mooring ropes.

Images of the ship, including of the forecastle were also provided to the crew prior to departure.

Following receipt of the information from the RCC, the pilot and the available two crew officers[6] discussed the procedure for retrieving the patient. A plan was developed to request the ship to manoeuvre to provide a relative wind[7] that was about 30° off the starboard side in order to provide the pilot with a visual reference of the ship (Figure 4). The ACO reported that, in order to reduce the overall time required to conduct the retrieval, the RCO suggested that he and the paramedic be winched together directly onto the forecastle.[8]

Figure 4: Planned winching area[9] and relative wind



The pilot reported that no formal risk assessment of the proposed task was conducted, although the potential hazards associated with the movement of the ship were considered during the planning. The pilot and ACO reported that the suitability of the plan, including the conduct of the double winch, was to be reviewed on arrival at the ship. Additional equipment to enable the conduct of a Hi-line winch transfer (see the section titled *Ship-helicopter transfers*) was carried in the event that the plan proved unsuitable.

Based on the expected position of the ship and weather conditions, the pilot calculated that the helicopter had sufficient fuel to remain with the ship for about

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6 The paramedic was based at the nearby Thursday Island hospital, and not present for the initial flight planning.

7 The wind measured with respect to an aircraft in flight. In this case, the relative wind during the winch was a combination of that affecting the helicopter as a result of the ship's movement and the ambient wind.

8 Commonly termed a 'double winch', where two persons are winched simultaneously.

9 Image taken while the ship was berthed. The intended winching area was clear of ropes and other obstructions during the winch.

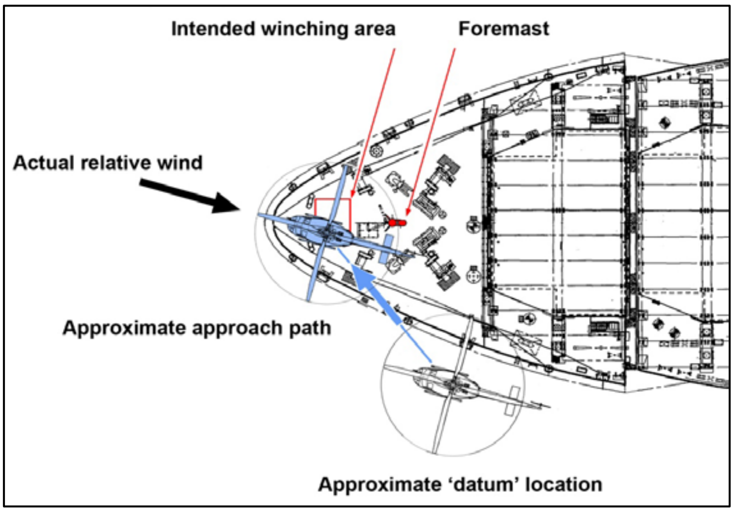
20 minutes. The pilot reported that due to the conservative nature of the fuel planning, he estimated that the actual time available on arrival at the ship may increase by 8 to 10 minutes; and that this was conveyed to the crew. In order to maximise the available time at the ship, the paramedic was picked up from his Thursday Island base and the helicopter returned to Horn Island, shutdown and refuelled before departure for the ship's position. During this time the planned retrieval, including the intention to conduct the double winch, was discussed with the paramedic.

At about 1538, the helicopter arrived in the vicinity of the ship. The pilot assessed that there was 'plenty of fuel' to conduct the operation and stated that he would have advised the ACO of this. The pilot conducted a number of orbits of the ship to assess the proposed winching area and the relative wind via smoke from the ship's funnel. Following that reconnaissance, the pilot requested that the ship's master change the ship's heading and reduce speed in order to obtain the originally planned relative wind. There was no restriction to the manoeuvring of the ship in preparation for the winch.

While the ship was altering onto the requested heading, the pilot conducted a final orbit and confirmed that the crew were ready to commence the winch. The ship's master then advised the pilot that the ship was established on the requested heading, the speed was reducing to the target speed of 10 kts and that he was cleared to commence winching.

At about 1550, the pilot approached the ship and terminated to the hover alongside at a position known as the 'datum' (Figure 5), from which the crew had a clear view of the winching area. While established at the datum with the helicopter facing into the relative wind, the pilot and ACO assessed the obstacles in the proximity of the winching area and confirmed that the helicopter had sufficient power margin[10] to conduct the winch. The pilot reported that although the helicopter airspeed indicator showed about 30 kts while hovering at the datum, there was no associated turbulence.

Figure 5: Helicopter approaching the forecastle (shown to scale)



[10] The difference between the power available from the helicopter's engines and the power required to hover. In this instance the headwind provided a beneficial aerodynamic effect and reduced the power required.

The ACO obtained permission from the pilot to commence the winch and began lowering the crew while the pilot began moving the helicopter towards the forecastle with the helicopter facing into the relative wind (Figures 5 and 6). A short time later, the pilot called 'losing sight'[11] and the ACO commenced providing verbal guidance to allow the pilot to manoeuvre the helicopter towards the designated winch area. The pilot recalled that this guidance included instructions to descend as the helicopter approached the forecastle. The ACO reported that the crew had agreed to maintain about 20 ft vertical clearance from the foremast.

Figure 6: Approaching the winching area[12]

The pilot reported that as the helicopter approached overhead the target area with the ship's structure as a hover reference, he glanced inside the cockpit to check the cockpit instruments. On looking back outside he could no longer see the ship. In response, the pilot changed hover reference to the view of the horizon directly to the front of the helicopter and announced to the ACO that he had 'lost reference'. The pilot reported that although he had not considered the possibility of losing sight of the ship, he believed that any unintended movement of the helicopter due to the inferior hover reference would be compensated for by guidance from the ACO.

The ACO recalled that at the time the pilot called 'lost reference', the RCO and paramedic were about 6 m above the forecastle deck and nearing the centre of the winch area. He stated that on hearing the term 'lost reference', he understood that the pilot could no longer see the ship. A short time later, the ACO observed the helicopter begin to drift rearwards towards the ship's foremast. The ACO immediately announced the drift to the pilot and requested that he move the helicopter forward. In response, the pilot applied a forward correction that he assessed would be sufficient to arrest the movement. However, the helicopter continued to drift towards the foremast.

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11 This statement indicated that the pilot had lost sight of the winching area. Given the relative position of the pilot to the helicopter winch this will always occur approaching overhead the winching area. The statement is a signal to the ACO to commence providing verbal guidance to assist the pilot to position the helicopter overhead the winching area (see the section titled *Ship-helicopter transfers*).

12 These images were taken from the bridge of the *Maersk Duffield* as the helicopter approached the forecastle. The final image, showing the helicopter about 33 ft above the foremast, was taken shortly before the RCO and paramedic were lowered out of view towards the winching area.

The ACO again requested that the helicopter move forward and in response, the pilot applied a second, larger correction. Despite this, the helicopter continued to drift towards the foremast and the RCO and paramedic contacted the radar scanner platform railing on the foremast. The ACO started lowering the winch cable at full rate to reduce tension on the cable and informed the pilot that the cable was fouled on the foremast.

The helicopter continued to drift backwards over the ship and to the left of the foremast. The ACO observed that the winch cable was caught on the helicopter's skid guard and running at an angle down towards the foremast (Figure 7), and that despite continuing to pay out on the cable, it remained under tension.

The pilot stated that following the announcement by the ACO that the cable had fouled the foremast, and before he had time to make another correction, he felt a slight movement of the helicopter and the ACO informed him that the winch cable had separated and the RCO and paramedic had fallen to the ship's deck. Neither the pilot nor the ACO recalled any sound or movement associated with activation of the winch overload clutch (see the section titled *Aircraft information*) prior to the separation of the cable. Following the cable separation, the ACO reported seeing the loose cable; however, neither he nor the pilot recalled any indication that the cable had contacted the helicopter.

Subsequent to the separation of the winch cable, the pilot climbed the helicopter and moved to the left to regain sight of the ship. Once visual reference with the ship was regained, the helicopter was established in a hover. The ACO then retrieved the winch cable while the pilot advised the ship's master of the accident and requested all available medical assistance be provided to the fallen crewmembers.

Following an assessment by the ship's crew members who were standing by on the forecastle to assist with the transfer, the master advised the helicopter pilot that both his crewmembers had sustained serious injuries. As retrieval of the crewmembers using the helicopter was not possible, the helicopter crew commenced organising medical assistance from Horn Island via satellite telephone and radio before departing for Horn Island at about 1615.

The paramedic was subsequently winched from the ship's forecastle at about 1820 using a second helicopter and transferred to hospital. The RCO and the original patient were recovered by boat later that evening and transferred to medical facilities.

Personnel information

Pilot

The pilot held an Air Transport Pilot (Helicopter) Licence that was issued in 1993. He was endorsed on the Bell 412 and held a Class 1 Aviation Medical Certificate without restriction. The pilot was also endorsed to conduct winching operations.

The pilot reported that his total flying experience was in excess of 8,000 flying hours, of which about 2,000 hours were obtained in command of the Bell 412 helicopter. He was the operator's senior pilot at the Horn Island base and a company-assigned line-training pilot with approval to conduct in command under supervision (ICUS) training.

The pilot's most recent flight review was conducted on 25 June 2009 in the form of a company night winching check flight. The pilot stated that, although he was familiar with operations to ships, as a result of past experience conducting marine pilot transfers, he had not previously conducted winching operations from a ship's forecastle.

Air crew officer

The ACO had about 7 years experience in various crew-related roles, including as a rescue crew officer and winch operator. He had been employed as an ACO on Bell 412 and BK117 helicopters at the operator's Adelaide base since 2007. His experience prior to 2007 was obtained on a volunteer and casual basis.

The ACO reported that he had about 690 hours of operational experience, including in excess of 25 winch sorties of which about eight had been conducted to ships. The ACO's most recent flight review was conducted on 13 June 2009 in the form of a company night operations check flight that incorporated winching.

At the time of the occurrence, the ACO was conducting a relieving tour at Horn Island to accommodate the leave requirements of other flight crew. He had conducted a number of flights with the pilot in the 4 days prior to the accident.

Aircraft information

The Bell 412 is a single main and tail rotor-equipped helicopter that is powered by two gas turbine engines, and equipped with skid-type landing gear (Figure 6). The occurrence aircraft was equipped with an electrically-powered rescue winch that was fitted on the right of the helicopter, adjacent to the rear cabin (Figure 7).

Figure 7: VH-EMZ

The winch and 76 m long cable had a maximum allowable lifting weight of 272 kg and a rated speed of 76 meters per minute (m/min) when lowering the cable. The cable retrieval speed varied between 46 m/min and 76 m/min depending on the weight on the cable. The investigation determined that the weight on the cable at the time of the occurrence was below the maximum allowable.

The nominal breaking strength of the winch cable was 1,510 kg and in order to limit the load that could be applied to the cable, the winch incorporated an overload clutch assembly. That assembly was designed to slip and reel out cable if a weight between 578 kg and 694 kg was applied to the winch cable.

Ship information

The *Maersk Duffield* was a 281 m long cellular container ship that was powered by a single diesel engine driving a single, fixed-pitch propeller (Figure 8). The ship had a service speed of 24.9 kts (46 km/h). The forward mast (foremast) radar scanner platform was 9.9 m above the forecastle deck and the scanner itself was about 1.8 m above the platform. The foremast was located about 10.5 m behind the ship's bow.

Maersk Duffield was not equipped for routine helicopter operations. In order to conduct the medical evacuation, the ship's master assessed that the forecastle was the only area that was suitable for winching operations, based on a consideration of the ship itself and his experience of helicopter operations on other ships.

Figure 8: *Maersk Duffield*

Helicopter examination

An examination of the helicopter's rescue winch identified that the cable separated about 14 cm from the hook (Figures 9 and 10). There was also evidence of white paint on the bump stop striker plate (Figure 11), which was consistent with contact between the winch cable and the ship's white-coloured foremast structure.

Additionally, marks on the helicopter's main and tail rotor blades, right horizontal stabiliser and cabin roof were consistent with the cable having recoiled following the separation and contacted the helicopter (Figures 12 to 14). The winch and remaining cable, together with the winch hook and cable segment were retained for detailed technical examination.

Figure 9: Winch cable hook and bump stop

Figure 10: Winch cable

Figure 11: Contact marks on bump stop striker plate

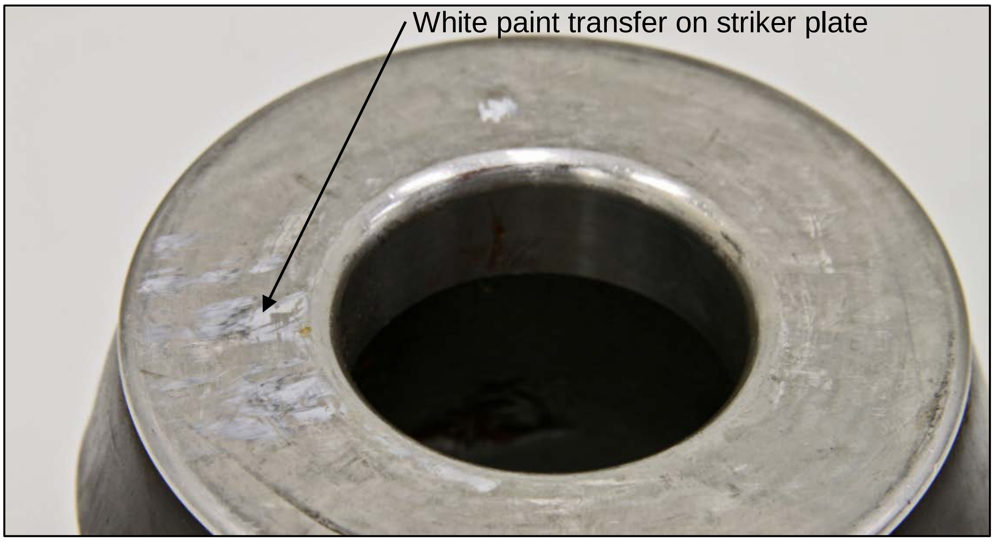


Figure 12: Contact marks on the main rotor

Figure 13: Contact marks on the tail rotor

Figure 14: Contact marks on the horizontal stabiliser

Winch examination

Operational testing[13] of the rescue winch, including actuation of the overload clutch, was conducted at a Civil Aviation Safety Authority-approved maintenance facility under the supervision of the Australian Transport Safety Bureau (ATSB). The clutch operated normally during the testing and all other aspects of the operation of the rescue winch were found to be within the required limits.

Following functional testing, the rescue winch was disassembled to assess the internal serviceability of the clutch assembly and other components that may have potentially inhibited the operation of the winch. As a result of that examination, the winch was found to be in good condition and no defects were identified that would have affected its operation.

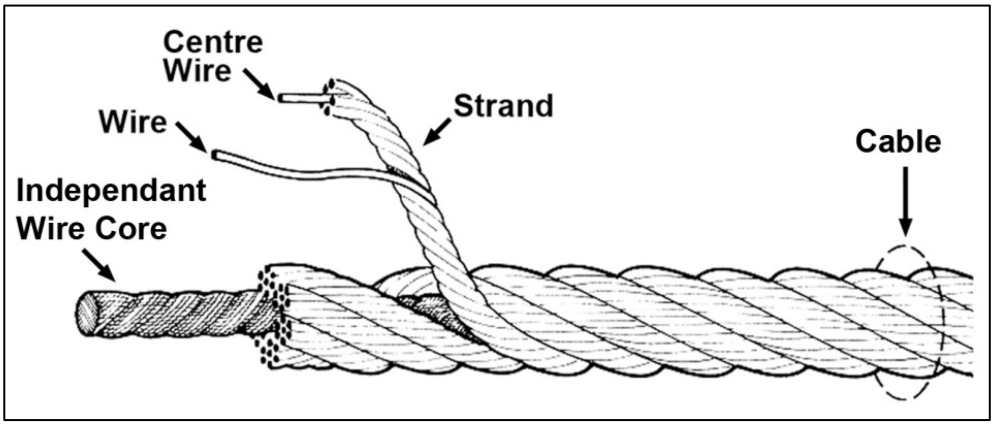
The overload clutch was constructed of a series of alternating friction plates and steel discs. The inherent material characteristics of the friction plates may permit the application of a dynamic load to the cable that is greater than the static loads necessary to activate the clutch during the technical testing.

Winch cable examination

The 3/16th inch diameter winch cable comprised an independent wire core that was surrounded by a layer of central strands. The 19 strands each consisted of seven smaller diameter individual wires (Figure 15).

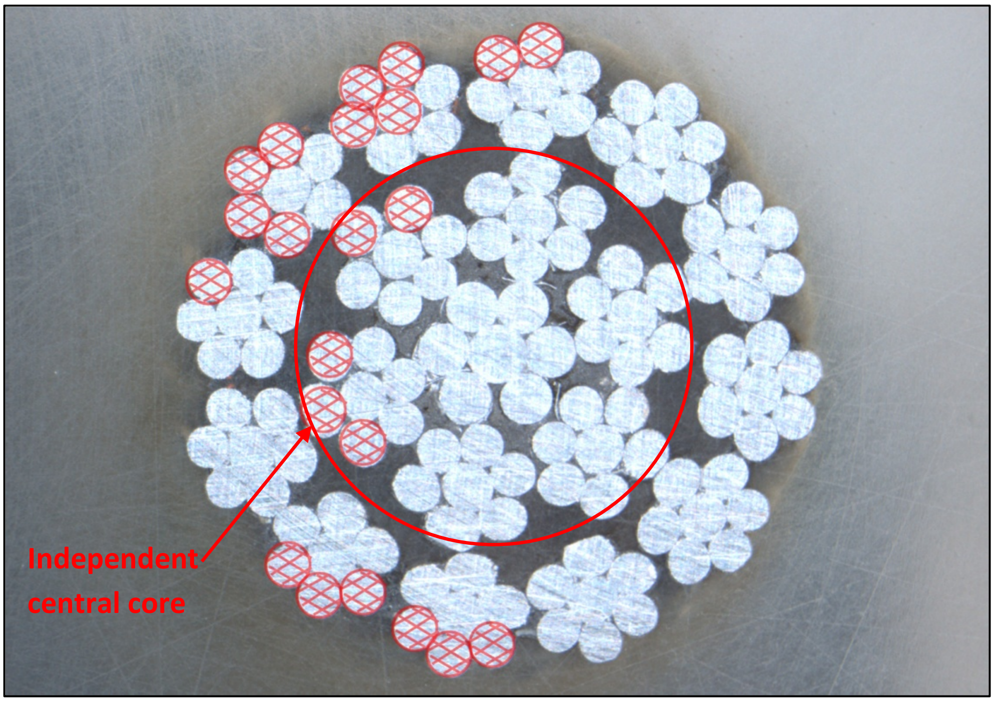
13 The original winch cable was replaced prior to the commencement of the test.

Figure 15: Winch cable construction



Examination of the winch cable via visual and scanning electron microscopy techniques identified that about 17% of the cable had been severed through abrasive contact with the foremast structure (Figure 16). The separation of the remainder of the cable was consistent with the effects of a combination of shear and tensile overstress. There was no evidence of fatigue failure within any of the cable strands.

Figure 16: Cross-section of the winch cable - abrasion-damaged strands highlighted in red[14]



An inspection of the entire cable length revealed that, aside from the damage close to the separation point, there were no other forms of degradation such as corrosion, broken wires or kinks.

In order to determine the breaking strength of the cable, six samples of the winch cable were subjected to tensile strength testing at an approved test facility. [15] The

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[14] Owing to the disruption of the individual strands, the exact location of the abraded wires could not be determined. The Figure provides an indication of the total number of abraded wires.

test results identified that the ultimate strength of the cable exceeded the military specification to which it had been manufactured. [16] The chemical composition of the cable was also assessed and found to comply with the military specification required by the hoist manufacturer.

Ship examination

An examination of the foremast structure following the ship's arrival in Brisbane identified marks that were consistent with contact between the winch cable and the radar scanner and the associated platform railing (Figures 17 to 20).

Figure 17: Contact marks on the radar scanner

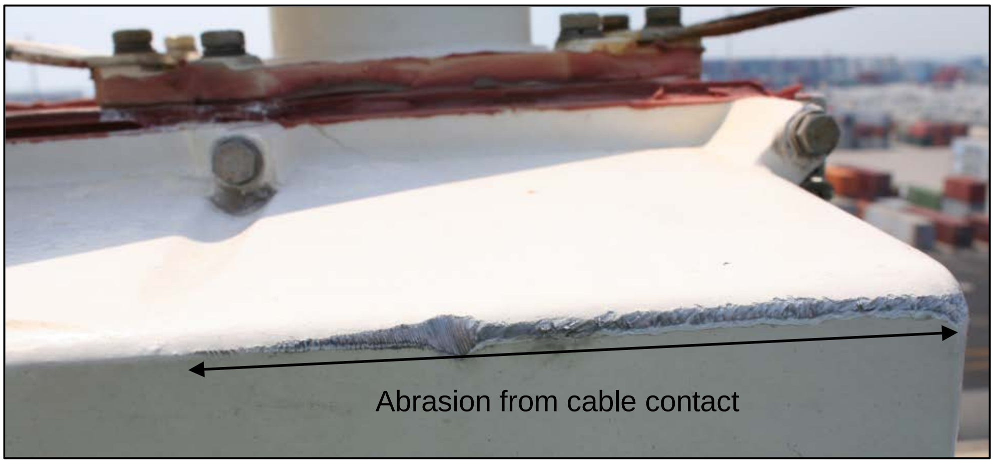
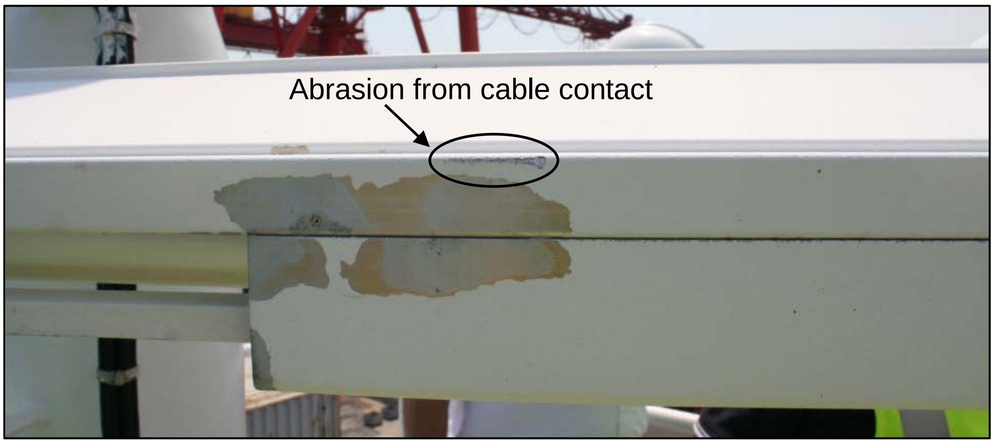


Figure 18: Additional contact marks on the radar scanner



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[15] The cable was tested at a National Association of Testing Authorities, Australia-accredited laboratory.

[16] One of the test results was discarded as the sample failed at the fitting that was used to apply tensile load to the cable.

Figure 19: Additional contact marks on the radar scanner

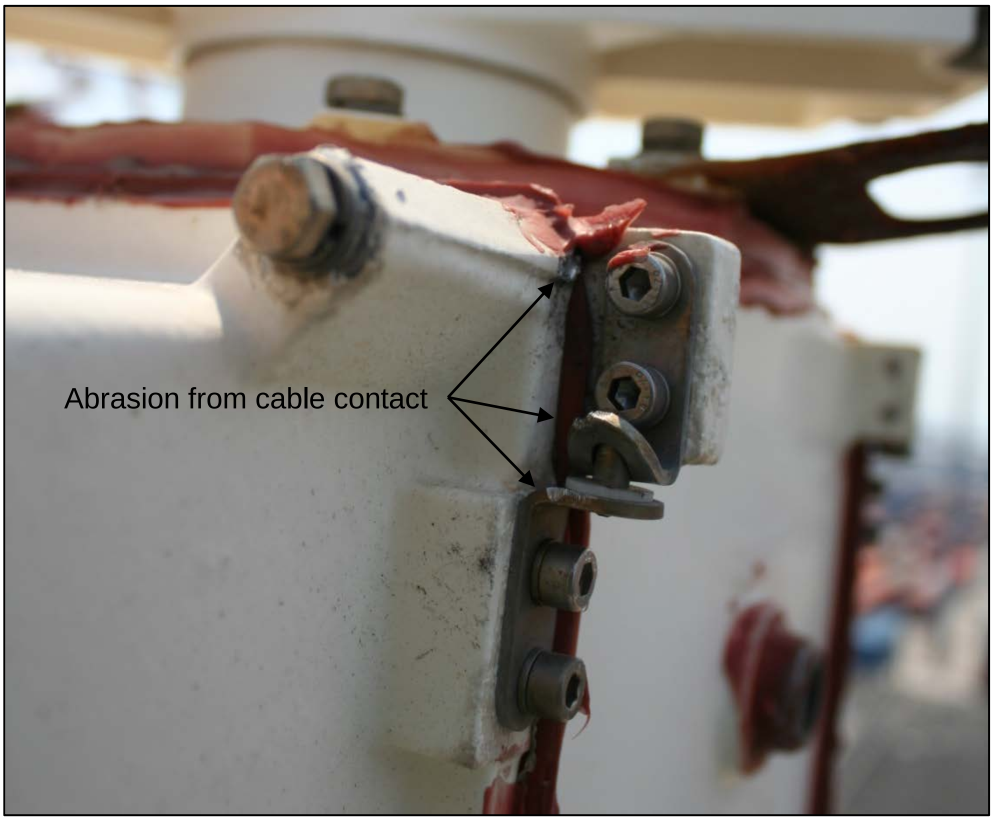
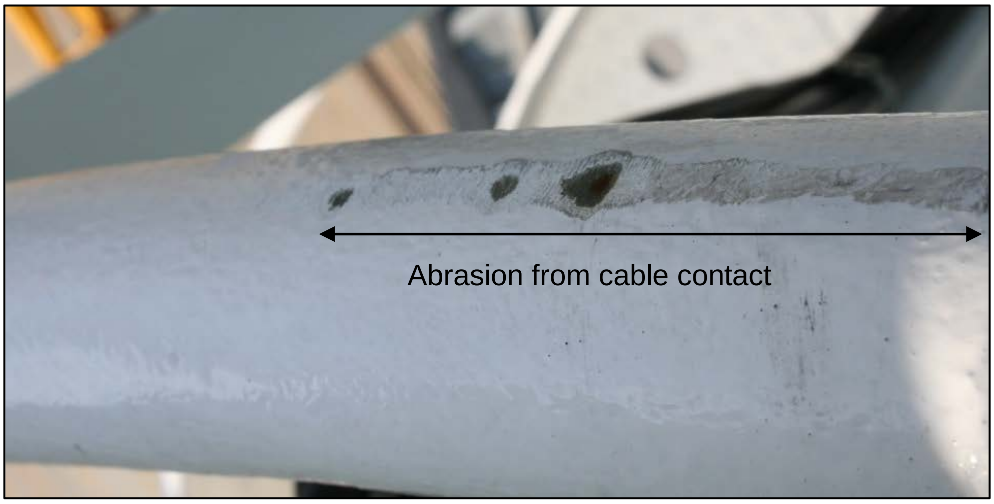


Figure 20: Contact marks on the radar scanner platform railing



Meteorological information

The relevant Area Forecast[17] and Horn Island Aerodrome Forecast both indicated the presence of a strong south-easterly wind. That was consistent with the relative wind from 016° to the right of the ship's centreline at 27 kts, and the ship's

[17] For the purposes of providing aviation weather forecast to pilots, Australia is sub-divided into a number of forecast areas. The occurrence flight was contained within area 45.

movement that was recorded by the ship's voyage data recorder (VDR)[18] at the time of the occurrence. The pilot's recollection of the helicopter's indicated airspeed while hovering at the datum was consistent with the recorded relative wind.

The ship's master stated that there was no observable pitching or rolling of the ship's deck during the winching operation.

Organisational and management information

Winching procedure

The helicopter operator's operations manual detailed the conduct of winching to and from ships using both vertical lift and Hi-line transfer techniques. The procedure for the conduct of vertical lifts included that:

> The approach is to be carried out to the winch area and this position maintained while the Rescue Crewman is lowered. If a clear run in is possible, the Rescue Crewman may be lowered early, however the presence of obstructions may necessitate delaying winch out until the hover is established over the winch area.

The discussion in the operations manual of the suitability of an intended winching area stated that:

> On every occasion the priority must be to provide the helicopter crew with a clear unrestricted view whilst affecting the transfer into the relative wind.
>
> ...Whilst in the hover the transfer area should be ideally an area which affords the pilot maximum hover references. It is important that where ever possible the pilot has a substantial part of the vessel as a reference.

There was no requirement for the crew to confirm the existence of adequate reference prior to lowering personnel on the rescue winch.

The chief pilot stated that there was the option for an initial 'dummy' approach and termination overhead the target area to assess the hover reference, prior to overshooting for a second approach for the winch. The decision to conduct such an approach was left to the pilot's discretion, based on their assessment of the expected hover reference overhead the winch area.

A discussion with the chief pilots of five other comparable organisations identified two operators that similarly left the decision of the need to assess the adequacy of the available hover reference prior to placing personnel on the rescue winch up to the pilot. The other three chief pilots advised that their procedures required confirmation that adequate hover reference existed prior to deploying personnel on the rescue winch.

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18 The voyage data recorder is similar in function to the commonly-known aircraft 'black box' flight recorder. It records a number of vessel parameters and sounds from the vessel's bridge, including radio transmissions and conversations between the crew.

The operations manual also stipulated the phraseology between the pilot and ACO associated with the approach to the hover. That included the definition of the key words 'losing sight' as meaning:

> The pilot is losing sight of the intended winch area or target/survivor.

There was no reference in the operations manual to the procedure to be followed in the event of a loss of hover reference. The pilot stated that there was no discussion among the crew of the procedure to be followed in the event of a loss of hover reference, as it was assumed that adequate reference would exist during the conduct of the winch.

During the course of this investigation, the ATSB was notified of another event involving a different helicopter operator that occurred during a winching sortie to a small vessel. In that instance, the pilot lost visual reference with the vessel and while manoeuvring to regain reference, a crewman was injured. The involved pilot reported that there was no discussion among the crew of the potential for the loss of visual reference, and that no assessment of the hover reference was conducted prior to commencing winching.

Risk management

The helicopter operator had conducted task risk assessments for a number of regular activities, including winch recovery. The potential hazards identified during the operator's winching risk analysis included:

> Insufficient hover reference causes excessive drift leading to hoistee [sic] impact with obstacles.

The associated treatment included the calculation of out-of-wind helicopter performance to facilitate improved hover reference, and the use of the ACO to assist the pilot to maintain position as follows:

> Crewman to provide continual commentary of height and position and obstacle clearance in a hover position with no hover reference.

The chief pilot stated that formal risk assessment processes, including the consideration of a task risk analysis, were in use at the company's Adelaide base; however, no such activity was undertaken for operations at the Horn Island base.

With regards to the risk assessment of winching activities, the operations manual required:

> Before any winching operation takes place a risk assessment should be undertake [sic] using formal processes or during the pre-flight briefing and three (3) important considerations MUST be applied. These are:
>
> - When to winch
> - Time in the hover, and
> - Crew qualifications & recency

The pilot reported that the potential hazard posed by the movement of the ship's deck was discussed during the pre-flight briefing.

Additional information

Ship-helicopter transfers

Maersk Duffield's helicopter winching area

While *Maersk Duffield*'s master and chief mate had undertaken several marine pilot helicopter winch transfers in the past on other ships, this was the first time the remainder of the crew had taken part in a helicopter winching operation on the ship.

The ship's safety management system did not contain any specific procedure for helicopter winching operations from the ship. Therefore, preparations for the winch were undertaken following the guidance provided in two on board publications that are required to be carried on merchant ships; the International Chamber of Shipping's (ICS) *Guide to helicopter/ship operations* and the *International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual*, Volume III (mobile stations).[19] The master also followed the directions given by the helicopter pilot when he set the ship's course and speed for the transfer of the helicopter crew.

The ICS *Guide to helicopter/ship operations* provides guidance for ship's staff on the safe performance of helicopter/ship operations. That advice has been obtained from many aviation and maritime sources, and includes details on winching operations and recommendations on the dimension of a helicopter winching area.

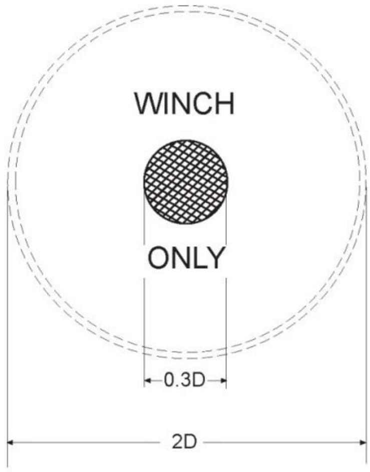
The dimension of a helicopter winching area is based on the overall length of the helicopter (labelled 'D'). The dimension of a generic winching area was listed as a circle with a diameter of 0.3D and of a manoeuvring area,[20] a circle with a diameter of 2D (Figure 21). In the case of a Bell 412 helicopter, that corresponded to a winching zone of 5 m diameter and a manoeuvring area of 34 m diameter.

In Australia, the Australian Maritime Safety Authority (AMSA) Marine Order Part 57 *Helicopter operations* and *Ship-Helicopter Transfers Australian Code of Safe Practice* for the conduct of transfers between helicopters and ships, reflects the content in the ICS guide.

19 Jointly published by the International Maritime and Civil Aviation Organizations (IMO & ICAO).

20 The area necessary to allow for such things as sudden up-draughts or cross-draughts due to ground effect, or turbulence caused by the proximity of ship's superstructure.

Figure 21: International Chamber of Shipping-recommended helicopter winching area



Maersk Duffield is a large container ship, on which large open spaces required for helicopter operations did not exist. Consequently, any temporary winching area on board the ship could not comply with the winch zone and manoeuvring area dimensions contained in the ICS guide. This problem was recognised in the ICS guide, which provided assistance to ship's staff with regard to the selection of a suitable location on board to safely conduct helicopter winching operations. That was particularly the case in the event of an emergency, when the ICS guide allowed that:[21]

> On ships which, because of their size or design or nature of their cargoes, are not suited for routine helicopter operations, consideration should nevertheless be given to the best position for a helicopter to take off or land people and/or equipment in an emergency.
>
> This type of emergency operation will normally be carried out by winching, and whenever possible the requirements for a winching area specified [in this guide] should be met. However, there will be many ships which cannot provide even these minimum requirements. In such cases, the ship must look for the highest area clear of obstructions to which a helicopter can safely manoeuvre and over which it can hover.

The decision to undertake the winch to the forecastle was made by the master. The other options available for consideration were the ship's bridge wings, the monkey island;[22] or the top of the containers on the deck. The bridge wings and monkey island were considered unsuitable because of the number of aerials and other obstructions present, and the height of the containers above the deck meant that they were not accessible by the ship's crew. The forward part of the forecastle was chosen because it was clear of obstructions and considered to be large enough for the operation to be carried out safely (Figure 4).

As *Maersk Duffield* steamed towards the rendezvous position, the forepart of the forecastle was cleared of equipment and debris and a temporary winch landing area

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21 See section 7.3 (Emergency operating areas), page 55. The International Chamber of Shipping. (2008). *Guide to helicopter/ship operations (Fourth edition)*, London, UK: Marisec Publications.

22 The part of the ship located above the bridge/wheelhouse on which the main mast, flag halyards and communications aerials/domes are situated.

of about 4 m by 4 m was indicated by pieces of fabric between the foremast and the ship's bow.[23] A landing party that was headed by the chief mate was standing by on the forecastle, clear of the winching area, to assist the helicopter crew when they arrived on board. The crew member to be evacuated was also taken to the forecastle so that he could be quickly assessed by the paramedic and then strapped into a stretcher and winched on board the helicopter.

Helicopter crew coordination

Given the relative position of the pilot to the helicopter's winch (Figure 7), as the helicopter approaches overhead a winching area, the pilot always loses sight of the target area. The height of the helicopter during the approach to the hover will influence the position at which that loss of sight of the target area takes place. The higher the approach height, the earlier the pilot will lose sight. The pilot therefore has to rely on nearby hover references to maintain position over the target. The ACO provides assistance to the pilot, via running commentary-type directional instructions, to manoeuvre the helicopter over the area and maintain the hover position during the conduct of the winch.

As the helicopter approaches the winching position, the call 'losing sight' from the pilot (see the section titled *Organisational and management information*) provides the signal to the ACO to commence providing directional guidance. This call can be made prior to the pilot actually losing sight of the intended winching area, in order to allow the ACO a period of transition in guiding the helicopter prior to terminating in the hover overhead the target area.

Hi-line transfer

Hi-line transfer is a ship-helicopter winching technique that utilises personnel on the affected vessel to assist the positioning of winch occupants to and from a winching area. The technique involves the attachment of one end of a rope (Hi-line) to the rescue winch hook and the delivery of the other end to the vessel using either the rescue winch or via an RCO swimming to the vessel. The personnel on the vessel use the Hi-line to manoeuvre the winch hook and occupants as the rescue winch is raised or lowered. Throughout the transfer, the helicopter remains clear of the vessel.

The characteristics and use of Hi-line transfer were discussed in the Royal Australian Navy (RAN) publication titled *Australian Book of Reference (ABR) 5419*.[24] That text highlighted that:

> ...The Hi-line Winch Transfer method:
>
> (a) Involves the majority of the winching evolution being conducted with the aircraft clear of the vessel/obstructions.
>
> (b) Requires personnel being on the deck to assist in the recovery of the wireman or strop.
>
> (c) Provides an additional measure of safety and control when conventional deck winching methods are considered too hazardous.

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23 The foremast was located about 10.5 m behind the ship's bow.

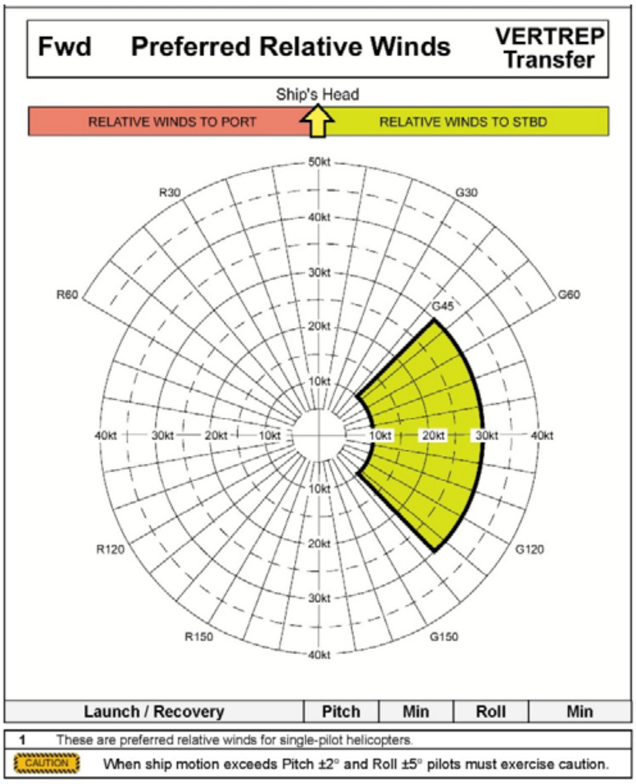
24 See Annex B to Chapter 6 of ABR 5419. http://www.navy.gov.au/w/images/ABR_5419_Vol_1_Chap_6_Annex_B-Transfer_Evolutions.pdf

(d) Should be considered in conditions such as:
   i. the winching area is confined or obstructed, and there is a risk of the wireman/passenger striking or snagging any obstructions;
   ii. the vessel is too small, or the winching area is located in a position that does not allow the pilot to maintain visual contact with the vessel while hovering;
   iii. the vessel/submarine movement is assessed as hazardous to the aircraft due to sea state and/or winds; and
   iv when normal winching areas are unusable for any reason such as weather conditions or damage to the vessel...

Relative wind

The RAN book of reference provided the following guidance[25] for helicopter crews in respect of the relative wind for VERTREP transfer:[26]

> Normally the helicopter will hover into the relative wind and the pilot should be able to see part of the ship as a hover reference and have a line of approach and departure clear of obstructions. As a general guide ships should provide relative wind conditions as follows:



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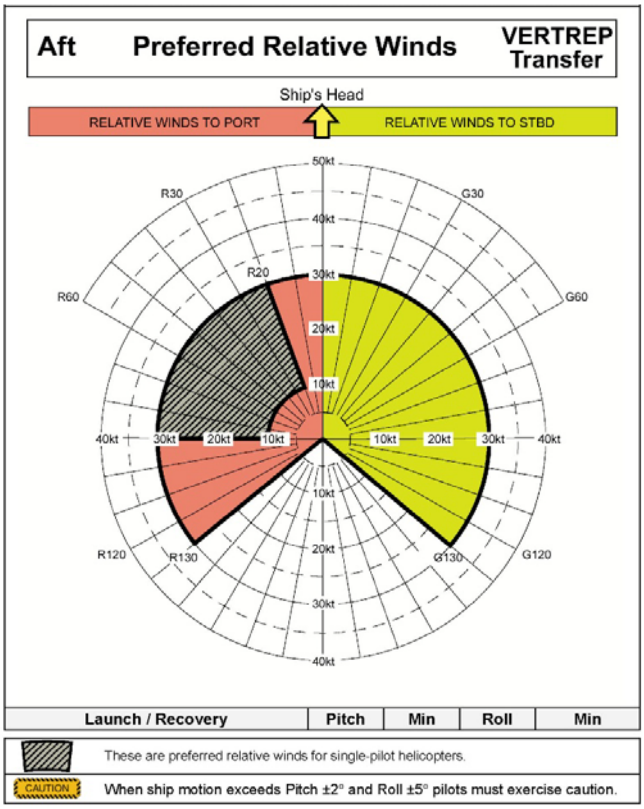
25 Not generally available to cilvil helicopter operators.

26 VERTREP. Vertical replenishment, which includes the conduct of external load and winching operations to HMA Ships.

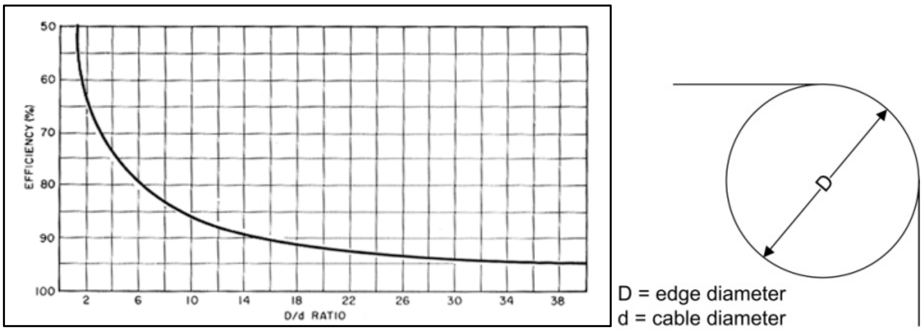


Wire cable strength reduction due to bending

Wire cable can experience a significant reduction in strength when passed over a curved surface due to the inability of the individual strands and wires to reposition (Figure 15). This results in an increase in bending stresses, particularly within the larger diameter wires.

A cable that is bent about a surface of its own diameter will have less than 50% of its nominal strength. The strength loss depends on the severity of the bend, and can be expressed it terms of the D/d ratio; where 'D' is the edge diameter and 'd' is the cable diameter (Figure 22). Relatively small bend angles (less than 45°) can still result in a significant loss of strength.

Figure 22: Reduction in strength due to bending



ANALYSIS

Accident development

The flight path of the helicopter associated with the selected relative wind resulted in the pilot losing sight of the ship as the helicopter approached overhead the forecastle. The height of the helicopter during the approach and at the hover may also have influenced that loss of sight. Given that the height of the helicopter during the final stages of the approach is unknown, any specific influence on the pilot's loss of sight of the ship could not be assessed.

The resulting degraded hover reference deprived the pilot of the means to directly identify any movement of the helicopter or to assess the effectiveness of his flight control inputs. This situation, combined with the strong headwind, resulted in a rapid movement of the helicopter towards the foremast. This movement could not be prevented by the verbal guidance that was provided by the air crew officer (ACO).

The confined nature of the winching area, although acceptable in accordance with international guidelines for the conduct of the emergency medical task, reduced the available time for the pilot to correct the drift prior to the fouling, and subsequent separation of the rescue winch cable.

Despite the pilot's extensive operational experience, he had not considered the possibility that he might lose sight of the ship during the approach. A requirement to confirm that adequate hover references existed, prior to the deployment of personnel on the rescue winch, would have identified that visual reference with the ship would be lost as the helicopter approached the forecastle. This would have highlighted to the crew that a modification to the plan, such as the use of a Hi-line transfer or different relative wind, was required to ensure that the helicopter and flight crew were not exposed to any significant hazard. The lack of any restriction on the ability of the ship's master to manoeuvre would suggest that an alternate relative wind may have been possible.

The application of a structured risk management process generally provides a safety benefit, and the operator's risk assessment identified that, should hover reference be lost, the risk treatment was for the ACO to provide an increased level of verbal guidance to the pilot. In this instance, that treatment was applied by the crew but was ineffective in arresting the drift and the subsequent fouling of the winch cable.

Winch cable separation

Based on the accounts of the pilot and ACO, the winch cable separated without activating the rescue winch overload clutch. Given that the strength of the cable was found to far exceed the clutch design activation load, either the overload clutch was defective or a mechanism existed that permitted the cable to separate at a load significantly less than its nominal strength.

A technical examination of the winch confirmed that the clutch operated normally. Consequently, the investigation focussed on identifying a mechanism that would facilitate the separation of the cable without the activation of the overload clutch.

The observed abrasion damage to the cable reduced its cross sectional area by about 17%, which produced a corresponding reduction in the load-carrying capacity of the winch cable. Additionally, contact marks evident on the ship's radar scanner and associated railing indicated that at some point during the accident sequence, the cable became bent over the edges of this structure, further reducing the strength of the cable.

The continued drift of the helicopter following the cable's fouling on the ship's structure applied a load to the weakened cable. That load was sufficient to cause the separation of the winch cable. The movement of the helicopter, combined with inherent frictional effects associated with the clutch, may have facilitated the application of a dynamic load to the cable that was greater than the static load normally limited by the overload clutch. Alternatively, the weakening of the cable due to the combination of abrasion and bending may have contributed to the separation of the cable at a load below the static load required to activate the overload clutch. Either would explain why the clutch did not activate.

This occurrence highlights the importance of preventing contact between the winch cable and any metal surface, including the helicopter's skid landing gear at all times when conducting winching operations. In the event that the cable does become fouled, it is vital that the movement of the helicopter relative to the target area is minimised to prevent the application of dynamic or 'shock' loading to the potentially weakened winch cable.

FINDINGS

From the evidence available, the following findings are made with respect to the winching accident that occurred 132 km west of Horn Island, Queensland on 9 November 2009 and involved Bell Helicopter Company 412 helicopter, registered VH-EMZ. They should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The relative wind and approach path to the hover resulted in the pilot losing sight of the ship as the helicopter approached overhead the forecastle.
- The pilot's unexpected loss of sight of the ship resulted in a degraded hover reference that, combined with the strong headwind, led to rapid movement of the helicopter towards the ship's foremast.
- The control inputs by the pilot, based on the verbal guidance provided by the air crew officer, were ineffective in arresting the drift of the helicopter.
- The confined nature of the winching area reduced the time available for the pilot to correct the drift.
- The helicopter drifted back and the winch cable became fouled on the ship's foremast.
- The continued drift of the helicopter applied load to the fouled winch cable and contributed to the separation of the cable at a load significantly below its nominal strength, resulting in serious injury to the paramedic and rescue crew officer.
- The winch operation commenced without confirmation that adequate hover reference existed overhead the proposed winching area.
- The operator's winching procedure did not include the requirement to confirm adequate hover reference overhead an intended winch area prior to deploying personnel on the winch. *[Significant safety issue]*

Other safety factors

- There was no formal risk assessment process in use at the operator's Horn Island base. *[Minor safety issue]*

Other key findings

- The results obtained during testing and technical examination of the rescue winch and cable identified that there were no defects that would have contributed to the accident.

SAFETY ACTION

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 organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) 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.

Helicopter operator

Winching procedure

Significant safety issue

The operator's winching procedure did not include the requirement to confirm adequate hover reference overhead an intended winch area prior to deploying personnel on the winch.

Safety action taken by the helicopter operator

Shortly after this occurrence, the operator issued a flying staff instruction reemphasising the hazards and risks associated with winching operations. The instruction detailed the importance of adequate power margins and hover reference and that, where practical, they should be assessed over the intended winch area at the intended hover height.

The instruction also stated that where it was expected that the hover reference may be inadequate, the reference was to be assessed overhead the intended winch location prior to lowering personnel below the level of any obstructions or recovering personnel.

The operator also conducted a number of reviews of the section of the operations manual concerning winching operations. An initial review shortly after the occurrence concluded that the content was appropriate and contained sufficient guidance. Subsequently, a more detailed review of the operations manual, taking into account a number of established best practice procedures within the industry, was initiated. This ongoing review, including the development of an appendix detailing the procedures for application when winching to ships, will emphasise the need to ensure that adequate hover reference exists during those operations.

ATSB assessment of action

The ATSB is satisfied that the action by the helicopter operator will, once in place, adequately address this safety issue.

Risk management

Minor safety issue

There was no formal risk assessment process in use at the operator's Horn Island base.

Safety action taken by the helicopter operator

Following this occurrence, the operator commenced a revision of the existing task risk analysis (TRA) related to winching operations. Once completed, the revised TRA will be disseminated to all of the operator's search and rescue/emergency medical service bases as part of the initiation of formal aviation risk management training. That training will cover all aspects of the operator's operations and be introduced in early 2011.

ATSB assessment of action

The ATSB is satisfied that the action by the helicopter operator will, once in place, adequately address this safety issue.

Other safety action

In response to this occurrence, the operator has advised of the following proactive safety action.

Fuel planning

Safety action taken by the helicopter operator

Although no safety issue was identified concerning the period of time the helicopter was able to remain at the ship, the operator intends to provide additional guidance detailing scenarios in which the carriage of additional fuel should be considered. This guidance is proposed to be included in the operations manual and winching task risk assessment.

Operational equipment

Safety action taken by the helicopter operator

Although no safety issue was identified concerning the equipment that was carried by the paramedic and rescue crew officer, the operator intends to limit the equipment carried on the rescue winch hook to reduce the potential for fouling or injury.

The operator is also developing a policy on the carriage and availability of medical equipment during the conduct of actual winching operations, or the training for such operations. This policy is proposed to be included in the operations manual.

APPENDIX A: SOURCES AND SUBMISSIONS

Sources of Information

The sources of information during the investigation included:

- the pilot and air crew officer of VH-EMZ
- the master and crew of *Maersk Duffield*
- *Maersk Duffield* voyage data recorder
- the Australian Maritime Safety Authority (AMSA)
- the Royal Australian Navy
- Queensland Health
- A number of chief pilots of other organisations conducting similar winching operations.

References

The International Chamber of Shipping. (2008). *Guide to helicopter/ship operations (Fourth edition),* London, UK: Marisec Publications.

Australian Maritime Safety Authority (1995). *Ship-Helicopter Transfers Australian Code of Safe Practice*. http://www.amsa.gov.au/Publications/Shipping/Ship-Helicopter_Transfers.pdf

Royal Australian Navy. *Australian Book of Reference (ABR) 5419 Annex B to Chapter 6*. http://www.navy.gov.au/w/images/ABR_5419_Vol_1_Chap_6_Annex_B-Transfer_Evolutions.pdf

Wire Rope Technical Board. (2005). *Wire Rope Users Manual (Fourth Edition).*

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the Australian Transport Safety Bureau (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 the flight crew and operator of VH-EMZ, the master and operator of *Maersk Duffield*, the rescue winch manufacturer, a number of chief pilots of other organisations conducting similar winching operations, Queensland Health, Emergency Management Queensland, the Civil Aviation Safety Authority, AMSA and the Directorate of Defence Aviation and Air Force Safety.

Submissions were received from the operator of VH-EMZ, the rescue winch manufacturer and a number of chief pilots of other organisations conducting similar winching operations. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.