Australian Government
Australian Transport Safety Bureau

Loss of propulsion of the passenger cruise ship *Norwegian Star*

Bass Strait, 18 nm SW of Cape Liptrap, Victoria on 10 February 2017

ATSB Transport Safety Report
Marine Occurrence Investigation
329-MO-2017-003
Preliminary – 27 April 2017

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

This investigation was conducted under the *Transport Safety Investigation Act 2003* (Cth) by the Chief Investigator, Transport Safety (Vic) on behalf of the Australian Transport Safety Bureau in accordance with the Collaboration Agreement.

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Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

Addendum

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Safety summary

The information contained in this Preliminary report is released in accordance with section 25 of the Transport Safety Investigation Act 2003 and is derived from the initial investigation of the occurrence. Readers are cautioned that new evidence will become available as the investigation progresses that will enhance the ATSB's understanding of the occurrence as outlined in this Preliminary report. As such, no analysis or findings are included in this report.

What happened

On 9 February 2017, the passenger cruise ship *Norwegian Star* departed Melbourne, Australia, on a scheduled cruise to Dunedin, New Zealand. There were 2113 passengers and 1017 crew on board. On departure, the starboard propulsion unit (Azipod[1]) was operational and the port Azipod was under repair.

At about 0134 on 10 February, the vessel was about 18 nautical miles south-west of Cape Liptrap, Victoria, when the starboard Azipod failed. Propulsion power could not be restored and two tugs were deployed from Melbourne to tow *Norwegian Star* back to Melbourne. The vessel arrived back without further incident at about midnight on 11 February 2017.

What the ATSB has found so far

Based on the preliminary information, the ATSB found that the Norwegian Star experienced three separate propulsion unit failures over a period of about nine weeks. In each case, the field exciter unit for the main propulsion motor failed. The first two failures (the starboard unit in December and the port unit in January) involved a breakdown of electrical insulation and the third failure (on 10 February 2017) related to a modification made to the starboard Azipod exciter unit during its earlier repair.

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1 Azipod is the registered trademark of ABB Oy (Finland).

Contents

The occurrence

Norwegian Star is a passenger cruise ship built in November 2001 and registered in the Bahamas. The vessel is owned and operated by Norwegian Cruise Line Holdings (NCL) Ltd, Miami, and is engaged in round-the-world cruises, predominantly cruising the northern hemisphere ports during the northern summer season and the southern hemisphere ports during the southern summer season.

Figure 1: *Norwegian Star*

Source: Norwegian Cruise Line Holdings Ltd

The vessel was scheduled to cruise south-east Asia towards the end of 2016, moving to the Oceania region (Australia, New Zealand and Pacific Islands) in January 2017, then far-east Asia in March 2017.

Norwegian Star was built with two electric-driven Azipod[2] propulsion units, manufactured by ABB Industry Oy (ABB), Finland. Each Azipod was constructed with a brushless type exciter unit (see Context).

On 11 December 2016, the vessel was preparing to depart Singapore when the starboard Azipod power breaker tripped and the alarm panel indicated an 'overcurrent earth failure'. Inspection of the unit confirmed that one of the exciter windings was earthed with visible electrical flashover marks.

Replacement of the brushless type exciter unit could only be achieved if the vessel was taken out of operation. However, the units could be modified from brushless to slip ring (and brush) type with the vessel still in operation. *Norwegian Star* was capable of operating with one propulsion unit, giving it full manoeuvrability but at a reduced speed of between 13 to 16 knots.[3]

The vessel's schedule was amended to allow for the reduced propulsion speed. Repair to the starboard Azipod exciter unit continued whilst *Norwegian Star* cruised the south-east Asia ports between Singapore and Hong Kong. The modified exciter unit was commissioned on 14 January 2017 and tested at full load on 20 January 2017.

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[2] ABB's podded azimuth thrust propulsion system consists of an electric motor inside a submerged pod. The propulsion module with speed controlled fixed pitch propeller can be rotated 360 degrees around its vertical axis.

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

Norwegian Star resumed its cruise schedule with both propulsion units operational, departing Singapore on 22 January 2017 for Darwin, Australia, via the Pacific islands. On 24 January 2017, the exciter unit of the port Azipod failed. It was noted that the failure of the port unit was similar to that of the starboard unit. The vessel was now operating solely with the modified starboard propulsion unit.

The vessel called at Bali, Darwin, Cairns and Sydney before arriving in Melbourne on 8 February 2017. ABB technicians were on board to repair the port propulsion by modifying the port exciter unit to slip ring design (similar to the starboard unit). *Norwegian Star* departed Melbourne on the evening of 9 February 2017 bound for Dunedin, New Zealand. There were 2113 passengers and 1017 crew on board.

The vessel exited Port Phillip Heads (the Heads) at about 2118[4] and at about 2133 dropped off the pilot and commenced its voyage across Bass Strait towards Dunedin. At about 0134 on 10 February 2017, *Norwegian Star* was about 18 nautical miles south-west of Cape Liptrap (on the south coast of Victoria) when the starboard propulsion unit failed.

Inspection of the modified exciter unit found arcing marks on the outer slip ring, indicating that the brush holders had come into contact with the slip ring.

Norwegian Star was disabled and drifting in an approximately north-north-easterly direction in about 75 metres depth of water. The wind at that time was from the SE at about 5 knots, the sea condition was slight and the swell about one metre. It was partly cloudy and the visibility was good. The current was negligible. The master used the vessel's bow thrusters to manoeuvre the ship's head into the wind and reduce the drift from about four knots to about one knot.

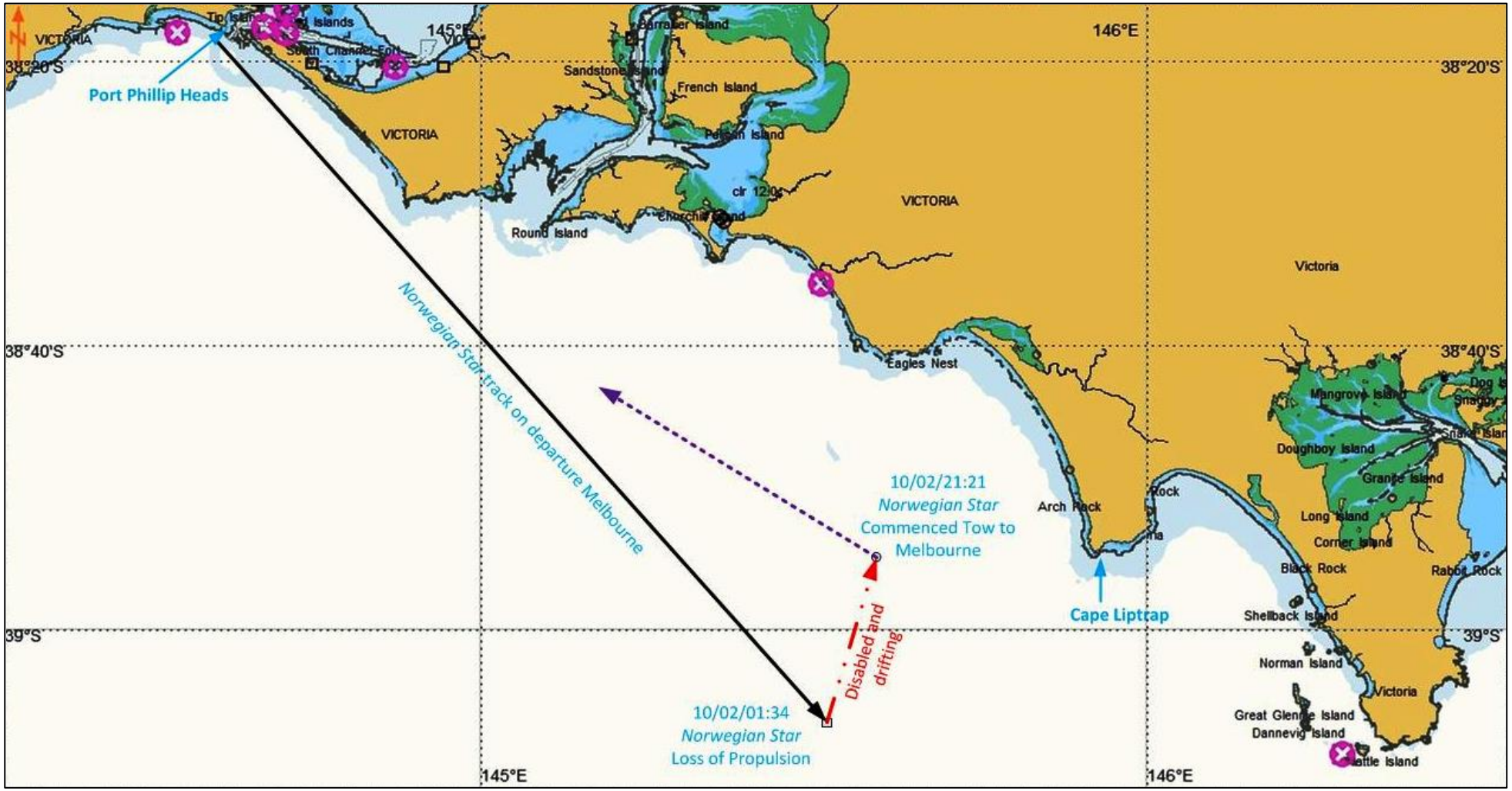
The owners and relevant shore authorities were informed and arrangements were made to deploy two tugs to tow the vessel back to Melbourne. At about 1957 the same day, the tug Hastings arrived and at about 2048 the tow line was connected. At 2121 tug Hastings commenced towing *Norwegian Star* at a controlled speed of about 4.5 knots. The tug Tom Tough arrived at 2212 and followed the tug and tow towards Melbourne.

At about 1107 on 11 February 2017, tug Tom Tough was made fast to the starboard quarter to assist *Norwegian Star* manoeuvre through the Heads. At about 1338 *Norwegian Star* arrived at Port Phillip Heads and a pilot boarded the vessel. The vessel entered Port Phillip Bay through the Heads at 1506 and at 1528 a third tug, Marysville, was made fast on the port quarter to assist with the berthing. The vessel berthed at Station Pier at about 2358 without further incident.

Both Azipod units were repaired in Melbourne with further modifications to the slip ring exciter units. On 14 February 2017 both propulsion units were commissioned and *Norwegian Star* resumed its voyage to New Zealand.

[4] All times referred to in this report are local time, Coordinated Universal Time (UTC) + 11 hours.

Figure 2: Pictorial of *Norwegian Star's* track and drift before being towed back to Melbourne



Source: Australian Hydrographic Office, with annotations by Chief Investigator, Transport Safety

Context

Norwegian Star

Norwegian Star is a 294 m long passenger cruise ship built in November 2001 at the Meyer Werft shipyard in Papenburg, Germany. It is owned and operated by Norwegian Cruise Line Holdings (NCL) Ltd, Miami. The vessel is registered in Bahamas and classed with Det Norske Veritas Germanischer Lloyd (DNV GL).

The crew were appropriately qualified for the positions they held and the vessel's classification certificates were current.

Norwegian Star was built to comply with the requirements of SOLAS (the International Convention for the Safety of Life at Sea 1974, as amended) and the DNV[5] rules for ships (July 1997 edition). The propulsion system of *Norwegian Star* consisted of two independent ABB V02300 Azipods, each unit producing 19,500 kW of propulsion power at 137 RPM for a maximum ship speed of about 25 knots. Each propulsion unit complied with the class requirements with respect to steering and propulsion.

Norwegian Cruise Line

Norwegian Cruise Line Holdings Ltd. (NCL) is headquartered in Miami, Florida. The company began operations in 1966 under the name Norwegian Caribbean Line and in 1987 changed to its current name. NCL operates as a cruise company, providing cruise itineraries ranging from 1 to 180-days calling on worldwide locations.

At the time of the incident, NCL operated a fleet of 15 passenger vessels worldwide. Ten of those vessels were fitted with the ABB brushless Azipod propulsion systems and *Norwegian Star* was the oldest in that fleet.

Azipod propulsion system

Azipod propulsion is a gearless steerable propulsion system where the electric drive motor is in a submerged pod under the ship hull. The propeller is a fixed pitch type mounted directly on the motor shaft. The Azipod can rotate 360 degrees, replacing the need for a separate rudder. On the *Norwegian Star,* the Azipod propellers face forward in a pulling configuration.

Speed and rotational direction control of the propulsion motors is achieved by a frequency converter (cycloconvertor[6]), which consists of selectors, power supply contactors and the control electronics for the main propulsion motor circuits.

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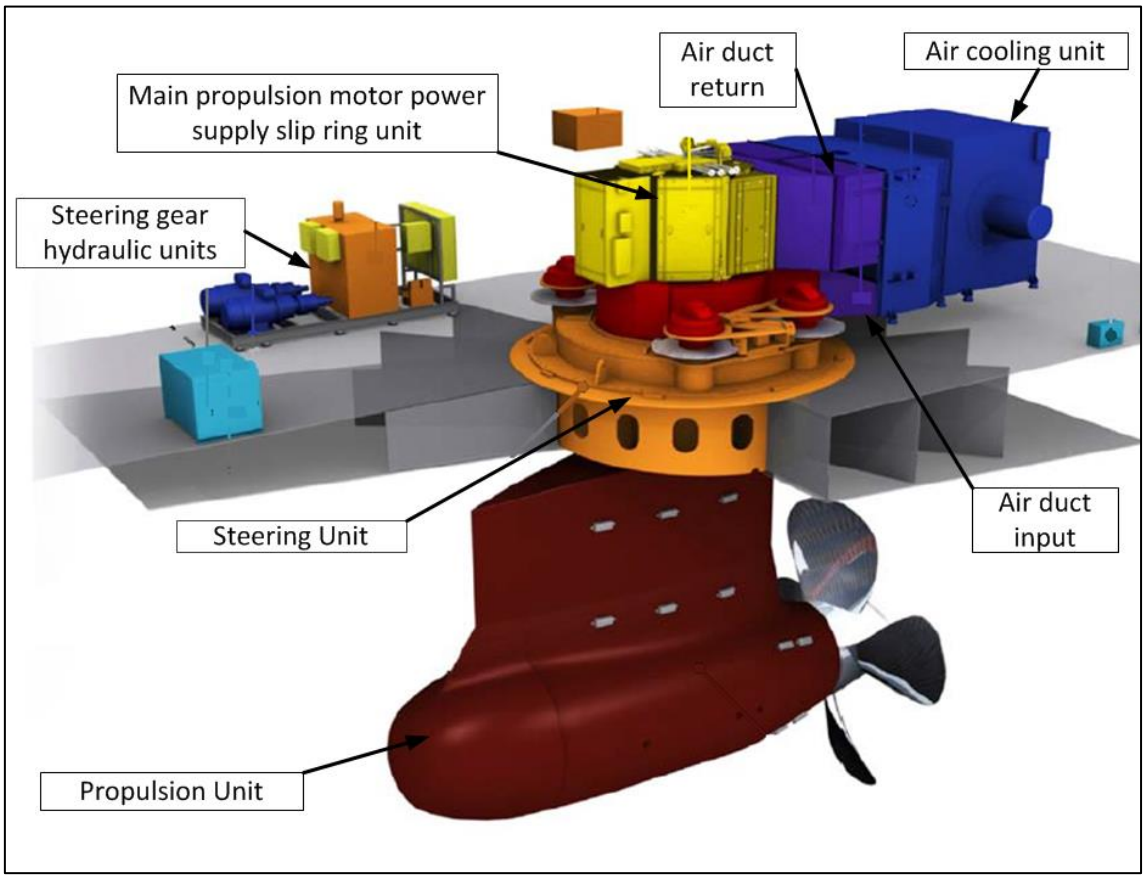
5 DNV merged with GL in 2013 to become DNV GL.

6 The cycloconvertor is the trade marked name given to frequency converters designed and manufactured by ASEA Brown Boveri.

Figure 3: Azipod unit



Source: ABB Industry Oy with annotations by Chief Investigator, Transport Safety

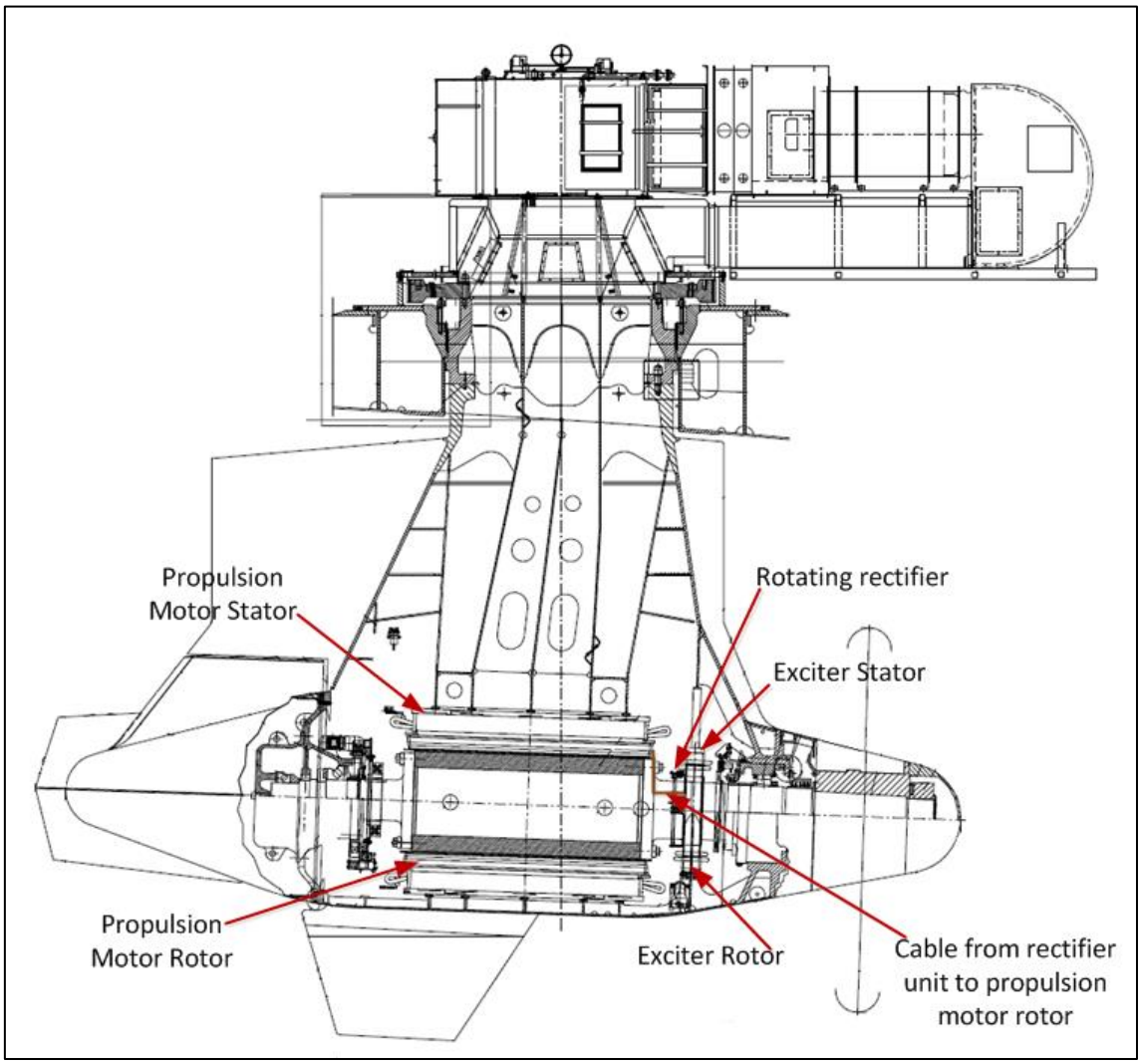
Propulsion motor and excitation units

The propulsion motors were of the synchronous type. Synchronous motors require DC current to be supplied to its rotor windings in order to create the excitation for a constant magnetic flux, develop torque and therefore induce rotation. The DC current was supplied to the rotor of the propulsion motor from an exciter unit[7] mounted on the same shaft as the main rotor. There are two methods to provide excitation for field windings, either by sliprings and brushes or by using a brushless excitation machine.

In its original configuration, this propulsion system used the brushless exciter system. The AC generated in the exciter rotor was converted to DC via a rotating diode rectifier unit and supplied to the propulsion rotor. The rectifier is connected to the rotor in the propulsion motor via cables attached to the shaft.

[7] An AC generator.

Figure 4: Schematic drawing of motor mechanical and electrical components



Source: ABB Industry Oy with annotations by Chief Investigator, Transport Safety

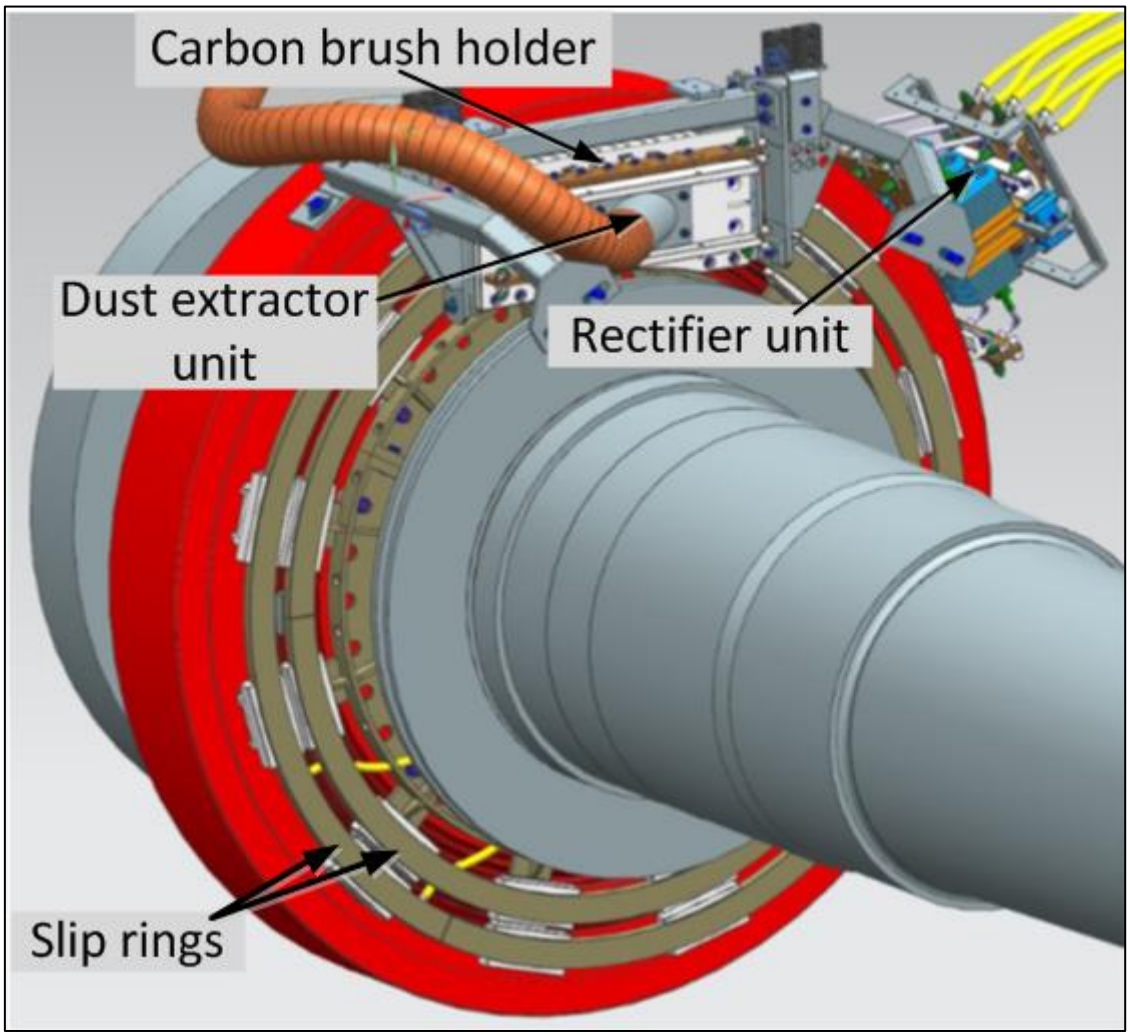
Conversion from brushless to slip ring

When the brushless starboard exciter unit failed on 11 December 2016, the operating company decided to initiate emergency measures to repair the unit by carrying out a modification of instituting a slipring system with brushes. This decision was made to avoid decommissioning the vessel to carry out permanent repairs to the brushless system.

The modification to a slip ring unit with brushes consisted of the installation of a slip ring assembly, diode bridge assembly, carbon brush assembly and dust removal unit mounted on the existing exciter rotor and stator hub assembly. The transformers for each phase were mounted in the cycloconvertor room and cabling installed from the transformers to the slip ring unit in the pod.

There are two slip rings of the face type located concentrically, mounted on the original exciter rotor. The carbon brush unit and the rectifier unit are mounted with supporting brackets on the original exciter stator frame.

Figure 5: Modified slip ring design exciter unit



Source: ABB Industry Oy with annotations by Chief Investigator, Transport Safety

Investigation direction

The investigation is ongoing and will focus on:

- the failures of the propulsion units
- vessel operation with one propulsion unit
- modifications to the propulsion systems.

General details

Occurrence details

Date and time:	10 February 2017 – 0134 EDT (UTC + 11 hours)	
Occurrence category:	Incident	
Primary occurrence type:	Loss of propulsion	
Location:	Bass Strait, 18 nautical miles south west of Cape Liptrap, Victoria, Australia	
	Latitude: 39° 06.8’ S	Longitude: 145° 31.8’ E

Ship details

Name:	M/S *Norwegian Star*
IMO number:	9195157
Call sign:	C6FR3
Flag:	Bahamas
Classification society:	Det Norske Veritas Germanischer Lloyd (DNV GL)
Ship type:	Passenger vessel
Builder:	Meyer Werft, Germany
Year built:	2001
Owner(s):	Norwegian Cruise Line Holdings Ltd
Manager:	Norwegian Cruise Line Holdings Ltd
Gross tonnage:	91740
Deadweight (summer):	10039T
Summer draught:	8.60 metres
Length overall:	294.13 metres
Moulded breadth:	38.10 metres
Moulded depth:	11.50 metres
Main engine(s):	4 x MAN B&W 14V 48/60 Diesel Engines 2 x ABB VO2300 Azipods, 19.5 MW each
Total power:	58,800 kW
Speed:	25 knots
Damage:	Damage to slip rings and brush holders in the starboard Azipod exciter unit. Vessel disabled and drifting, requiring a tow to return to port.

Sources and submissions

Sources of information

Investigators from the Chief Investigator, Transport Safety (Victoria) under delegation from the Australian Transport Safety Bureau attended *Norwegian Star* on 14 February 2017 while the ship was in Melbourne, Victoria, and again on 22 February 2017 while the ship was in Sydney, New South Wales.

The sources of information during the investigation included:

- Vessel owners, Norwegian Cruise Line Holdings Ltd
- Equipment manufacturer, ABB Oy
- Classification Society, Det Norske Veritas Germanischer Lloyd
- Australian Maritime Safety Authority
- Victorian Ports Corporation (Melbourne).

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB 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 operations involving the travelling public.

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 factors related to the transport safety matter being investigated.

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.