



Marine Safety Investigation Unit



MARINE SAFETY INVESTIGATION REPORT

Safety investigation into the grounding of the
Maltese registered container vessel

APL DANUBE

in position 30° 10.529' N 032° 34.242' E
on 19 April 2019

201904/029

MARINE SAFETY INVESTIGATION REPORT NO. 08/2020

FINAL

CONTENTS

LIST OF REFERENCES AND SOURCES OF INFORMATION	iv
GLOSSARY OF TERMS AND ABBREVIATIONS	v
SUMMARY	vi
1 FACTUAL INFORMATION	7
1.1 Vessel, Voyage and Marine Casualty Particulars	7
1.2 Description of Vessel	8
1.2.1 The bridge.....	9
1.3 Crew.....	10
1.4 Admiralty Sailing Directions – NP 64	11
1.5 The Suez Canal – Rules of Navigation	12
1.6 Safety Management System Guidelines on Transiting of the Suez Canal	15
1.7 Passage Plan.....	16
1.8 Environment.....	16
1.9 Narrative	16
1.10 Refloating.....	21
1.11 Damages Sustained by <i>APL Danube</i>	22
1.12 Previous Marine Incident	24
2 ANALYSIS	25
2.1 Purpose.....	25
2.2 <i>Note Verbale</i>	25
2.3 Immediate Cause for the Loss of Steering	25
2.4 Natural Phenomena	26
2.5 Initial Grounding.....	30
2.6 Further Grounding by the Stern	31
2.7 Planning and Monitoring of the Passage.....	33
2.8 Bridge Team and Pilot Relation	34
2.9 Actions of the Bridge Team and the Pilot	35
2.10 Fatigue and Alcohol	37
2.11 Previous Marine Incident	37
3 CONCLUSIONS	40
3.1 Immediate Safety Factor	40
3.2 Latent Conditions and Other Safety Factors	40
3.3 Other Findings	41
4 ACTIONS TAKEN	42
4.1 Safety Actions Taken During the Course of the Safety Investigation.....	42
5 RECOMMENDATIONS.....	43

LIST OF REFERENCES AND SOURCES OF INFORMATION

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GLOSSARY OF TERMS AND ABBREVIATIONS

BV	Bureau Veritas
Channel	The navigable part of the Suez Canal
ECDIS	Electronic Chart Display Information System
EMCIP	European Maritime Safety Information Platform
ENC	Electronic Navigational Chart
gt	Gross Tonnage
HW	High Water
Km	Kilometre
LW	Low Water
m	metre
MLC 2006	Maritime Labour Convention, 2006, as amended
rpm	Revolutions per minute
S-band radar	This radar utilizes a 3 GHz frequency and is especially used in restricted visibility or long range tracking due to its long wavelength of 10 cm
SC	Suez Canal
Sheer	The movement of a vessel away from her intended heading
SOG	Speed over ground
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, as amended
STCW Code	Seafarer's Training, Certification and Watchkeeping Code, as amended
STW	Speed through the water
UKC	Under Keel Clearance
VDR	Voyage Data Recorder
Venturi effect	The effect of an increase in the velocity of water, as it goes from a wide section to a narrow section.
X-band radar	This radar utilizes a 9 GHz frequency which produces sharper images and better resolution at short range

SUMMARY

APL Danube was transiting Southbound through the Suez Canal, en route to her destination. The weather was clear and the sea was reported to be smooth.

A pilot had embarked earlier and was providing navigational advice to the master. While approaching the Km 133 mark, the vessel suddenly started to swing to starboard. The helm was ordered hard over to port and the main engine's revolutions (rpm) of the vessel were increased in an attempt to correct the heading. However, *APL Danube* continued to swing to starboard until she ran aground by her bow. The main engine was set to full astern, leading to the vessel running aground by her stern shortly after. As a result, the vessel lost her steering capability and was later refloated with the assistance of two tugs.

APL Danube was eventually towed to a dry dock in Dubai for repairs.

The immediate cause of the accident was identified to be loss of steering due to bank effect.

The MSIU has issued four safety recommendations to the Company, designed to ensure that its fleet are adequately prepared for pilotage waters.

1 FACTUAL INFORMATION

1.1 Vessel, Voyage and Marine Casualty Particulars

Name	<i>APL Danube</i>
Flag	Malta
Classification Society	BV
IMO Number	9674517
Type	Container Ship
Registered Owner	Eternal City Global Limited.
Managers	CMA Ships, France
Construction	Steel (Double bottom)
Length Overall	299.95 m
Registered Length	286.86 m
Gross Tonnage	95,263
Minimum Safe Manning	15
Authorised Cargo	Containers
Port of Departure	Port Said, Egypt
Port of Arrival	Jeddah, Saudi Arabia
Type of Voyage	Short International
Cargo Information	Containerised cargo (91,823 mt)
Manning	25
Date and Time	19 April 2019 at 17:22 (LT)
Type of Marine Casualty	Serious Marine Casualty
Place on Board	Bow, engine-room, steering gear, rudder, propeller
Injuries / Fatalities	Nil
Damage / Environmental Impact	Damage to the rudder, steering gear, propeller and propulsion system
Ship Operation	Normal Service – On passage
Voyage Segment	Transit
External & Internal Environment	Weather was clear and the visibility was good. A gentle breeze was blowing from a Northwesterly direction. Air and sea temperatures were recorded at 20 °C and 21 °C respectively.
Persons on Board	25

1.2 Description of Vessel

APL Danube (Figure 1) was a 95,263 gt (99,413 SC gt) container vessel, built in 2014 and registered in Malta. She was owned by Eternal City Global Limited, managed by CMA Ships of France, and was classed with Bureau Veritas (BV). The vessel had a length overall of 299.95 m and a breadth of 48.20 m. Her summer draft was 14.80 m, corresponding to a deadweight of 114,428.5 metric tonnes. *APL Danube* had a total container capacity of 9,289 TEU and, at the time of occurrence, she was carrying a total of 5,006 containers, equivalent to 91,823 metric tonnes, which brought her drafts to 14.5 m forward and 14.8 m aft.

Propulsive power was provided by a 9-cylinder MAN B&W 9S90ME-C9.2, two-stroke, internal combustion, marine diesel engine, producing 47,430 kW at 78 rpm. This drove a single, right-handed, fixed-pitch propeller, to reach an estimated service speed of 22 knots. The vessel was also equipped with a bow thruster which had a rated power of 3,200kW.

APL Danube was equipped with a Rapson-slide type steering gear, consisting of two rams and four cylinders. Her steering gear pumps were bent-axis type axial piston pumps. Steering gear pump no. 1 was the designated emergency steering pump and was electrically wired through the vessel's emergency switchboard.



Figure 1: MV *APL Danube*

1.2.1 The bridge

APL Danube was fitted with the following navigational equipment:

- standard magnetic and gyro compass;
- two SAM electronics Radars (S-band and X-band with Automatic Radar Plotting Aid (ARPA) and Automatic Tracking Aid (ATA));
- two skipper electronics echo sounders;
- Raytheon Anschutz rudder angle indicator and rate-of-turn indicator;
- two SAM electronics Electronic Chart Display Information System (ECDIS) and nautical charts¹; and
- INTERSCHALT maritime systems Voyage Data Recorder (VDR).

The vessel was supplied with SC 01 and SC 02 charts, issued by the Egyptian Naval Hydrographic Department (ENHD). At the time of the accident, the bridge team was following the vessel's progress on ECDIS. *APL Danube*'s bridge layout is shown in Figure 2.

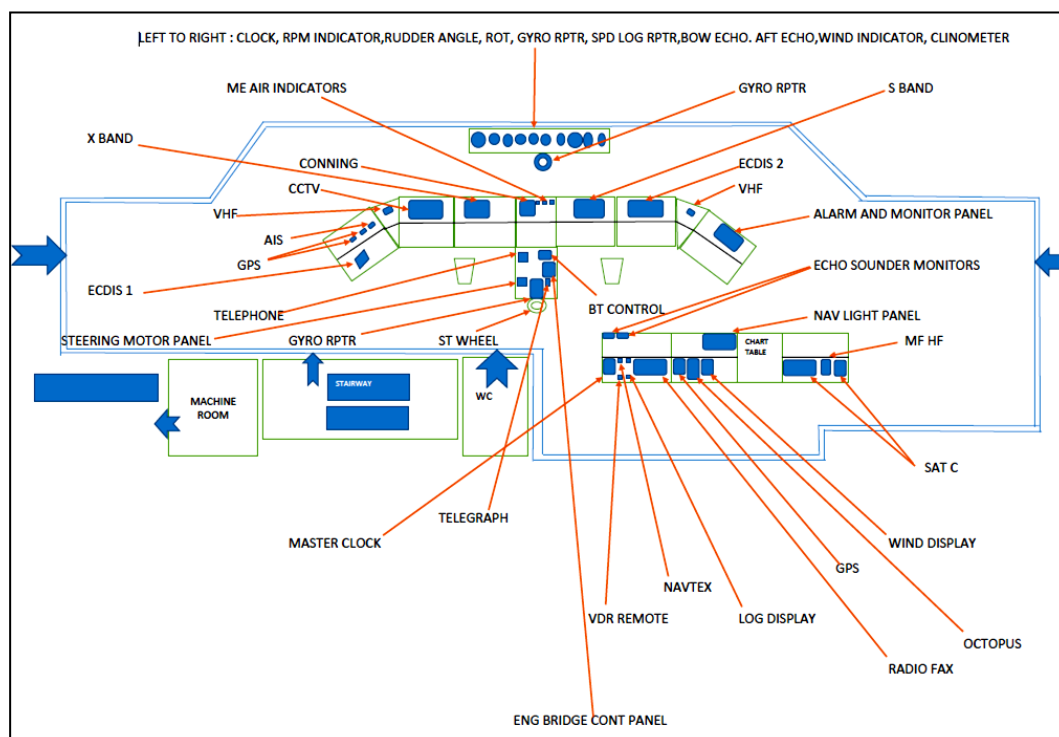


Figure 2: Bridge layout on *APL Danube*

¹ As per Form E of the Safety Equipment Certificate, the back-up arrangements for the ECDIS were listed as paper charts. However, the Record of Approved Ship Safety Equipment (which is not a SOLAS requirement) indicated that the vessel was provided with paper nautical charts and ECDIS, with the back-up arrangements for ECDIS listed as a second ECDIS.

1.3 Crew

APL Danube's Minimum Safe Manning Certificate required a crew of 15. There were 25 crew members on board, at the time of the grounding. The crew members were from Croatia, Montenegro, Serbia and Sri Lanka.

The master was a Croatian national. He had obtained his STCW II/2 Certificate of Competence in 2016 and had been sailing as a master for the past three years. He had almost 11 years at sea, of which nine were spent on board container vessels. He started working as a master with CMA Ships 11 months prior to the grounding. The master was also in possession of generic and type-specific (SAM Electronics) ECDIS training certificates, as well as a Bridge Team Management training certificate. He joined *APL Danube* in Ambarli, Turkey on 05 February 2019.

The chief officer, who was from Serbia, had joined the vessel four days prior to the grounding at Ambarli, Turkey. He had been working with the Company for six years and was promoted to the rank of chief officer in 2018. He held an STCW II/2 Certificate of Competence as chief officer, issued by the authorities of Montenegro.

The third officer, from Sri Lanka, had embarked *APL Danube* from Singapore, on 21 October 2018. He had started his career with CMA Ships five years prior to occurrence and had been working in his present rank for two years. His STCW II/1 Officer of the Watch (OOW) Certificate of Competence was issued in 2015 by the Sri Lankan Authorities. In 2013, he had successfully completed his ECDIS Generic course and in 2017, he had undergone a type-specific (SAM Electronics) ECDIS training course and was issued with a certificate. At the time of the grounding, the third officer was the OOW on the bridge.

The able-bodied seafarer (AB) who was on the bridge acting as a helmsman at the time of occurrence, had embarked on *APL Danube* on 30 March 2019 at Port Said. He held an STCW II/5 Certificate of Proficiency as a 'rating able seafarer deck'. He had a total of six years service at sea, four of which had been spent as an AB.

1.4 Admiralty Sailing Directions – NP 64

Chapter 2 of NP 64 contained various information, which could be used in the preparation of a passage plan through the Suez Canal. This information included, amongst others, passage requirements, ship handling, natural conditions in the Canal, *etc.* The total length of the Canal, measured from Km 3E, on Port Said by-pass, to Km 162.15 at Port of Suez, was 87.5 nautical miles (nm).

Sub-chapter 2.53 indicated that the normal speed of vessels (through the water) in the canal was 7.5 knots. It recommended that when a vessel passes from a wider part of the Canal to a narrower section, the speed should be reduced so as to maintain good steerageway. It also required caution to the proximity of the propeller in relation to the banks of the Canal.

Sub-chapters 2.56 and 2.73 contained relevant information on tidal streams in the Suez Canal. In general, in the section between Little Bitter Lake and Būr Tawfīq (Figure 3), the North-going stream slackens and the South-going stream begins five hours after HW. At the South end of Little Bitter Lake, the tidal streams turn 50 minutes later than at Būr Tawfīq. Streams near the bed of the Canal turn between five minutes and 10 minutes earlier than at the surface. The greatest rate of about 1.75 knots is said to be attained near Km 149, about seven nm within the South entrance to the canal. This section of the Canal passage was described to be the most difficult to navigate through, due to the aforementioned tidal streams.

Sub-chapter 2.93 described the passage from Little Bitter Lake to Suez Bay. It indicated that the bottom in this section of the Canal was generally hard ground and rocky in places.



Figure 3: The Suez Canal and the location of the accident

1.5 The Suez Canal – Rules of Navigation

The Suez Canal is maintained and regulated by the Suez Canal Authority (SCA), which has in place a set of Rules of Navigation for all vessels to follow while using the Canal.

The Rules of Navigation (August 2015 edition) (Rules), contained information on pilotage, navigational features in the Canal, and lake characteristics, *etc.*

The Rules' section on pilotage made it clear that all vessels navigating through the Canal must take a Canal pilot on board. It further clarified that the pilot's role was to give advice to the vessel on matters of navigation. If the master, in the interest of quick manoeuvres, would have allowed the pilot to give orders directly for helm, engines and tugs, it was to be considered as if such orders were given by the master.

The Rules gave specific details of pilot ladder arrangements, under article 24. This included the requirement to have a responsible officer in attendance during the rigging of the ladder, the embarkation and the disembarkation of the pilot². Vessels with the size and criteria of *APL Danube* were allowed to transit with a speed of 8.6 knots³.

The Rules also explained natural conditions, such as tides and currents, which change at various sections of the Suez Canal. The Southern region of the Canal, through which *APL Danube* was transiting at the time of this occurrence, was stated to be semi-diurnal⁴. Peak tidal currents were said to occur after high or low water times at the port of Suez, with a phase lag⁵ ranging between 30 minutes to 90 minutes at any given location in the Southern region. In winter (between December and May), the Northbound tide was predominant. In this region, the average peak current⁶ was stated to be about 2.2 knots and in spring tides, currents were predicted to reach 4.0 knots. Tidal streams were said to have different rates at different depths, with the maximum rate occurring at depths between 6 m and 9 m, most of the time.

The channel's cross sections were indicated to be trapezoidal in shape, having side slopes of 4/1 in its Northern part, and 3/1 in its Southern part. The Rules contained various drawings of cross sections of the channel. Figure 4 details the cross section before and after Km 133. From Figure 5 it can be seen that near Km 133, the channel's width is enlarged to include a garage⁷ section.

² This requirement is almost identical to the one in SOLAS regulation V/23.2.2.

³ The SCA Rules of Navigation did not indicate whether this was STW or SOG.

⁴ There are two high peaks and two low peaks every day.

⁵ The delay on the effect of tides on a location, due to the distance from the main tidal port HW/LW times.

⁶ The Rules refer to tidal current, herein referred to as tidal stream.

⁷ In the Admiralty Sailing Directions NP 64, these were referred to as *gares* or *siding*. At these positions, the Canal was especially widened to enable a vessel to secure to the bank so that another vessel will be able to pass.

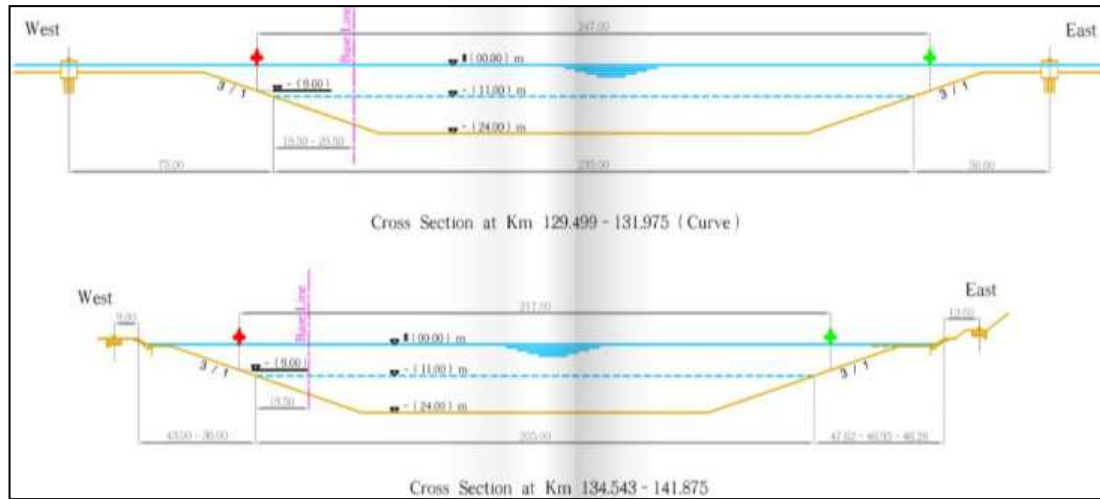


Figure 4: Cross sections before and after Km 133

Adopted from: Suez Canal Authority. (2015). Rules of navigation

The garage's width (Figure 5) was measured to be 100 m and its length as 500 m. Between Km 132.75 and Km 133.075 the channel's width, at a depth of 22.25 m⁸, was stated to be 137.5 m. The depth of the dredged channel in the section of Km 133 was reported to be 24.0 m.

⁸ The Rules listed the widths of the channel, at various sections, at a uniform depth of 22.25 m, which was the navigational depth of the East Channel.

1.7 Passage Plan

APL Danube's passage plan was prepared from the vessel's departure berth at Port Said, Egypt to Light Float No. 2, located South of Suez Bay. The passage plan was compiled using the Company's dedicated software, and was signed by the master and all other OOWs. A list of charts (including both paper charts and electronic navigational charts (ENC)) formed part of the reference documents listed in the plan.

In addition, the passage plan also made reference to a number of nautical publications, amongst which were NP 208 (Admiralty Tide Tables, Volume 8 – South East Atlantic Ocean, West Africa and Mediterranean) and NP 202 (Admiralty Tide Tables, Volume 2 –North Atlantic Ocean and Arctic Regions). The plan also included extracts from the Admiralty Tide Tables for Port Said and Suez (AS Suways).

1.8 Environment

At the time of the grounding, the weather was reported to be clear, with a Northwesterly gentle breeze and smooth sea state. The air temperature was 20 °C. No unusual currents were reported for the passage through the Suez Canal. The times of high water (HW) at Suez for 19 April 2019, were at 1122 and 2349 respectively, with both heights reaching a maximum of 2.1 m.

1.9 Narrative⁹

On 19 April 2019, at around 0930, *APL Danube* departed from Port Said, Egypt, with the assistance of a Canal pilot (first Canal pilot). She was bound for Jeddah, Saudi Arabia. Upon entering the Canal, the first Canal pilot requested that the route from the radar and the ECDIS is removed, since he preferred not to see the plotted course of the route on the screens. The master obliged with this request by deactivating the route from the ECDIS, which remained deactivated¹⁰ throughout the passage. The second Canal pilot (the pilot) embarked at 1412, and after speaking with the outgoing pilot (first Canal pilot), the latter left the bridge.

⁹ Unless otherwise stated, all times are ship time (UTC +2).

¹⁰ Deactivation of the route leaves the ECDIS route marked as 'dashed' lines, instead of solid.

The master had appointed the deck cadet as a designated escort to pick up the pilot. On entering the bridge, the pilot was agitated, complaining that he was escorted by the deck cadet rather than an officer. A master – pilot exchange form had been completed and signed by both the master and the pilot at 1415.

During the passage through the Canal, the pilot stood behind the X-band radar, which was situated on the port side of the bridge front console (Figure 6). The helmsman was at the wheel and the third officer was close by his side. The master was stationed behind the S-band radar, which was on the starboard side of the bridge console.

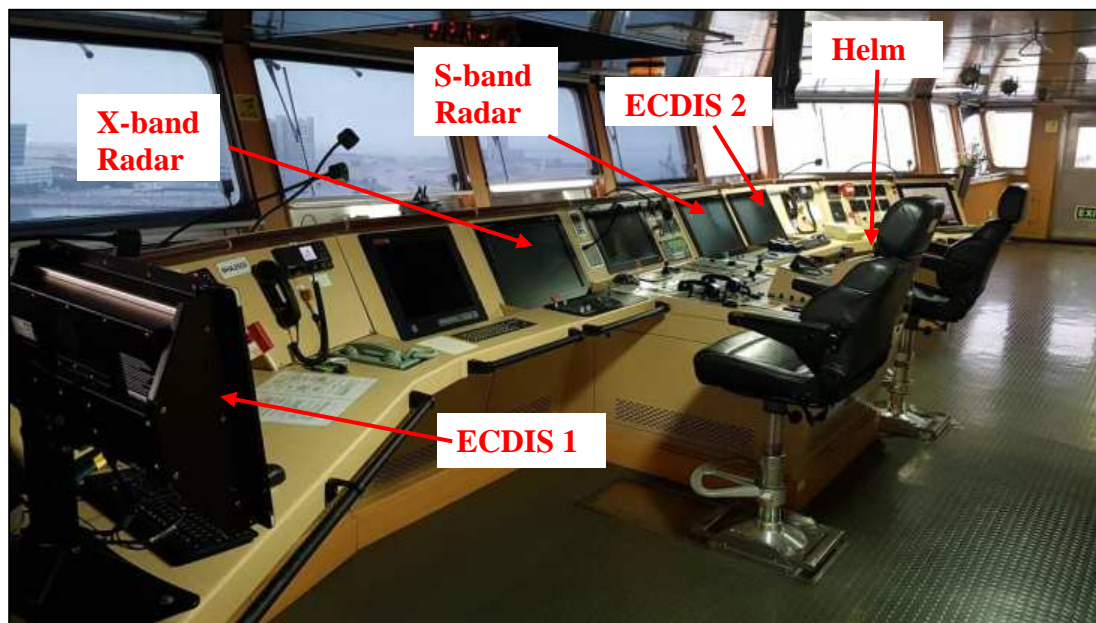


Figure 6: Forward bridge console as viewed from port side

At 1651 (Figure 7), the chief officer entered the bridge.

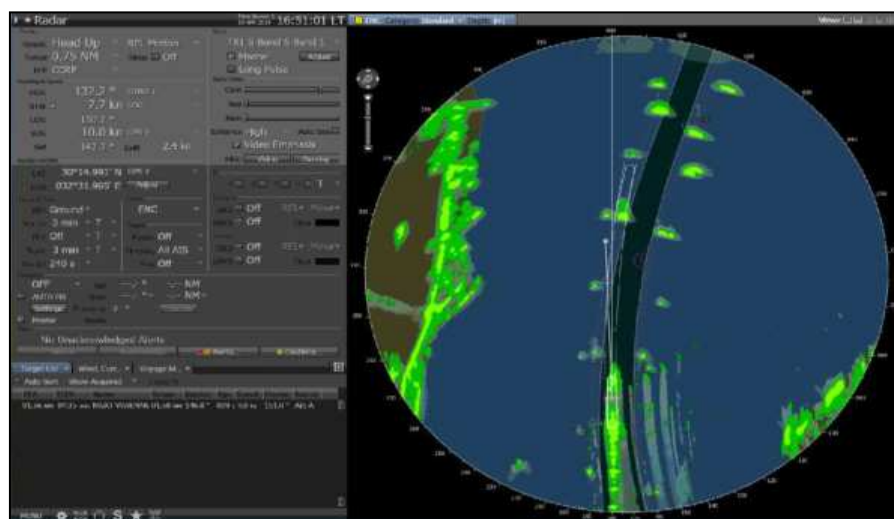


Figure 7: Extract from S-band radar showing the vessels' position at 1651

The master, who was standing behind the S-band radar / ECDIS, walked towards the starboard side of the conning console (Figure 6) to discuss the vessel's maintenance with the chief officer. The last helm order given by the pilot was 182°, at around 1718 (Figure 8). At this time, the master and the chief officer were still engaged in conversation, near the starboard side of the console. As the vessel approached the Km 133 mark, the bow of *APL Danube* took a sheer to starboard.

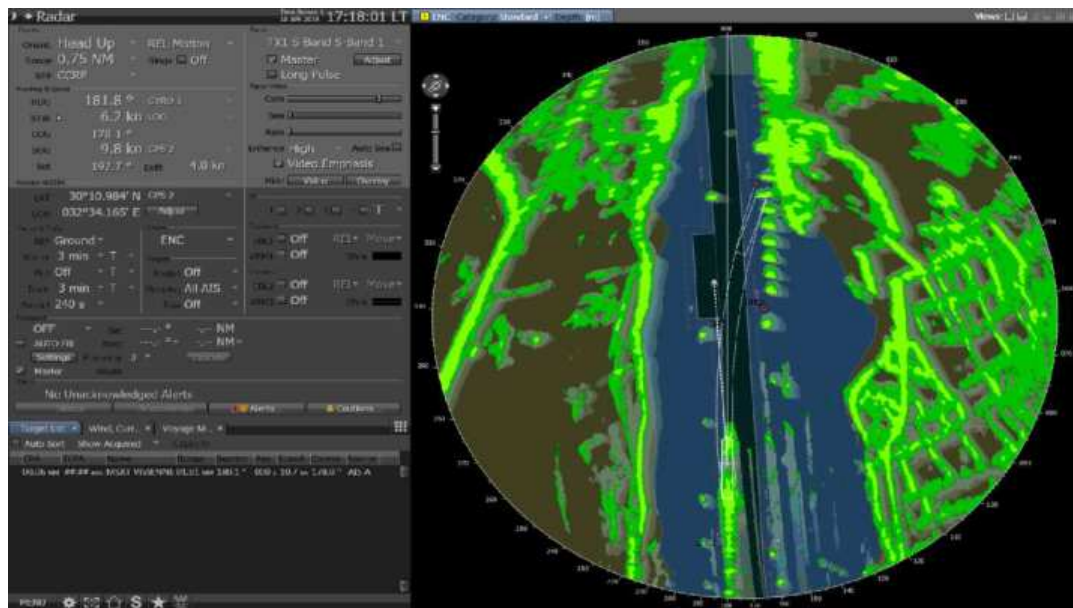


Figure 8: Extract from S-band radar showing the vessels' position at 1718

The sudden turn to starboard was reported by the helmsman, who also informed that he already had the wheel hard over to port. The pilot then requested a slight increase in the main engine's rpm. Following this, the master pushed the telegraph on 'half ahead' from 'slow ahead'. At 1719, the pilot requested to run the main engine at 'full ahead', in an attempt to increase the water flow on the rudder and get a response. The master acceded to the pilot's request.

About 15 seconds later, following the pilot's advice, the master stopped the main engine, pulled the telegraph to 'dead slow astern' and subsequently to 'full astern'. Within 12 seconds, the main engine was reversed and running astern. The vessel's speed at that time was 9.2 knots ahead and the wheel was placed amidships (Figure 9).

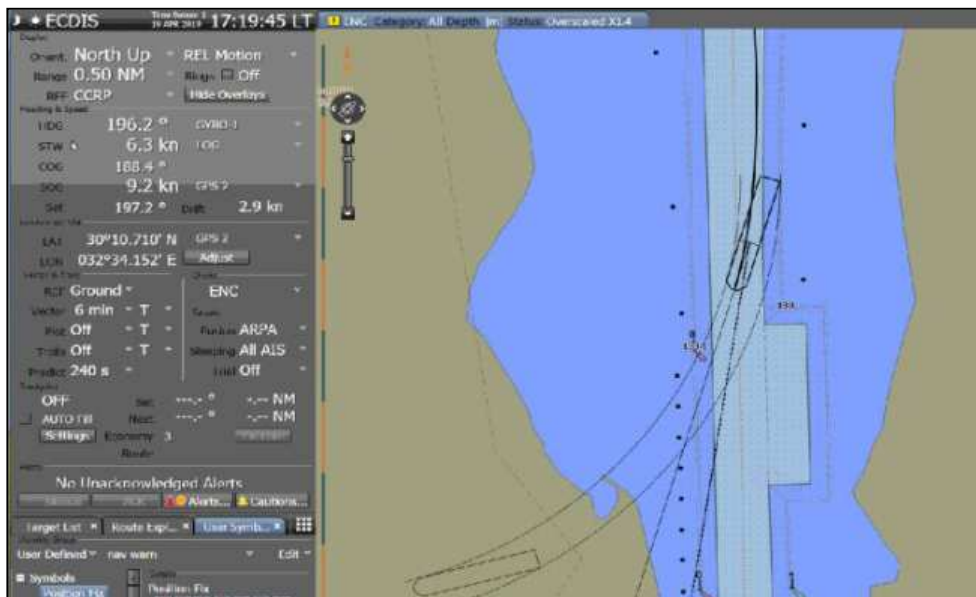


Figure 9: 1719:45 Extract from ECDIS¹¹ showing the relative position of the vessel to the channel; at the time, the vessel's main engine had started running astern

Within the short time frame that the engine movements took place, the anchor team was asked to stand by. The chief officer, who was on the bridge at the time, left the bridge and proceeded forward to assist the anchor team. At 1720, the forward echo sounder lost data and a minute later, an alert for invalid water speed was received on the ECDIS. Around the same time, *APL Danube* ran aground by her bow (Figure 10). At around 1721, the master ordered to 'let go' the port anchor. The speed over ground, at that time, was reported by the master to have been 0.9 knots astern.

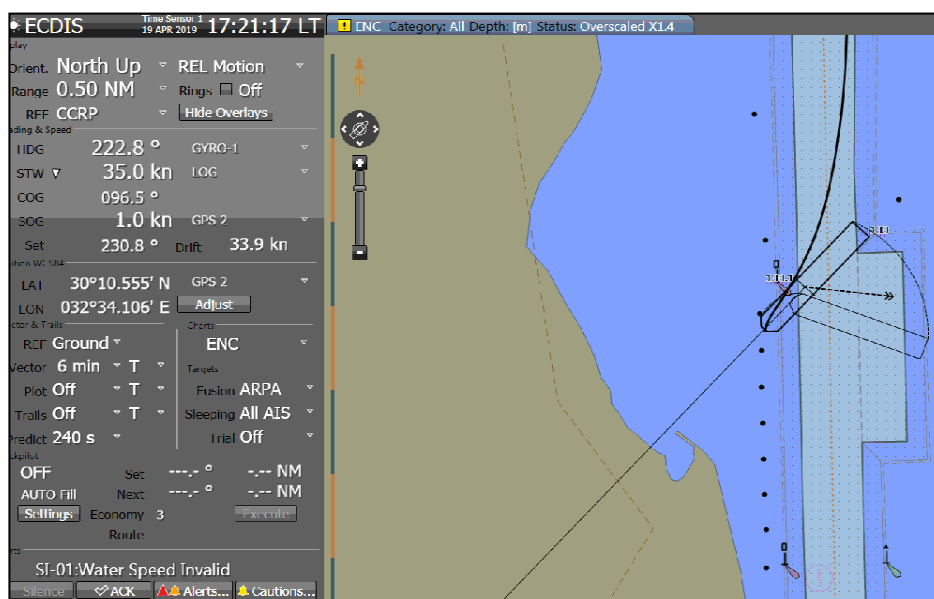


Figure 10: 1721:17 ECDIS extract – showing relative position of the vessel's bow to the channel

¹¹ Vessel symbols displayed on the ECDIS screenshots reflect the actual dimensions of the vessel.

At around 1722, the vessel had five shackles of her port anchor in the water and her speed was three knots astern. The master then reported that the bow thruster was ready.

In the engine-room, the first steering gear alarm came in at 1722:40, thereafter, the emergency switchboard breaker tripped due to an overload on steering gear pump no. 1. The vessel was still making sternway with a speed of three knots (Figure 11) and with the main engine telegraph still on ‘full astern’.

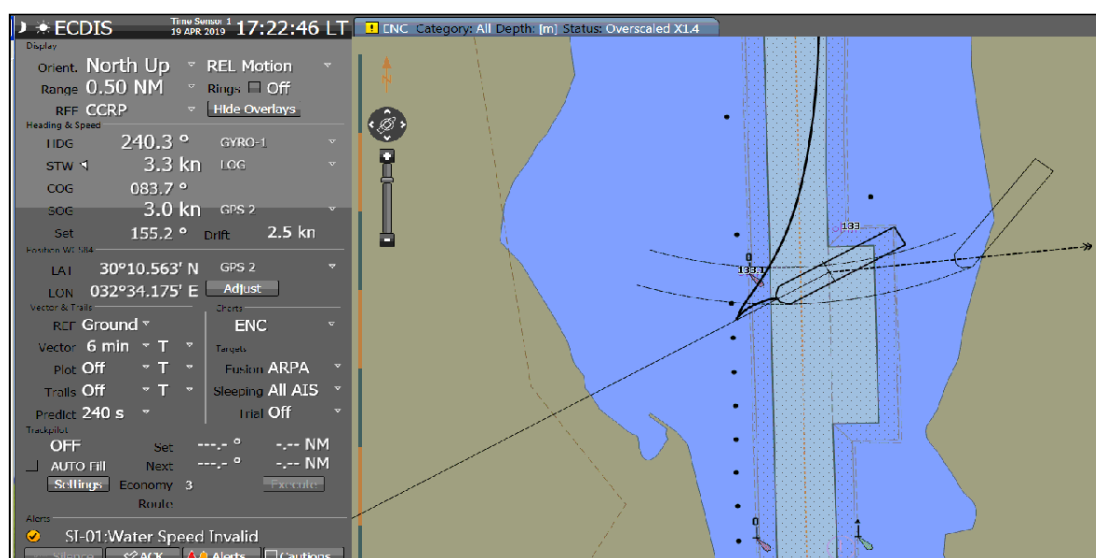


Figure 11: 1722:46 ECDIS extract – Steering gear alarms, vessel moving astern with three knots

In the meantime, it was decided to heave up the anchor and, in a matter of seconds, the bosun started weighing up the port anchor.

At around 1723, it was agreed to apply full bow thruster to port and the pilot advised to stop the engine, shortly thereafter. The wheel was ordered hard over to port, however, after some time, the bridge team noticed that the rudder angle indicator was showing a starboard rudder angle and was not responding to the helmsman's command. It was deduced that the vessel had no steering.

The minutes ensuing these events were spent in attempting to restart the main engine and the steering gear. The port anchor was heaved up to one metre above the water. The vessel was being kept from swinging to starboard by means of her bow thruster, which was being engaged on full to port, from time to time. At around 1731, when the master checked the echo sounder displays, he observed that the vessel had a UKC of 10.4 m forward and 6.4 m aft and reported that the vessel was not aground.

At around 1736, a situation report from the steering gear room to the bridge revealed that the vessel was not able to proceed in that condition, as the roller and ram pin from the steering gear were found broken. At around 1752, the pilot requested the use of the main engine and bow thruster, to which the master responded that the engineers would inform them when the main engine was ready. During this entire period, some of the engineers were busy trying to assess the situation of the steering gear. The other engineers trying to start the main engine noticed that it was not turning, even on the turning gear.

Thereafter, the Company was contacted and advised of the situation, and the crew members were called to stand by at the mooring stations. At about 1840, the depths around the vessel were manually measured and the vessel was confirmed to be aground (Figure 12).

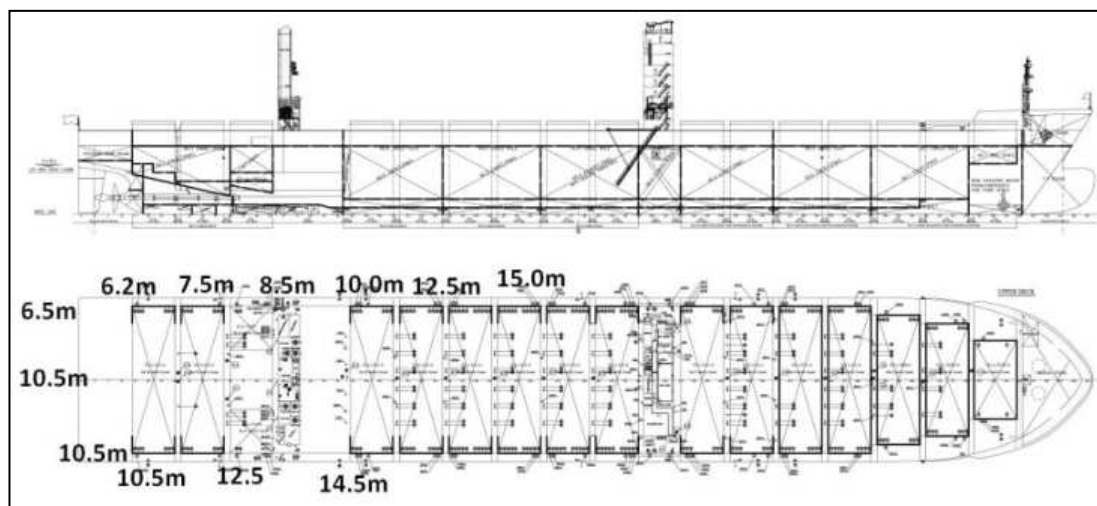


Figure 12: Plan showing the sounding depth results taken manually around the vessel

1.10 Refloating

Two harbour masters and a chief engineer from the Suez Canal Authority, boarded the vessel at 1909. Shortly after, preparations were made to make fast one tug forward and one tug aft. To assist in refloating, ballast water was transferred from the port side ballast tanks to the starboard side ballast tanks, thus creating a list to starboard. At 2058, the vessel was refloated and subsequently towed to a suitable anchorage area in Suez Bay.

1.11 Damages Sustained by *APL Danube*

During the vessel's stay in the anchorage, an in-water survey was carried out to assess the damages sustained. The underwater inspection revealed that 60% of the rudder was damaged (total length of rudder being 10,200 mm):

- the lower part of the rudder, approximately 6,440 mm, was found heavily bent to starboard (Figure 13a);
- the rudder position was found deflected from the centreline by about 15° to starboard (Figure 13b);
- the clearances between the rudder and the rudder dome were noticed to be 25 mm forward and 105 mm aft (Figure 13b).

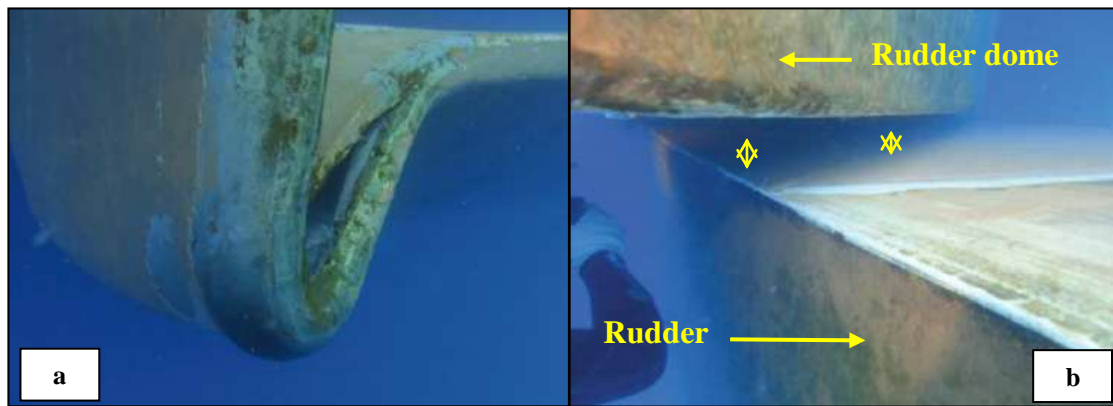


Figure 13: a) showing rudder bent/twisted to starboard; b) showing rudder deflected 15° to starboard and clearances from rudder dome misaligned

The upper plug of the stern tube (poker gauge plug) was missing. No leakages were reported to have occurred from the stern tube or from the shaft's sealing gland.

The edges of all six propeller blades had sheared off (Figure 14).



Figure 14: Extent of damages to the propeller blades

Paint scratches were also noticed at the bulbous bow area (Figure 15) and on the aft portion of the bilge keel, both port and starboard.



Figure 15: Various paint scratches on the bulbous bow, evidence of bottom contact

A survey of the machinery installation by the BV surveyor, revealed that the internal shaft of the turning gear was broken. Slight misalignments were found on the crankshaft and on the main bearing shell plating nos. 7 and 8.

In the steering gear room, the Chockfast® on the foundation of the steering gear was found to have moved and three thrust blades were found broken.

1.12 Previous Marine Incident

During the course of the safety investigation, the MSIU became aware that on 29 March 2019, while in the Northbound transit through the Suez Canal, *APL Danube* had experienced a near accident. The MSIU had not been notified of this occurrence.

At the time, the vessel was on a Northerly course making 10 knots, when suddenly her heading started to swing off course to starboard. The master had decided to abort the planned passage and adjusted the vessel's heading into the entrance of the new Suez Canal, which at the time happened to be lying on her starboard bow. The steering gear was tested before berthing and the Company also investigated this marine incident, following which, steering gear issues were dismissed and the occurrence was attributed to the vessel passing close to the West side of the channel and may have created a bank suction effect.

The Company's analysis of this marine incident had not been concluded at the time of the vessel's grounding on 19 April 2019.

2 ANALYSIS

2.1 Purpose

The purpose of a marine safety investigation is to determine the circumstances and safety factors of the accident as a basis for making recommendations, to prevent further marine casualties or incidents from occurring in the future.

2.2 *Note Verbale*

Although a formal request for a pilot's statement was made during the course of the safety investigation by the MSIU through the Maltese Ministry for Foreign Affairs and Trade Promotion, the MSIU was informed that the Suez Canal Authority was unable to provide a report because this was prohibited by the Suez Canal instructions and regulations. A short summary of events was communicated to the MSIU.

2.3 Immediate Cause for the Loss of Steering

APL Danube was leaving Little Bitter Lake to proceed Southbound through the last leg of the Canal. VDR data indicated that during this time, the vessel was closer to the Eastern side of the channel. Helm orders were constantly being given by the pilot to correct the vessel's heading, however, shortly before reaching the garage at Km 133 in the Canal, the helmsman reported that the vessel was swinging to starboard. Attempts to correct her heading by rudder and engine movements were futile, and the vessel eventually ran aground.

The vessel's draft, in relation to the trapezoidal-shaped channel and the speed at which she was proceeding, suggested that the vessel had experienced a bank suction effect. It appears that once *APL Danube*'s hull was closer to the Eastern bank, a venturi effect had arisen due to the restricted flow of water on one side of the vessel.

While a vessel moves in close proximity to a bank, there would generally be a build up in the water level near her bow, and a gradual reduction of pressure towards her stern (Figure 16). As in the case of water poured through a funnel, where water tends to accumulate before the stem of the funnel, the water would tend to accumulate ahead of the vessel's bow. This would create a bank cushion effect which would

cause the bow to move away from the closest bank. In the case of *APL Danube*, this had caused the vessel's bow to sheer to starboard. Additionally, the proximity of a vessel's hull towards the bank would restrict the flow of water between the vessel and the bank. This would result in a loss of pressure along her stern, leading to an increase in the water's velocity and a drop in water level on that side. This in turn would result in a thrust towards the bank (bank suction effect). In the case of a vessel of the size of *APL Danube*, having a longer parallel body with a transom stern, the thrust would be exacerbated at the stern.

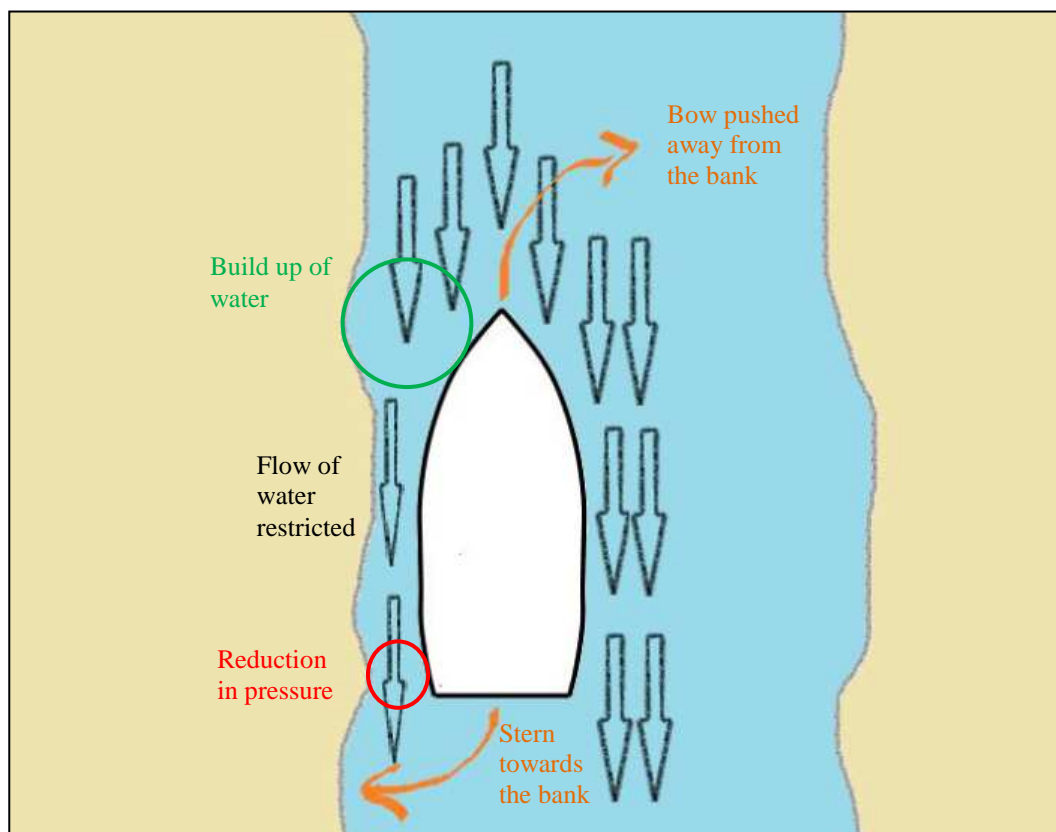


Figure 16: Bank Effect

2.4 Natural Phenomena

HW at the Port of Suez was at 1122 on 19 April, reaching a height of 2.1 m. As mentioned earlier in this report, five hours after HW, which was around 1622 on 19 April 2019, the North-going stream would have slackened and the South-going stream would have started. Keeping in mind the phase lag of the stream from Port of Suez to the vessel's position at 1622, according to the sailing directions, *APL Danube* should have been affected by the South-going stream 50 minutes later *i.e.*, around 1712.

However, the VDR data indicated that the vessel had already been affected by the South-going stream earlier than 1712, as a marked difference of two knots between the STW and the SOG (drift) was noted. Furthermore, as the vessel was leaving Little Bitter Lake to her stern, and rounding the Canal's bend, the drift had increased to almost four knots (Figure 17). This marked increase in the drift experienced by *APL Danube* would most probably have been the effect of water being channelled to pass through a narrower part of the Canal, causing a venturi effect.

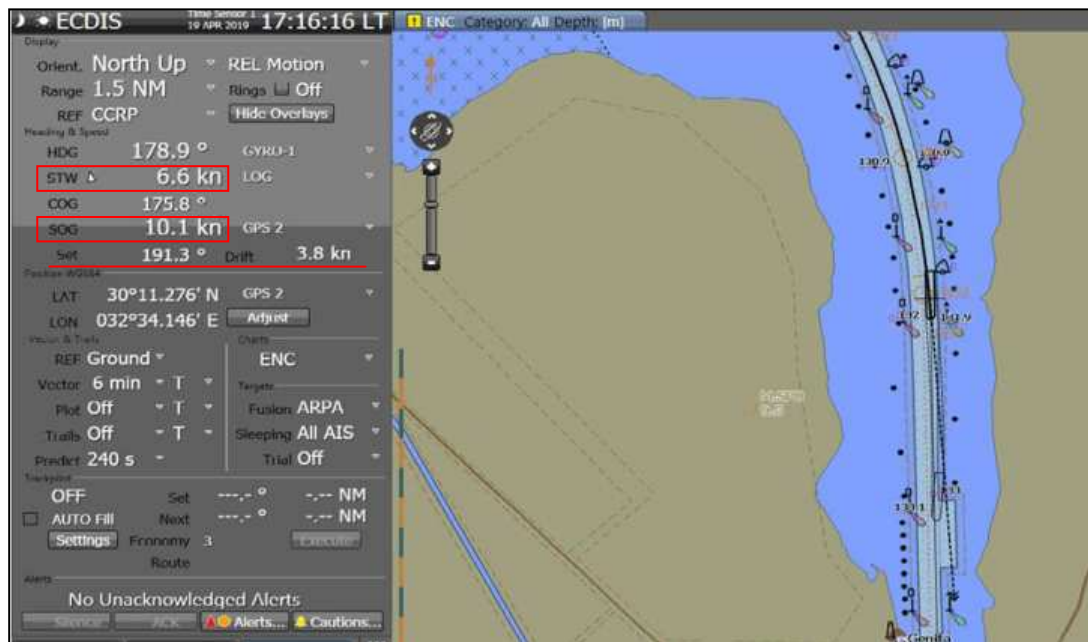


Figure 17: Vessel experienced a sudden increase of drift

In accordance with the SCA Rules of Navigation, the average peak tidal stream¹² is about 2.2 knots; however, in spring tides, the tidal stream may reach a rate of four knots. It so happened that on the day of occurrence, the moon's phase was full moon, producing the effects of spring tides on the Suez Canal.

While rounding the bend, the vessel was noted to come closer to the Eastern bank. In the absence of concrete evidence whether the keeping of the vessel's course to the Eastern bank was intentional or not, the MSIU suggests that the marked increase of drift was, most probably, not taken into account while executing the turn.

¹² Vide footnote 5.

This increase in drift was most likely caused due to any one or both of the following:

- the South-going stream was enhanced by the spring tide; and
- the increase in the velocity of water flowing from Little Bitter Lake to a narrower section of the Canal.

2.5 Speed & Squat Effect

The Rules indicated that vessels similar in size to *APL Danube* are allowed to transit at a speed of 8.6 knots¹³. However, the rules did not specify whether the indicated speed was STW or SOG¹⁴. The Admiralty Sailing Directions NP 64, paragraph 2.61, established that the normal speed of vessels in the Canal was 7.5 knots through the water. Furthermore, the Company's SMS section on the Suez Canal Transit¹⁵ cautions the masters that the transit speed in the Canal was limited to 9.5 knots, although it had to be adapted to the circumstances and the behaviour of any vessels ahead. During the course of the safety investigation, the Company explained that the transit speed had been established based on experience and a meeting held with the Suez Canal Authorities, a few years prior to the accident. It was also confirmed that the speed quoted in the SMS procedures referred to SOG.

Before the occurrence, the engine was set on 36 rpm, slightly above slow ahead (35 rpm). The vessel was making a ground speed of 10 knots and her speed through the water was around 6.6 knots. The speed was set on the basis of the prevailing situation, the required transit speed in the Canal, and also to allow the vessel to have enough manoeuvrability with the tidal stream that she was experiencing.

The speed was also important because of potential dangers of vessel's squat. Squat is the effect of lesser water passing under the vessel's hull. This happens due to the water flow being restricted when the vessel is in shallow waters (Figures 18a and

¹³ SCA Rules of Navigation Section II Art., 54 – Transit Speed. The rules actually stipulate a speed of 16 kmhr⁻¹.

¹⁴ During the consultation period, the Company advised that during its last meeting with SCA on the 03rd March 2020 in Ismaïla, it was explained by SCA chief pilot that the maximum speed for the type of vessel such as *APL Danube* was 16 km/h (8.6 knots). The Company further submitted that this speed was the maximum average speed over ground for the transit and therefore, whilst the speed can exceed 16 km/h, the average speed shall be below this value.

¹⁵ Card No. Bridge - 161.

18b), which causes an increase in the water's velocity passing beneath the hull and consequently a loss in pressure (Venturi effect), which results in an increase in the vessel's draft and a trim by the head or stern. The main factors which contribute to squat are the vessel's block coefficient and her speed through water.

In fact, with the speed through the water with which the vessel was proceeding, it would have resulted in a squat (Figure 18b) of about half a metre, thereby increasing *APL Danube*'s draft by the same amount. Although squat did not contribute directly to the vessel's loss of steerageway, it would have caused the vessel's bow and stern to touch the bottom earlier than expected.

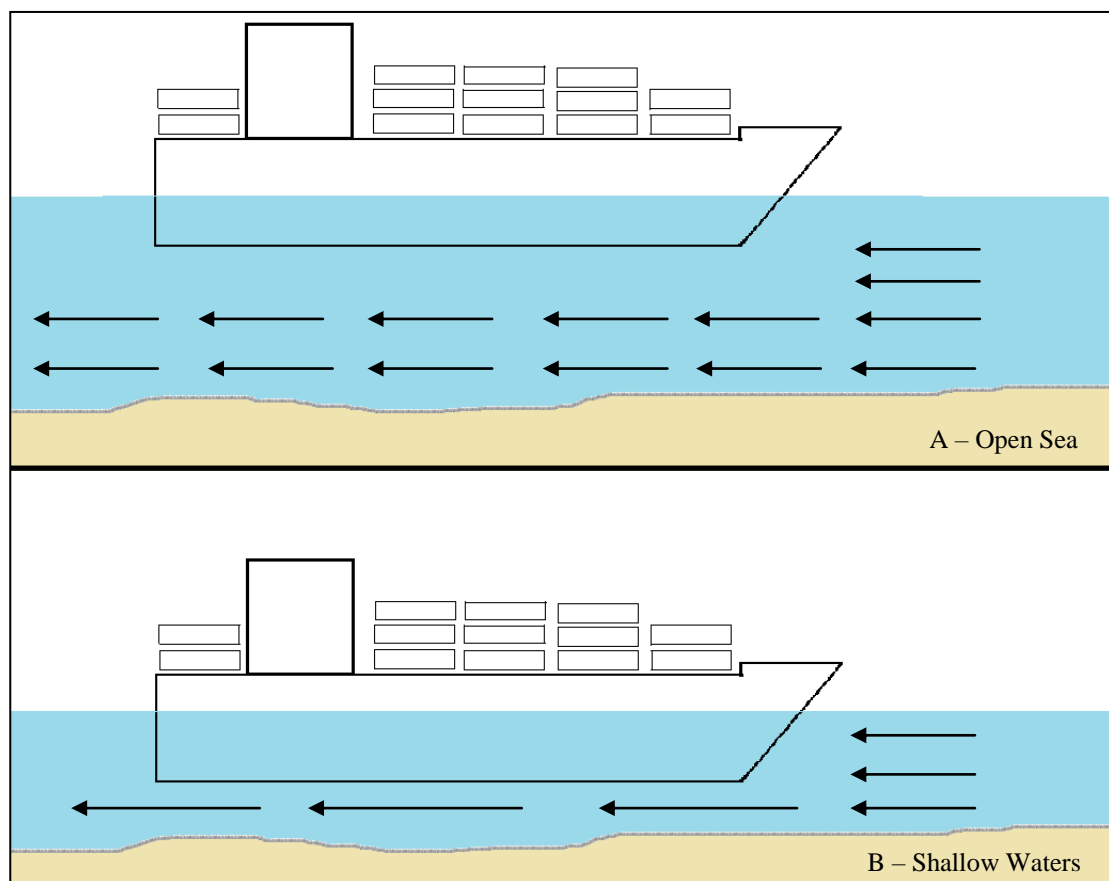


Figure 18: Squat effect

2.5 Initial Grounding

At 1721:06, an alert¹⁶ activated, indicating that the water speed was invalid, thus confirming to the bridge team that the bow had touched the bottom of the Western bank¹⁷.

The main engine was running on full astern and, at around 1721:21, the vessel was making a sternway of about one knot. At 1721:38, while the port anchor was dropped, and the vessel was positioned in between the Western bank and the corner of the garage in the Eastern bank (Figure 19).

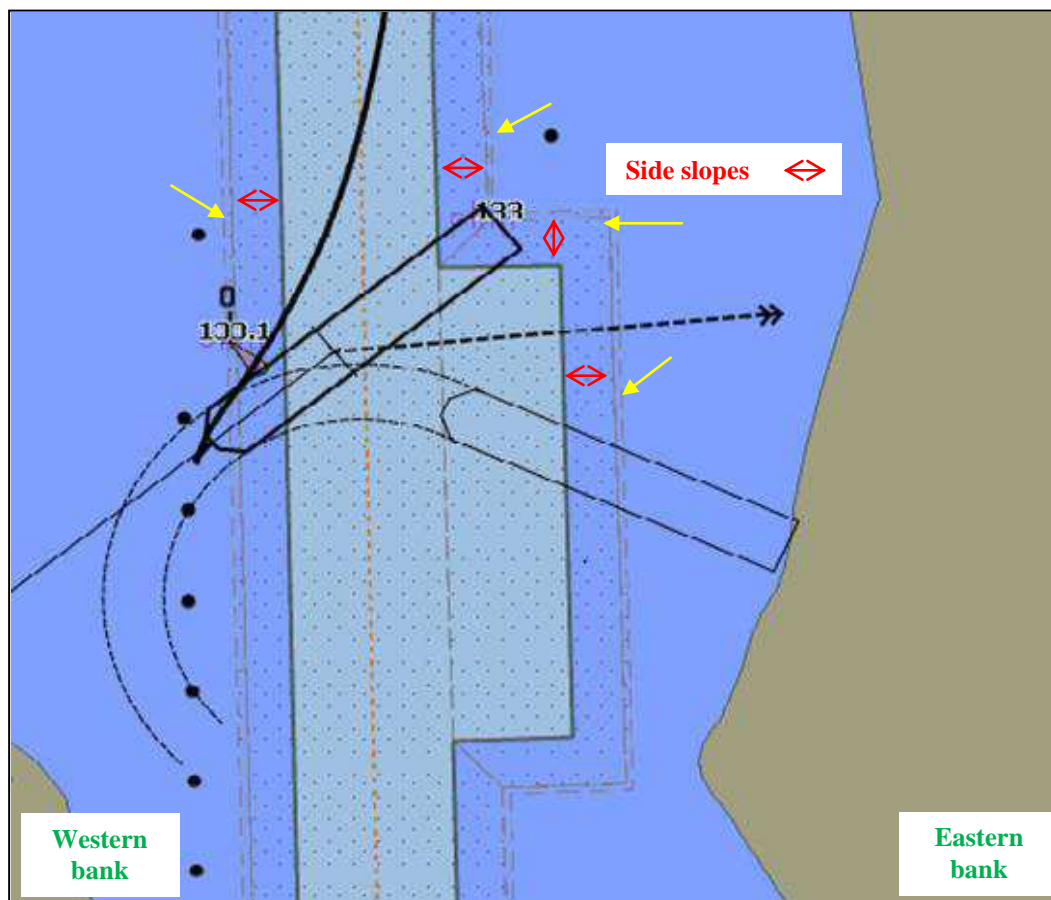


Figure 19: 1721:46 ECDIS extract – showing the position of the vessel in relation to the canal. The yellow arrows indicate the line on which lateral marks have been positioned – in this Southern part of the canal, the depth on this line were estimated to be 9m (vide Figure 4).

The safety investigation was particularly interested in the stern's position in relation to the channel, during this period. *APL Danube* was drawing an aft draft of 14.80 m and the buoyed line on the chart indicated an approximate depth of 9.0 m. Therefore,

¹⁶ The alert was automatically recorded in the engine-room alarm log.

¹⁷ The speed log sensor is located in the bow area of the keel, at frame 340 (the forward most part of the vessel ends at frame 367).

it is probable that, at this stage, the vessel's rudder and propeller were already in contact with the Eastern bank (Figure 20).

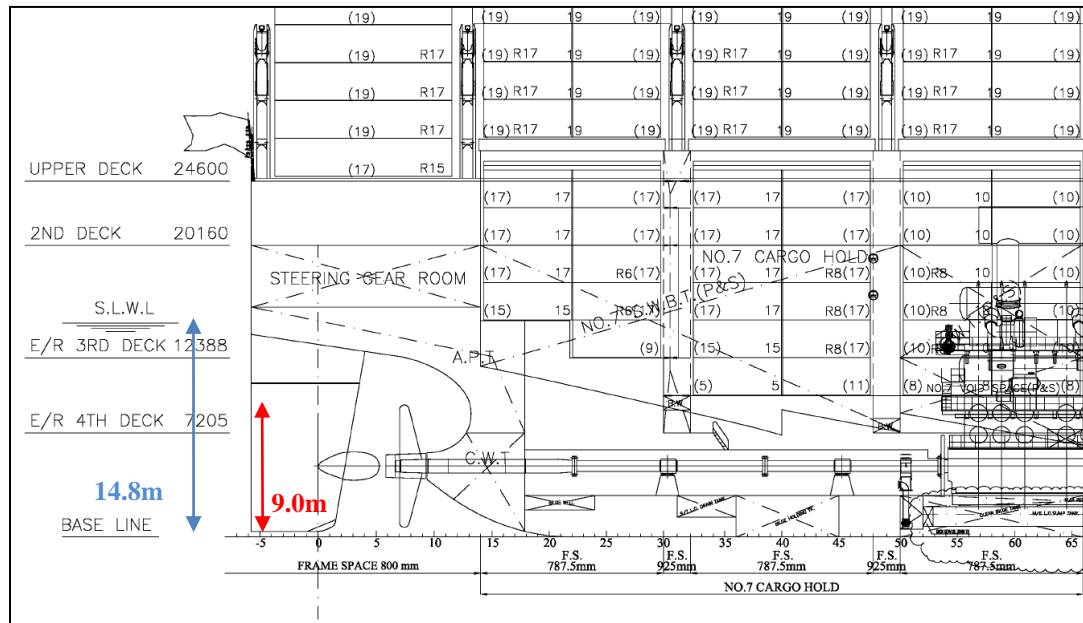


Figure 20: An extract from the General Arrangement Plan, showing the relation of the vessel's aft draft (blue) to the depth of the channel's slopes (red)

Furthermore, considering that the vessel's bow was still swinging to starboard (heading changed by 10° to starboard in between 1721:46 and 1722:46), and the stern was swinging to port, the rudder was already experiencing opposing external forces from the side slope of the garage. It is the conclusion of the safety investigation that the rudder had started to bend at this stage.

2.6 Further Grounding by the Stern

As was previously stated, the vessel's stern was already in contact with the Eastern bank when the bow had grounded (1721). The vessel's engine was set on full astern from 1719:37 until 1723:53, reaching a maximum sternway of three knots during this period. Throughout this time, it was evident that the bridge team, including the pilot, were focused on getting the bow off the Western bank. This was indicated in the insistent queries of the pilot to the bridge team, to know whether the vessel was making sternway or not, the dropping of the port anchor and the readiness of the bow thruster. In the meantime, it seemed that no one on the bridge was attentive to the position of the vessel's stern.

In the absence of concrete evidence, the safety investigation hypothesized that this crucial point may have been overlooked due to:

- the bridge position being set 173m forward of the stern (which was loaded with containers), in the absence of a lookout aft, it would have been difficult to approximate the position of the stern visually from the bridge; and/or
- the location of the vessel at the time of grounding gave a false visual impression to the bridge team and pilot, because the dredged channel was surrounded by shallow water as opposed to land surrounding the dredged channel in other areas.

In the engine-room, several alarms were activated while the engineers on duty observed that a ‘crash astern’ had been ordered by the bridge. All the engineering officers reported that an abnormal vibration was felt during this manoeuvre.

Although the telegraph setting at 1722:52 was full astern, the engine rpm had settled on -38 from -57.1 and the speed had dropped from three knots astern to 1.1 knots astern. It was only later that the telegraph was placed on ‘stop’ by the master. This suggested that there was external interference in way of the turning propeller. The VDR data revealed that during this time, the rudder angle indicator was recorded going from midship to hard-to-starboard. The engineering officers reported that the emergency switchboard breaker had tripped due to an overload. The safety investigation was of the view that this was due to the vessel’s rudder being forced against the Eastern bank slope; additional opposing forces, through helm orders were applied to the steering gear mechanism, resulting in extensive damages and the eventual failure of the steering gear.

It was evident that the bridge team was not aware, until much later, that the vessel had ran aground by the stern. At 1731:32, the master was still under the impression that there was 6.8 m of UKC at the stern, since the aft echo sounder was displaying this depth. This might have misled the master, since the aft echo sounder is placed well forward of the vessel’s aft perpendicular (approximately 70 m). Much time was used in attempting to restart the main engine and to operate the steering gear to proceed with the voyage. Indicative of this were the late depth soundings (Figure 12) taken by the crew at 1840.

2.7 Planning and Monitoring of the Passage

During the course of this safety investigation, it was noted that while the passage plan was prepared for a voyage from Port Said to Light float No. 2, the charts were listed in a reverse order, as if for a North-bound passage. Moreover, NP 202 (Admiralty Tide Tables, Volume 2 – North Atlantic Ocean and Arctic Regions) was listed in the passage plan, which was not relevant for this voyage. This led the safety investigation to believe that the passage plan was not specifically planned for the voyage intended.

It was reported that the planned route was deactivated on ECDIS. The motive behind this was to accommodate the first Canal pilot who preferred the plotted course and waypoints on the ECDIS and RADAR screens¹⁸ to be removed. Once the first Canal pilot had disembarked at 1415, the bridge team did not reactivate the planned route. During the course of the safety investigation, it was revealed that the Master had no difficulty in monitoring the vessel's position in Suez Canal and he was still able to follow her in real time on ECDIS and Radar. Once a route is deactivated, on an ECDIS, the monitoring feature is not engaged, thus any subsequent alarms and warnings related to the passage are disabled on that ECDIS. This was also the case on *APL Danube*. However, while alarms such as the anti-grounding alarm would have been relevant, the cross track error alarm would have been irrelevant. This would be because the minimum cross track limit setting available on *APL Danube*'s ECDIS was of 0.1 nm, whilst the width of the Suez Canal in the area of the occurrence was 0.13 nm.

Information also indicated that the route was not activated on the second ECDIS, thus suggesting that an important safety barrier system in the form of the anti-grounding alarm had been deactivated. This safety investigation endeavoured to clarify why the action of deactivating the route was taken by the bridge team, in lieu of removing the route from the radar display, which the pilot was using. According to the revised performance standards for radar equipment, a function for removal of any simple maps/navigation lines/routes *etc.*, should be available. However, neither could the

¹⁸ Although the Company stated that the first Canal pilot did not wish to see the plotted lines on both the radar and ECDIS screens, the MSIU is of the opinion that it was only the radar screen that the pilot wanted de-cluttered. This is because the ECDIS screen remained with the dashed lines from the deactivated route.

MSIU conclude why the bridge team opted to deactivate the route, instead, nor could the Company assist in providing an explanation on this matter.

Although the passage plan made references to both the Admiralty Sailing Directions NP 64 and the SCA Rules of Navigation, the plan neither indicated the expected current, nor the expected tidal streams at the different sections of the canal. Although extracts from the Admiralty Tide Tables for Port Said and Port of Suez were attached to the passage plan, these did not give a complete picture of the tidal streams which would be experienced during her passage. Furthermore, the tide tables indicated that a considerable tidal stream should have been expected due to the spring tide (full moon on that day).

During the safety investigation, it was revealed that it was not customary for CMA CGM vessels to have the tidal stream/currents reflected in their passage plan. The Company expected that the Suez Canal pilots would be aware of these.

2.8 Bridge Team and Pilot Relation

The pilot arrived on the bridge at around 1412. As soon as the first Canal pilot left, he immediately turned to the master in a heated approach because rather than an officer, it was the deck cadet who had escorted him from the pilot ladder to the bridge. The master tried to calm the situation down by admitting an omission from his end. Evidence indicated that this continued for several minutes, following which, the pilot eventually performed his role as advisor to the bridge team in a calmer manner.

The Company had incorporated guidelines on transiting the Canal in its SMS and which included a list of measures, to be followed by the masters when working with the Suez Canal pilots. However, it may have not been possible for the master to follow them at the time. When the Canal pilot boarded, the vessel was already in passage through the Canal. Reporting the pilot's behaviour to the Suez Canal authority by VHF (as indicated in the SMS), would have, most likely, worsened the (already tense) situation between the master and the pilot. This would have most likely delayed in the vessel's transit through the Canal, affecting the convoy of vessels behind. Even though, in the interest of safety, a delay would have been acceptable,

the master seemed to have opted to attain a calm situation and proceed with the voyage.

Although, not directly contributing to this occurrence, this situation was believed to have had an effect on the bridge team and pilot relation and, subsequently on the dynamics of the events leading to the grounding.

Documentary information provided to the MSIU indicated that the master / pilot exchange was carried out at 1415 *i.e.*, shortly after the pilot arrived on the bridge, however, this was not captured on the VDR. Taking into account the circumstances of this accident, the safety investigation, however, concluded that the lack of a master and pilot exchange was not a contributory factor to this occurrence.

2.9 Actions of the Bridge Team and the Pilot

At the time of the occurrence, the master, the chief officer, the third officer, the helmsman and a Canal pilot were on the bridge. The chief officer was not part of the bridge team. It was reported that he went on the bridge to relieve the master. The master opted to remain on the bridge. The chief officer also remained on the bridge a while longer to discuss matters on the vessel's maintenance. VDR audio recordings suggested that the chief officer entered the bridge at around 1651. Following this, the master had moved away from the bridge console, ECDIS and radar, and went further to the starboard side to discuss maintenance with the chief officer.

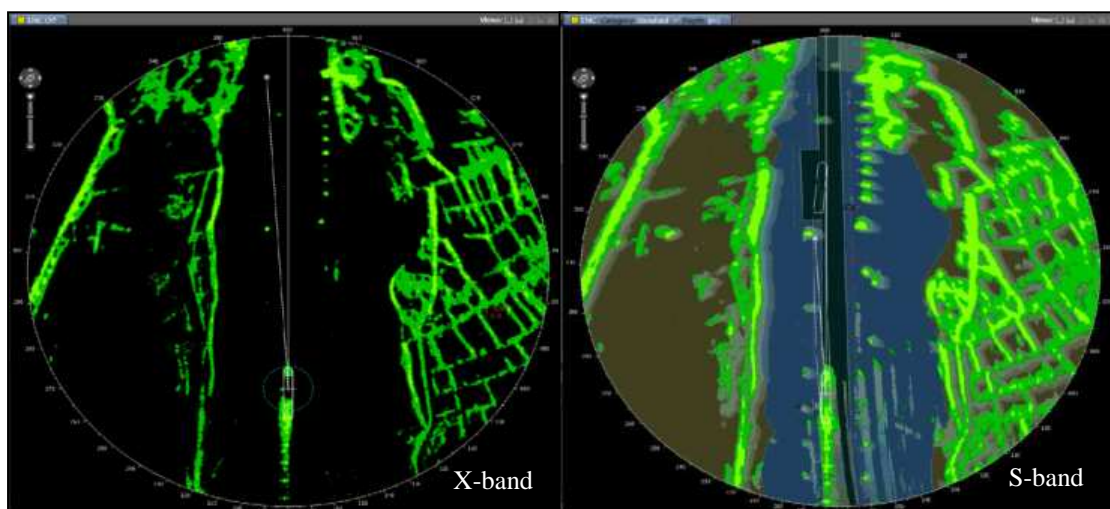
The pilot was directing the helmsman to steer courses which were roughly increasing by two degrees to starboard, at various intervals, after rounding the bend (Figure 17). At this stage, the vessel was already off-centre to port from her planned route. From 1715 onwards, the helmsman was applying port helm to steady the vessel's heading and at times, the rudder was also placed hard-to-port for the same reason. This suggested that the vessel was experiencing a bank effect much before the helmsman had reported difficulty in steering, however, these cues were not picked up by the bridge team.

At that time, the master was engaged in conversation with the chief officer and was following the vessel's progress visually. As he was away from the bridge's console,

he was not in a position to completely ascertain the vessel's planned passage. Visual monitoring of the vessel's progress was necessary, although by its own, it would not be sufficient; effects on the vessel, such as an increase in drift, would be difficult to deduce without the proper equipment. Therefore, the safety investigation concluded that the situation, as perceived by the master, standing away from the bridge console did not reflect the actual situation of the vessel.

The third officer's exact position on the bridge was not known; however, he was reportedly standing next to the helmsman. Assuming that as a look out, he was not stationary, he would have had a clearer view of the situation than the master. Nonetheless, it seemed that he was neither alarmed by the vessel's proximity to the Eastern bank, nor was he aware of the same. These hypothesis were drawn up in the absence of evidence which would indicate that the third officer had brought this to the attention of the master or questioned the pilot in this regard. However, the safety investigation did not exclude the possibility that he was either influenced by the initial situation which had occurred between the pilot and master, and/or he completely relied on the pilot for the navigation of the vessel. The pilot's constant advise for course alterations to starboard, may have been indicative that the situation was under control.

The pilot was positioned behind the X-band radar screen, on the port side of the bridge console. Figures 21a and 21b show the radars' displays at 1717:01, just before the vessel experienced the sheer to starboard.



Figures 21a and 21b: Displays at 1717:01. The figure to the left (21a) shows the display of the X-band radar and that on the right (21b) shows the display of the S-band radar

At this time, the pilot was advising for the vessel to be steadied on a heading of 180°. As indicated in Figure 21b, the vessel's position in relation to the navigable channel was prominent on the S-band radar, due to the ENC chart being overlaid on the display screen. On the X-band radar, the vessel's position in relation to the navigable channel is not clear. It may be claimed that due to this, the pilot was probably not aware of the vessel's exact position in relation to the navigable channel. Additionally, the sudden increase of drift of up to 4.0 knots might therefore not have been counteracted by the pilot.

2.10 Fatigue and Alcohol

The master started his work at 0800 on the morning of 19 April. He had previously rested for a total of 16 hours while the vessel was berthed at Port Said. Shortly before the grounding, it was reported that the chief officer offered the master to relieve him for a short break, however, the master insisted that he was still fine and that he intended to remain on the bridge until exit from the Suez Canal. Both the third officer and the helmsman had adequate hours of rest prior to the occurrence. There was no evidence which indicated that the bridge team was displaying signs of fatigue; therefore, fatigue was not considered to have contributed to this occurrence. Records of the hours of rest for the crew involved, prior to the occurrence, were in line with the requirements of the STCW Code and MLC 2006.

An alcohol test was also carried out on all crew members involved. All tests returned a negative result.

2.11 Previous Marine Incident

On 29 March 2019, under the same master, the vessel had also experienced a sheer to starboard while Northbound through the Suez Canal, just before passing Bur Fouad Peninsula (Figure 22), which was deduced to have been caused by bank effect.

The Company was notified about this marine incident by the master; however, the investigation and analysis had not yet been completed at the time of the vessel's grounding on 19 April 2019. Given that this marine incident was still under investigation, measures to prevent recurrence had not yet been identified and

implemented. Taking into consideration the scope behind the analysis of such occurrences, even in terms of Section 9 of the International Safety Management Code, the unavailability of the internal investigation's findings on board may be also considered to be a missing safety barrier.

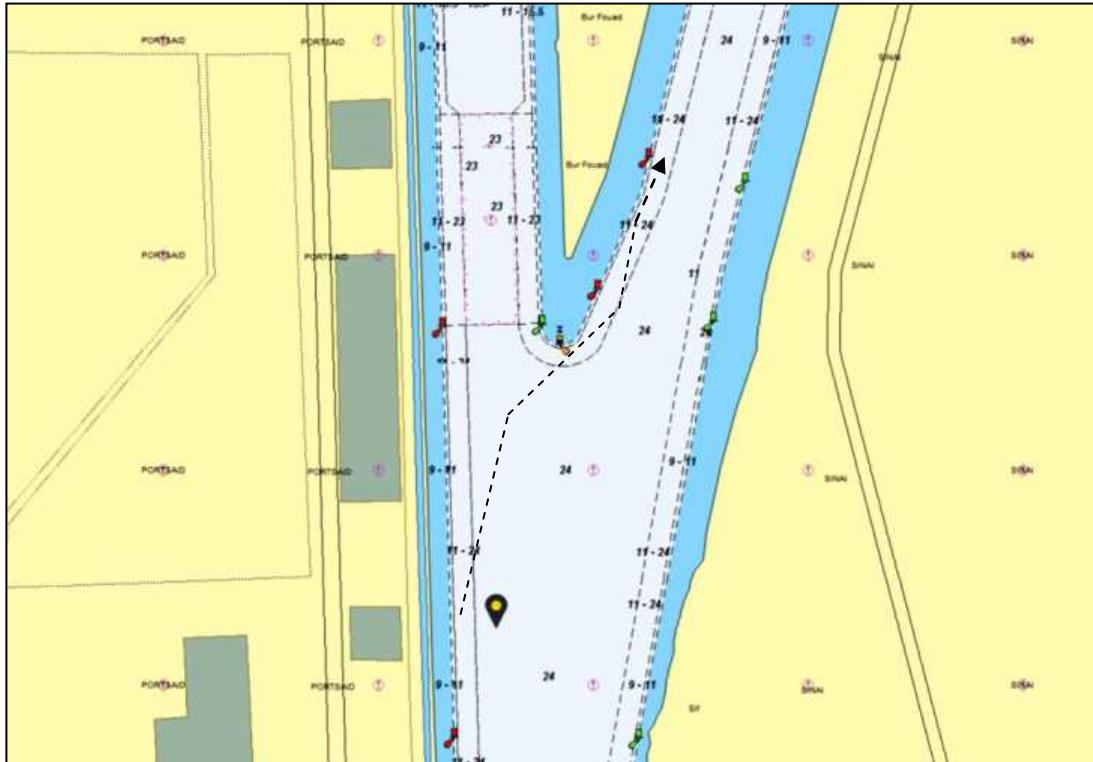


Figure 22: An approximate reconstruction of the path taken by APL Danube on 29 March 2019
(Adopted from the EMCIP)

THE FOLLOWING CONCLUSIONS, SAFETY ACTIONS AND RECOMMENDATIONS SHALL IN NO CASE CREATE A PRESUMPTION OF BLAME OR LIABILITY. NEITHER ARE THEY BINDING NOR LISTED IN ANY ORDER OF PRIORITY.

3 CONCLUSIONS

Findings and safety factors are not listed in any order of priority.

3.1 Immediate Safety Factor

The vessel suffered loss of directional power due to bank effect, since she was in close proximity to the Eastern bank of the Suez Canal.

3.2 Latent Conditions and Other Safety Factors

- .1 The preventive measures following the marine incident caused by bank effect, which had occurred on 29 March 2019, had not yet been identified and implemented at the time of grounding;
- .2 The route on the ECDIS had been deactivated and consequently, the monitoring feature alarms, including the anti-grounding alarm, were disabled;
- .3 It was not excluded that the master / pilot interaction was adversely affected by the initial confrontation on the bridge between the master and the pilot;
- .4 No corrective action was taken while the vessel was closing in on the Eastern bank, indicating that the bridge team was not alarmed by the developing situation;
- .5 The master was away from the console and discussing ship maintenance with the chief officer during the critical period of the ship's manoeuvre;
- .6 The sudden increase of drift experienced by the vessel was most likely not taken into account during the alteration of course, which influenced the vessel to drift closer to the Eastern bank;
- .7 Following the initial groundings of the vessel, she also ran aground by the stern, resulting in severe damages to her propeller and rudder.

3.3 Other Findings

- .1 The vessel's SMS did not specify that the designated escort for the pilot had to be a *Responsible Officer* although being a SOLAS requirement;
- .2 A number of items in the passage plan indicated that the plan was not specifically prepared for the voyage intended. The chart sequence reflected a Northbound voyage and a tidal publication for the North Atlantic was listed under the publications to be consulted;
- .3 The passage plan was not prepared from berth to berth but from Port Said, Egypt, to BR No.2 Lt Vessel in Suez Bay. The vessel's next port of call was Jeddah, Saudi Arabia;
- .4 Form E of the Safety Equipment Certificate and the Record of Approved Ship Safety Equipment did not agree in terms of back-up arrangements for the ECDIS;
- .5 The speed of the vessel was not considered to have been a contributing factor to the grounding, as it was considered necessary to maintain steerageway;
- .6 The squat, which was induced with the vessel's speed through the water, was not considered to have been contributory to the vessel's loss of steering.

4 ACTIONS TAKEN

4.1 Safety Actions Taken During the Course of the Safety Investigation

During the course of the safety investigation, the Company had carried out an internal investigation in accordance with the requirements of the ISM Code. Information with regards to the grounding of *APL Danube* were shared with all vessels within its fleet, in the form of safety alerts and accident feedback.

The Company's internal investigation report was shared with the Company's marine superintendents and training centres.

The hours of rest procedures that were incorporated in the SMS, were revised to include delegation of the con while the vessel was on passage through a long canal transit. This would allow / necessitate the chief officer to take over the con and for the master to be able to take some rest.

Deck officers were further trained specifically on pilot management and monitoring, bank effect and emergency manoeuvres;

5 RECOMMENDATIONS

In view of the conclusions reached and the safety actions taken by the Company, during the course of the safety investigation,

CMA CGM Ships are recommended to:

08/2020_R1 Include a section for ‘contingency plans’ in the master / pilot exchange checklist, to be discussed during the exchange;

08/2020_R2 Update the SMS of all vessels within its fleet to specify that a responsible officer is to supervise the rigging of the pilot ladder, the pilot’s embarkation and disembarkation and to escort the pilot to the bridge;

08/2020_R3 Instruct all deck officers serving on board fleet vessels to use the symbol removal function from the radar display, when pilots request the route to be removed from the display, rather than deactivating the ECDIS route;

08/2020_R4 Display, next to the echo sounder monitors, an indication of the transducers’ positions in relation to the extremities of the vessel.