



Marine Safety Investigation Unit



Transport Malta



MARINE SAFETY INVESTIGATION REPORT

**Safety investigation into the mooring equipment failure and
subsequent fatality of a Shipyard worker
on board the Cyprus registered ro-ro passenger**

GALAXY

**in Valletta, Malta
on 18 January 2016**

201601/024

MARINE SAFETY INVESTIGATION REPORT NO. 02/2017

FINAL

Investigations into marine casualties are conducted under the provisions of the Merchant Shipping (Accident and Incident Safety Investigation) Regulations, 2011 and therefore in accordance with Regulation XI-I/6 of the International Convention for the Safety of Life at Sea (SOLAS), and Directive 2009/18/EC of the European Parliament and of the Council of 23 April 2009, establishing the fundamental principles governing the investigation of accidents in the maritime transport sector and amending Council Directive 1999/35/EC and Directive 2002/59/EC of the European Parliament and of the Council.

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The objective of this safety investigation report is precautionary and seeks to avoid a repeat occurrence through an understanding of the events of 18 January 2016. Its sole purpose is confined to the promulgation of safety lessons and therefore may be misleading if used for other purposes.

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LIST OF REFERENCES AND SOURCES OF INFORMATION

Crew Members MV *Galaxy*

Palumbo Shipyards personnel

Pilot on board MV *Galaxy*

GLOSSARY OF TERMS AND ABBREVIATIONS

cm	Centimetre
Gt	Gross tonnage
kW	Kilowatts
LT	Local time
m	Metres
mm	Millimetre
MSIU	Marine Safety Investigation Unit
MV	Motor vessel
No.	Number
RINA	Registro Italiano Navale
Ro-ro	Roll-on roll-off
RPM	Revolutions per minute
SMC	Safety Management Certificate
SMS	Safety management system
S.p.A.	Società per Azioni
VHF	Very high frequency

SUMMARY

On 09 December 2015, MV *Galaxy* arrived in Malta under tow on a single, ballast, unmanned voyage from Piraeus, Greece to the Shipyard. Repairs commenced soon after, with the vessel afloat. On 08 January 2016, she was transferred to graving dock no. 4 for underwater hull inspections and repairs. She was subsequently re-floated and pulled out of the dry-dock on the morning of 18 January 2016 at around 0900 to continue repairs afloat alongside Boat House Wharf.

During the berthing operation, after the move out of the dry-dock, a roller from the pedestal fairlead at the aft mooring station became detached and flew off over the shipside and overboard. In its trajectory, the roller head hit the Shipyard's Assistant Repair Manager who was consequently fatally injured.

The Marine Safety Investigation Unit (MSIU) conducted a safety investigation into the occurrence. The safety investigation revealed that the immediate cause of the accident was the failure of the two 10 mm bolts holding the roller-keep in place, which sheared off under the tension from the mooring ropes.

As a result of the safety investigation, the MSIU has issued one recommendation to the ship owners with the aim of addressing risk management in shipyards.

1 FACTUAL INFORMATION

1.1 Vessel, Voyage and Marine Casualty Particulars

Name	<i>Galaxy</i>
Flag	Cyprus ¹
Classification Society	Withdrawn ²
IMO Number	7358755
Type	Ro-ro passenger
Registered Owner	Moby S.p.A.
Managers	Moby S.p.A.
Construction	Steel (Double bottom)
Length overall	115.35 m
Registered Length	103.0 m
Gross Tonnage	11907
Minimum Safe Manning	Withdrawn
Authorised Cargo	In ballast
Port of Departure	Piraeus, Greece
Port of Arrival	Valletta, Malta
Type of Voyage	Short International
Cargo Information	In ballast
Manning	4
Date and Time	18 January 2016 at 09:25 (LT)
Type of Marine Casualty	Very Serious Marine Casualty
Place on Board	Ship – Poop deck
Injuries/Fatalities	One fatality
Damage/Environmental Impact	None
Ship Operation	Normal Service – Alongside / Moored / Under pilotage
Voyage Segment	Arrival
External & Internal Environment	Daylight, moderate breeze, calm sea and clear skies
Persons on Board	13

¹ Since the accident happened, the vessel has now reflagged and is registered in Italy.

² A Towage Certificate for a single voyage was issued by RINA before the vessel commenced her voyage from Piraeus.

1.2 Description of Vessel

Galaxy, an 11907 gt ro-ro passenger vessel (Figure 1) was built in 1975 in Helsingør Værft, Denmark. She traded under various names and flags, the last being *Banasa* under the Moroccan flag. The vessel's overall length was 115.35 m, had a moulded breadth of 20.50 m and a moulded depth of 6.86 m. *Galaxy* had a summer draught of 4.90 m, corresponding to a summer deadweight of 1560 tonnes. Propulsive power was provided by four, 8-cylinder MAN-B&W 8L 27/38, four stroke medium speed diesel engines, each producing 2720 kW at 800 rpm. The main engines drove two controllable pitch propellers through reduction gearboxes. This arrangement gave a service speed of 19.0 knots.



Figure 1: MV *Galaxy* alongside in the Shipyard

Information available suggested that *Galaxy* had been retired from operations and in August 2015, she was towed to Piraeus where she was laid up. *Galaxy* was then reflagged under the Cypriot flag, being provisionally registered in Limassol and issued with a Non-operational Certificate of Registry on 11 November 2015. She was subsequently acquired by her present owners, Moby S.p.A. of Milan, on 02 December

2015. The new owners' intention was to carry out all the necessary repairs and refurbishment in order to reactivate her.

At the time of the accident, *Galaxy* neither had valid Class nor Statutory certificates.

1.2.1 *Galaxy's* aft mooring station

The aft mooring station equipment (Figure 2) consisted of two mooring winches (one on each side); each winch having a single drum holding a mooring line and a warping drum end. Additional mooring ropes were stored in steel containers close to amidships. The arrangement was identical (mirror image) on both port and starboard side mooring winches.

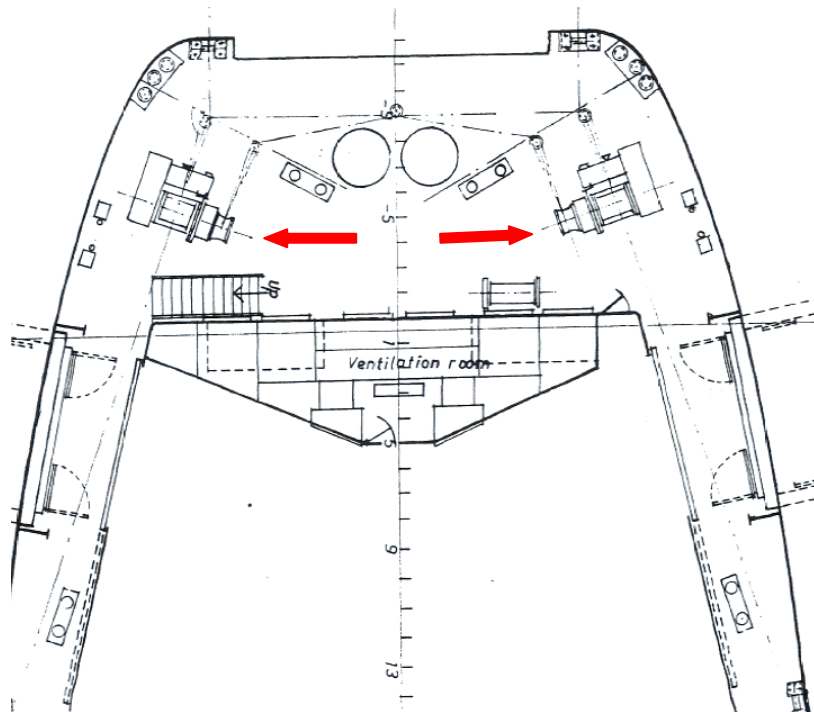


Figure 2: Aft mooring deck

Winch controls were fitted at each ship side and adjacent to each winch, providing the operator with a good view of the lines being handled ashore from the respective side. The design was such that the mooring lines could be led ashore through a chock of three open button-rollers at each quarter and on each side of the stern ramp. In turn, they led onto the mooring winches around two pedestal fairleads; one pedestal fairlead serving the rope on the single-drum winch and another pedestal fairlead (approximately 0.40 m higher than the other) serving the warping drum end (Figure 3).



Figure 3: Open button-roller chock and pedestal fairleads on the aft mooring deck

1.3 The Shipyard

Palumbo Shipyards have their main office in Naples, Italy and have been in the shipbuilding industry since 1967. The Company owns five shipyards and 14 docks, in a number of countries, including Malta. The Maltese Branch (Figure 4) was acquired by the Group in 2010. The Shipyard can accommodate ships up to 300,000 deadweight and has six graving docks and one floating dock.



Figure 4: The Shipyard in Malta

1.4 Persons on Board

The vessel's tow from Piraeus was carried out without crew members on board. Upon arrival at the Shipyard facility, a skeleton crew consisting of a master, chief engineer, bosun and engine rating, joined the vessel to attend to the Shipyard repairs. Both the master and the chief engineer held relevant certificates of competency issued by the Italian authorities. The only limitations were imposed on the chief engineer, whose Certificate of Competency was not valid on board liquefied gas, oil and chemical tankers and passenger ships, other than ro-ro passengers.

At the time of the accident, there were also seven Shipyard personnel on board, including the fatally injured Assistant Ship Repair Manager. The latter was a 27 year old Italian national, who had only joined the Shipyard about one month before the accident. He was a naval architecture graduate and prior to his employment with the Shipyard, he had been employed by a major classification society. The Assistant Ship Repair Manager was attending the vessel as an assistant to the Ship Repair Manager, substituting the latter, who was away on vacation leave at the time.

1.5 Weather Conditions

The wind was Northwesterly, force 5 and the sea state was calm with very low swell while alongside. Air temperature was recorded at 19 °C and sea temperature was 15 °C. Visibility was good.

1.6 Narrative

1.6.1 Towage operation

Following change of ownership to Moby S.p.A., *Galaxy* was subsequently issued with a Towage Certificate by RINA. The Certificate was valid for a single voyage from Piraeus, Greece to Valletta. A number of conditions were imposed, including that the ship had to be unmanned during the transit. The owners had planned a complete refit and refurbishment at Palumbo Ship Repair Shipyard (Malta) for re-entry into service.

The vessel left Piraeus on 04 December 2015 under tow, arriving at Valletta on 09 December, where she was berthed at Palumbo Shipyard facilities for the repairs

and refit. According to her master, repairs were expected to be completed by May 2016.

1.6.2 Events leading up to the accident

Repairs on *Galaxy* started at a layby berth afloat, and she subsequently moved to graving dock no. 4 on 08 January 2016 for an inspection of the underwater section of the hull and repairs. The vessel remained in position until the morning of 18 January 2016. No hull cleaning or painting was carried out since the plan was to dry-dock her again towards the end of the refit when full hull painting would have been carried out. The repairs in the dock were uneventful until 18 January 2016.

The railing around the aft mooring station had been removed during the repairs and replaced by a temporary railing, consisting of a single steel pipe secured by spot welding and clamps to secure to the ship. The deck around all the mooring station was covered with layer of grit which was about 1.5 cm thick. The grit had been left there after grit blasting of the entire superstructure. Markings, safety signs, snap back zones, *etc.*, were neither visible underneath the grit on the deck (Figure 5) nor was marking at the entrance to the mooring station (cautionary signage) noticed by the MSIU.



Figure 5: Temporary railing and grit on the aft mooring deck

1.6.3 The accident

It was planned that on the morning of 18 January 2016, graving dock no. 4 was to be flooded, *Galaxy* refloated, and then berthed alongside Boat House Wharf where repairs would continue afloat. The master recalled that owing to the shortage of crew members, he requested assistance from the Shipyard to provide personnel to man the

mooring stations for the dead-ship move from the graving dock. The master recalled that the Shipyard provided the services of seven of its employees to assist as necessary at the mooring stations. The master, being in command of the vessel, was responsible for the shifting manoeuvre and was assisted by a pilot, who was also on board¹. He also requested two tug boats to assist in the manoeuvre.

In the meantime, the pilot boarded the vessel at 0830. The two tug boats came alongside soon after to assist in the dead-ship move out of dry-dock no. 4. The tug boats were made fast hawser forward and hawser aft. The bosun and four of the Shipyard personnel were assigned the forward mooring station, while at the aft mooring station, there was the chief engineer (in charge with the VHF radio), together with the engine rating (who was at the winch controls) and three Shipyard personnel, namely, the Assistant Ship Repair Manager and two welders.

Galaxy was gradually pulled out of graving dock no. 4 and towed to Boat House Wharf where she was moved to starboard side alongside. The berth allocated was not straight and the vessel was berthed in such a manner that close to the forward end, half of the ship's length was overhanging (Figures 6 and 7), with the vessel touching alongside two Yokohama fenders placed one around amidships and another one some 25 m from the stern (Figure 8).



Figure 6: Overhang distance at the forward part of the vessel

¹ The manoeuvre neither fell under the competence nor the responsibility of the Shipyard.



Figure 7: Overhang distance at the forward part of the vessel from a different angle

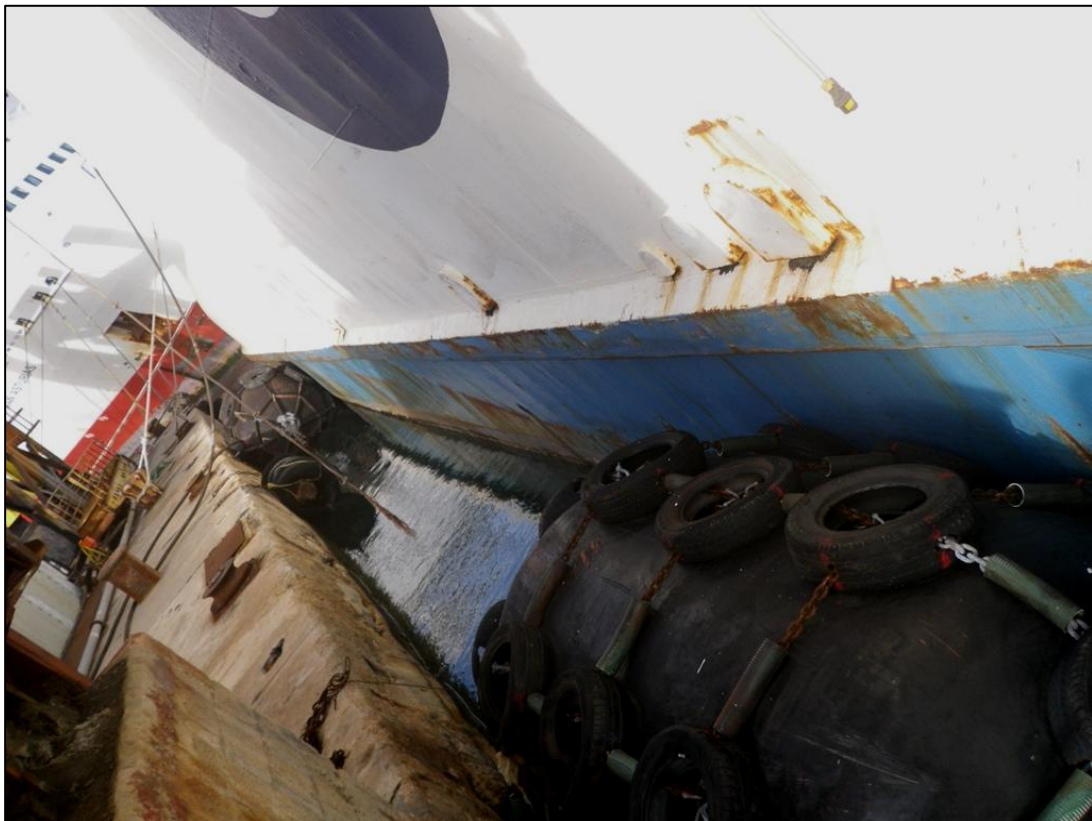


Figure 8: Yokohama fenders between the jetty and the vessel

According to the pilot, once the vessel was in this position alongside Boat House Wharf, the two tug boats were instructed to keep their engines on minimum ahead to maintain the vessel alongside while the mooring lines were being run out and the vessel made fast. The moderate wind at the time was from a Northwesterly direction, which made for a relative wind on the vessel's starboard quarter. It would appear that, in readying the mooring lines for the mooring operation, the loose rope (*i.e.* the one used as a spring) was led from the warping drum end, around the higher pedestal fairlead, and in between the forward-most button-rollers. The rope from the single drum winch (*i.e.* the one used as a stern line) was then run around the lower pedestal fairlead, over the loose rope, and in between the two aftermost button-rollers.

Evidence indicated that the first rope out of the starboard quarter was the one stored on the starboard single-drum winch. It was passed around the lower pedestal fairlead and sent out ashore as a stern rope in between the two aftermost button-rollers. A second rope from the aft was then taken out of the rope storage bin and sent out ashore between the two forward-most button-rollers on the starboard quarter and used as a spring. This resulted in the spring line (higher line) crossing from below the stern line (lower line) (Figure 9).

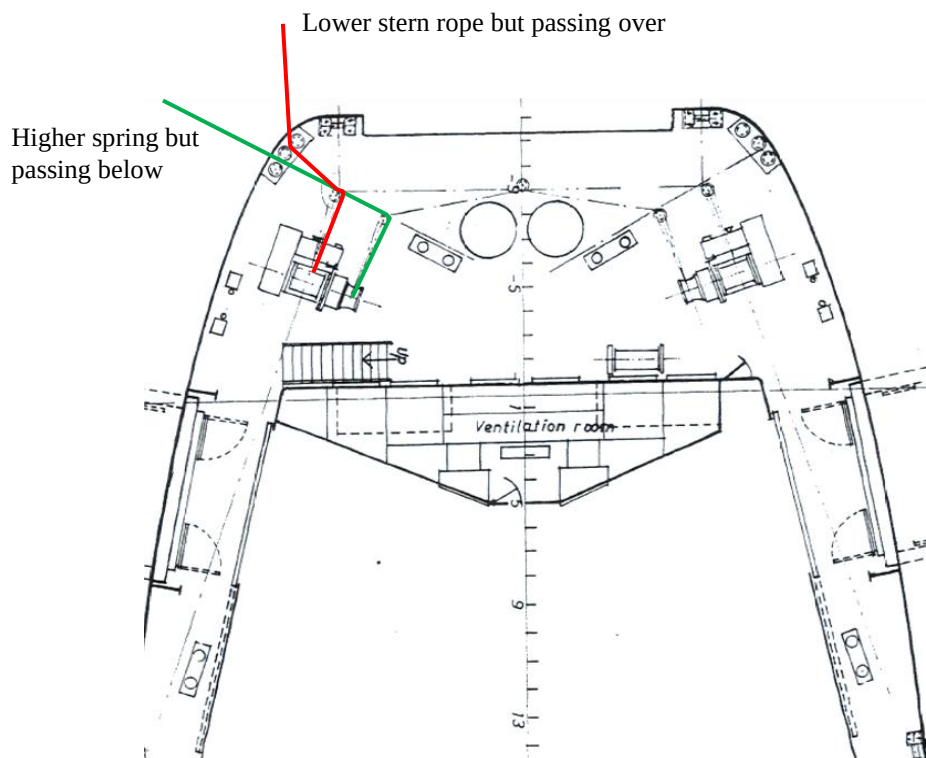


Figure 9: Aft mooring rope arrangement just before the accident happened (green - spring and red – stern line)

At the fore end, a head rope was also run out ashore and made fast. According to the pilot, the crew at the forward mooring station started heaving the slack and continued heaving with what he described as very powerful forward mooring winches. Reportedly, the master tried to order the forward mooring station to ease on the mooring winches but due to breakdown in radio communication with the forward mooring station, the message had to be passed via the mooring men ashore².

It would appear that the fatal accident occurred at around this time. Immediately prior to the accident, the engine rating was at the (aft) winch controls, the chief engineer with the portable VHF radio standing adjacently by the side railing next to the mooring winch, one of the Shipyard workers (welder 1) close to the side button-roller chock and the other Shipyard worker (welder 2) adjacent to the rope storage bins close to amidships. The Assistant Ship Repair Manager was initially close to welder 1 (outside the snap back zone) but then, for some reason, he moved to a position close to the shipside and entered the trajectory path of the lower pedestal fairlead, serving the mooring single-drum winch (Figure 10). The Dockmaster, who was standing ashore, spotted the Assistant Ship Repair Manager and yelled at him to walk clear of the area.

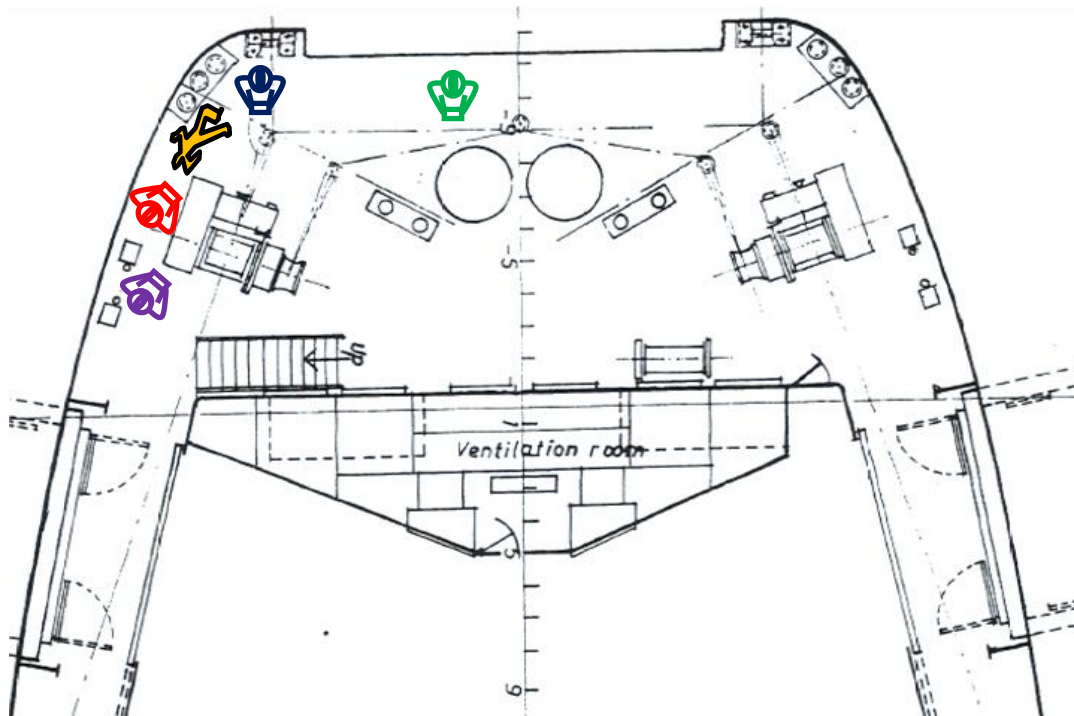


Figure 10: Sketch showing the (approximate) position of persons at the aft mooring station

² The vessel was fitted with an enclosed bridge and therefore it was not possible for any person to walk on the bridge wing and communicate directly with the persons on the forward mooring station.

At about 0925, both the stern rope and the spring came under extreme tension, possibly due to the ship's movement, with the result that the spring (which had inadvertently been led below the stern rope onto the higher pedestal fairlead) became very taut. In the process, this created an upward thrust, acting on the tight stern rope, which was passing out via the lower pedestal fairlead and over the spring. Under this tension, the roller from the pedestal fairlead flew off in a trajectory towards the shipside, fatally hitting the Assistant Ship Repair Manager in his head, who instantly fell on the deck.

1.6.4 Post-accident events

Upon witnessing this, the chief engineer immediately raised the alarm over the radio and the Shipyard emergency services were activated. The Shipyard prepared a crane and a personnel basket to lift emergency personnel on board since the gangway had not yet been rigged. The ambulance, together with Civil Protection Department emergency staff, arrived on scene approximately 10 minutes later. Paramedics were lifted on board and proceeded to the scene of the accident to assist the injured person but it was assessed that he had already passed away. A medical doctor arrived approximately 10 minutes later and certified the Assistant Ship Repair Manager dead. The victim was subsequently lowered from the ship at approximately 1330 and transferred to the morgue at the local hospital.

The hard hat worn by the Assistant Ship Repair Manager at the time of the accident was eventually found ashore on top of grit silo no. 3, about 20 m away. The roller of the pedestal fairlead was not found, presumably ending in the water, adjacent to the aft mooring station.

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 Immediate Cause of the Mooring Equipment on the Poop Deck

The immediate cause of the failure of the roller from the pedestal fairlead was the failure of the two 10 mm bolts holding the roller-keep in place. The bolts sheared off under the tension generated by the mooring ropes. Observation of the state of the failed roller-keep holding down bolts revealed two areas which had clear signs of corrosion (Figure 11). The MSIU was unable to extract the remaining parts of the sheared bolts shown in the figure and therefore no metallurgical tests have been carried out.



Figure 11: Details of the sheared bolts holding the roller-keep

The MSIU did not exclude that surface corrosion, which seemed evident in Figure 11, may have resulted in stress corrosion cracking at the thread. Considering the applied axial force on the thread and the generated high loads, it was hypothesised that the bolts eventually failed at the threads, which were weakened by corrosion.

Studying the layout of the moorings at the aft mooring station, it was noticed that the pedestal fairleads were of different heights above the deck (approximately 0.40 m difference) (Figures 12 and 13).



Figures 12: The two pedestal fairleads showing the different height



Figure 13: The shorter pedestal fairlead (with the missing roller)

This set-up actually necessitated that the mooring rope on the single-drum winch be sent out over the lower pedestal fairlead as spring around the foreword most button-roller on the starboard quarter, while the loose mooring rope (which would have to be hove in tight over the warping drum end) be sent out as stern rope around the aftermost button-roller on the starboard quarter, so that when both ropes are being worked and winched in, they would never cross (Figure 14).

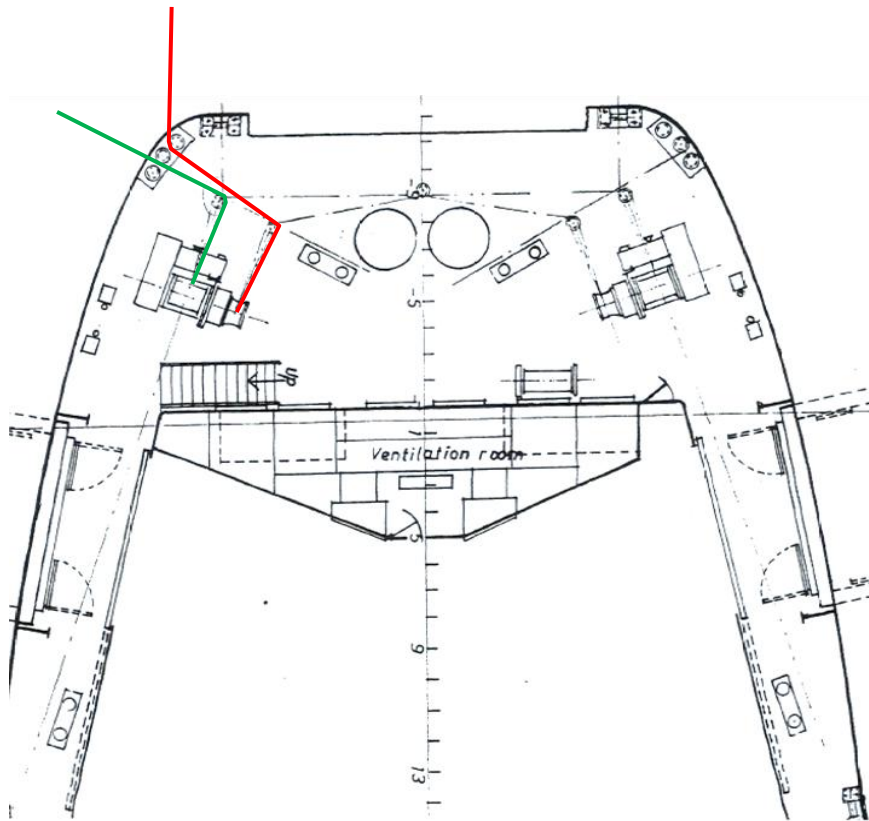


Figure 14: Mooring ropes laid out in a way which avoids crossing (green - spring and red – stern line)

The MSIU believes that this minute but important detail was missed by the persons at the aft mooring station on the day of the accident³.

The tremendous tensile forces on the mooring ropes caused the stern line to become very tight. Moreover, an upward component of the force in the spring line as it was being tightened by the warping drum end, acted on the stern rope passing over it and around the lower pedestal fairlead (Figure 15).

³ Sub-sections 2.4 and 2.5 provide a possible explanation as to why this detail was missed by the persons at the aft mooring station.

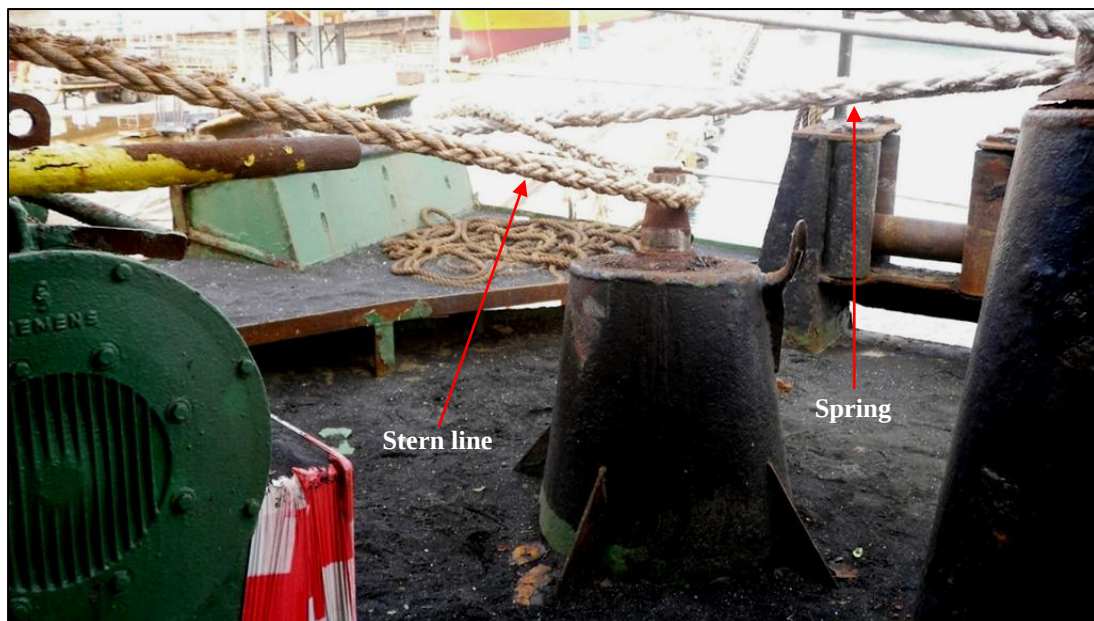


Figure 15: Reproduction of the rope arrangement at the time of the accident (photo taken after the accident)

This upward component of the force was enough to cause the two (weakened) bolts holding down the roller-keep over the lower pedestal fairlead (around which the stern rope was passing) to shear, causing the roller to fly off in a trajectory towards the shipside. The force was created by the difference in height of the pedestal fairleads and the way the ropes were positioned, with the rope on the higher pedestal fairlead crossing below the mooring rope on the lower pedestal fairlead.

The polypropylene mooring ropes in use had a diameter of 100 mm and were in good condition. Despite the considerable stress that they were placed under at the time of the accident, they did not fail / part.

Observations of the rollers at the aft mooring station revealed that although there was considerable rust and heavy scale with paintwork in poor condition, the other rollers at the aft mooring station could rotate freely (Figure 16).



Figure 16: Other rollers at the aft mooring station

2.3 The Vessel Manoeuvre Alongside

The MSIU believes that there were several factors which could have contributed to the stern ropes becoming under tremendous stress while making the vessel fast under those conditions. The Northwesterly wind (force 4 to 5), *i.e.* from *Galaxy*'s starboard quarter (and with the tug boats assisting to keep her alongside) was considered to generate a minor force.

The vessel was assigned a berthing position with a considerable part of it (almost half of her length) overhanging. The overhang resulted from the fact that the berth changed direction away from the ship, from about amidships towards the bow by about 25° (Figure 6). This meant that *Galaxy* was not lying fully alongside and when taking into consideration that the forward-most Yokohama fender against which the vessel was leaning, was positioned approximately adjacent the letter "O" of the name 'COMARIT' painted on the shipside, it meant that the forward half of the ship was overhanging the allocated berth.

Even more, it was considered highly probable that a turning moment could have been created at the time of shifting and which would have caused the ship to swing about the Yokohama fender amidships (serving as a pivot point). The moment about the fender could have been caused by uneven tension on the fore and aft mooring ropes; especially higher tension on the forward mooring ropes, which would have pulled the bow towards the quay and the stern away and causing an increase in tension on the mooring ropes astern. The MSIU considered it very probable that, as stated by the

pilot, the forward ropes were being heaved in too tight and the message from the bridge to the forward mooring station was delayed due to the radio problems, necessitating that the message to stop heaving had to be passed through the mooring men ashore.

Uneven pushing of the tugboats may have contributed to increased forces on the stern rope; however, this was not deemed to be excessive, given that according to the pilot, the tugs were only pushing at minimal power. Another possible force could have been created by the energy stored in the Yokohama fenders which, when pressed hard between the shipside and the quay (especially under the power exerted by the tugs), would have released that energy during the process of regaining its original shape. It was not known which of these forces (or combination of forces) came into play.

2.4 Operations on Board *Galaxy*

2.4.1 *Galaxy's* safety management system

Galaxy was undergoing an extensive refit, including steel replacement, total refurbishment, fitting of new equipment, and machinery repairs. Notwithstanding this work, only a skeleton crew was assigned on board. The vessel had no certification at the time of the accident; with the only certificate being the Towage Certificate, which had expired once *Galaxy* was delivered to Palumbo Ship Repair Shipyard in Malta. As such, at the time of the accident, there was no safety management system in place.

2.4.2 Experience in mooring rope operations

None of the seven Shipyard personnel at the mooring stations on board *Galaxy* had any training in mooring operations. For instance, the employment history of the deceased Shipyard worker did not indicate working experience at mooring stations. Moreover, no briefing on the handling of mooring ropes was provided and the dangers associated with mooring stations were not discussed. During the course of the safety investigation, the Shipyard clarified that the Assistant Ship Repair Manager had not been specifically assigned by it to assist the ship's crew members; it was explained that he was actually on board during the shifting operation and remained at the mooring station without participating in the actual manoeuvre⁴.

⁴ The MSIU did not investigate the operational management of the Yard since this falls within the remit of other National entities.

The crew members at the aft mooring station did not have the necessary experience to handle mooring ropes safely. The normal duties of the two crew members assigned at the aft mooring station were related to the engine-room and thus they had minimal experience of work at mooring stations, if any. This led to a possible situation where the severity of the hazards associated with mooring stations and handling of mooring ropes could not be appreciated.

It is the view of the MSIU that this issue was also manifested during the period of time, closer to the accident. According to the recollections of the crew members on the poop deck, the Assistant Ship Manager was initially standing outside the rope bights, going around the pedestal fairleads. Both Shipyard personnel were also reportedly standing clear of the bights passing around the pedestal fairlead (Figure 10).

It was reported that at one point in time, the Assistant Ship Repair Manager walked from this position towards the shipside railing, between the winch controls and the lower pedestal fairlead, which fell in line with the dangerous trajectory path of the pedestal fairlead. At this time, the mooring ropes must have been under tremendous stress, causing the spring to become very tight, exerting an upward component on the stern rope passing over it and around the lower pedestal fairlead, as described elsewhere in this safety investigation report.

The safety investigation did not have evidence to indicate that the ship's crew members drew the attention of the Assistant Ship Repair Manager on the dangerous position he was standing. The Dockmaster, however, who had more than 30 years of experience, did draw the attention of the Assistant Ship Repair Manager, although the accident happened before the latter was able to walk away from the area.

2.5 Trade-offs and Acceptance of Risk

The MSIU considered the situation to be as such that the options available were very limited in that with a small number of crew members on board the vessel, the choice was to either shift the vessel or postpone / delay the shifting until more crew members were made available.

The scope of a safety management system (SMS) is to achieve safety and protect the people from the complexity and ambiguity of the system. The effectiveness of the SMS is not judged by the safety policies (which were nonetheless suspended in this case) but by the practices applied on board. Since the vessel had no operational SMS, it would have been very unrealistic to expect the four crew members (only two of whom were senior officers) to implement the safety management practices established by the Company's SMS.

The MSIU believes that it would have been extremely challenging for the crew members to achieve safety. It was also determined that it was not possible for them, on their own, to attend to the demands imposed by the excessive work normally generated in a typical shipyard and at the same time represent the operational realisation of the SMS, irrespective of the fact that the SMC had been suspended for some time.

The safety investigation was of the view that although the Company officials must have had experience of ships in shipyards, they may have not anticipated the actual risk involved in this particular ship operation, where crew members had to a complex situation out of necessity.

It was the MSIU's concern that the lack of crew members on board may have been the result of 'production pressure' at the cost of safety, albeit not intended. The concern of the safety investigation was that the crew members on board found themselves in a situation where they had to trade thoroughness with efficiency. It would appear that this was a situation of safety not being a value but a priority and consequently, other pressures eventually took higher priority. If not, then the shifting of the vessel would not have been carried out. This is a typical phenomenon in almost all safety-critical domains.

Safety management of industrial systems (including maritime systems) require the monitoring of safety performance. This may necessitate the use of safety indicators to help anyone involved to monitor the level of safety, motivate action and provide sufficient information for the management to act accordingly. Naturally, the absence of an operational SMS frustrated the possible identification of safety indicators.

It is somehow ironic that when the vessel became more sensitive and exposed to more complexity (given that it was in a shipyard), its SMS had been suspended and non-functional!

Rather than the actions of the crew members or any other person on board or ashore, the MSIU believes that it was precisely the non-functional SMS during a sensitive time which had compromised risk management, *i.e.* the identification, assessment of risk and the allocation of resources in a cost-effective, yet safe manner. The absolute necessity to shift the vessel, irrespective of the limited availability of human resources suggested that the persons involved had no other option but to resort to a ‘quick-fix’ remedy in the form of utilising crew members and Shipyard personnel, who had limited experience in mooring operations, if any.

2.5.1 The aft mooring station and shifting operation

The MSIU has made specific reference to snap back zone markings which were not visible on the aft mooring station where the accident happened. Reference was also made to warning notices at the entrance to the mooring station.

The latter option reflects contemporary industry recommendations – producing a bird’s eye view of the mooring deck to identify potentially dangerous areas. The *impetus* behind this revision is the different mooring rope physical characteristics and variations in mooring rope configurations, leading to snap back zones, which may actually be too complex to be painted on deck.

Irrespective of the location of the warning sign, the latter remains nonetheless a symbolic barrier system, requiring whoever is in the area to interpret the warning in order for the barrier system to achieve its purpose. This is so because while symbolic barrier systems indicate where the hazardous area is, they only indicate a limitation, which may either be respected or not. To this effect, communication is an asset for symbolic barrier systems to function.

Whilst these recommendations provide for more resilience (by considering the entire area as a danger zone), it does require the necessity of analysing the proposed mooring plan and thoroughly assess it for risk to ensure that potential snap back zones and other hazardous areas are identified by the relevant crew members. That is not

necessarily straight forward and it remains to be seen how is it that this will be carried out.

As such, this practice would also require detailed pre-mooring ‘toolbox’ talks to ensure that all participating crew members are aware of the hazards of the snap back zones and other potential areas which may not be safe; more so if cautionary signage is missing. If effective, these talks would also ensure that hazards are clearly communicated.

Even possibly due to the trade-offs explained in sub-section 2.5, there was no evidence to suggest that there was communication between the Assistant Ship Repair Manager and the crew members on the aft mooring station. This problem was further augmented by the presence of crew members on the aft mooring station who themselves either had minimal or no experiences with winches and handling of mooring ropes. It is therefore doubtful as to how much safety information they could communicate to the Assistant Ship Repair Manager.

Per se, this stresses the point raised above on detailed ‘toolbox’ talks, where crew members with the necessary knowledge would be able to exchange safety information and knowledge to other persons prior to the start of a shipboard operation. However, it did not transpire that there were any formal risk assessments, joint meetings (crew members and persons from the Shipyard) and ‘toolbox’ talks before the ship’s mooring operation. That would have ensured coordination of activities, sharing of mental models and communication of risk.

It is the conclusion of the MSIU that there was a message failure on board the ship, where necessary information was not transmitted.

2.6 Emergency Services

The medical response by the emergency services was timely and efficient, but in any case, it did not have any bearing on the outcome of this accident.

**THE FOLLOWING CONCLUSIONS AND SAFETY
ACTIONS SHALL IN NO CASE CREATE A
PRESUMPTION OF BLAME OR LIABILITY.
NEITHER ARE THEY 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

- .1 The immediate cause of the accident was the failure of the two 10 mm bolts holding the roller-keep in place, which sheared off under the tension generated by the mooring ropes.

3.2 Latent Conditions and other Safety Factors

- .1 The safety investigation concluded that tremendous tensile forces in the mooring ropes caused the spring to become very tight and create an upward component of the force acting on the stern rope passing over it and around the lower pedestal fairlead.
- .2 The upward component of the force was created by the difference in heights of the pedestal fairleads and the way the ropes were positioned; with the rope on the higher pedestal fairlead crossing under the mooring rope on the lower pedestal fairlead.
- .3 Observation of the state of the failed mooring roller-keep holding down bolts revealed two areas which had clear signs of corrosion.
- .4 It is probable that surface corrosion may have resulted in stress corrosion cracking at the thread. Considering the applied axial force on the thread and the generated high loads, it was hypothesised that the bolts eventually failed at the threads, which were weakened by corrosion.
- .5 As a result of the berth configuration and the position of the Yokohama fender, a turning moment resulting from the uneven tension on the fore and aft mooring ropes could have been created at the time of shifting and which would have caused the ship to swing about the fender amidships (serving as a pivot point).
- .6 This force was enough to cause the two (weakened) bolts holding down the roller-keep of the lower pedestal fairlead (around which the stern rope was

passing) to shear and the roller of the pedestal fairlead to fly off in a trajectory towards the shipside.

- .7 The necessity (imposed by the mooring arrangement) to have the mooring rope on the single drum winch be sent out over the lower pedestal fairlead as spring while the loose mooring rope be sent out as a stern rope, was missed by the persons at the aft mooring station.
- .8 Communication between the bridge and the forward mooring station was not efficient due to the VHF radio problems.
- .9 No formal risk assessments and detailed 'toolbox' talks were carried out prior to the ship's mooring operation.
- .10 No briefing on the handling of mooring ropes was provided and the dangers associated with mooring stations were not discussed.
- .11 None of the seven Shipyard personnel present at the mooring stations on board *Galaxy* had any training in mooring operations.
- .12 The crew members at the aft mooring station did not have the necessary experience and knowledge to handle mooring ropes safely.
- .13 It was not possible for the four crew members on their own, to attend to the demands imposed on them by the excessive work normally generated in a typical shipyard and at the same time represent the operational realisation of the SMS.
- .14 The crew members on board found themselves into a situation where they had to trade thoroughness with efficiency.
- .15 Although the Company officials must have had experience of ships in shipyards, they may have not anticipated the actual risk involved, in particular with this particular ship operation.
- .16 It was the MSIU's concern that the lack of crew members on board may have been the result of 'production pressure' at the cost of safety, albeit not intended.
- .17 The absence of an operational SMS frustrated the possible identification of safety indicators to help anyone involved to monitor the level of safety,

motivate action and provide sufficient information for the management to act accordingly.

- .18 The non-functional SMS during a sensitive time, had compromised risk management, *i.e.* the identification, assessment of risk, and the allocation of resources in a cost-effective, yet safe manner.
- .19 The absolute necessity to shift the vessel, irrespective of the limited human resources available, suggested that the persons involved had no other option but to resort to a ‘quick-fix’ remedy, in the form of utilising crew members and Shipyard personnel, who all had limited experience in mooring operations, if any.

3.3 Other Findings

- .1 The polypropylene mooring ropes in use were in good condition.

4 RECOMMENDATIONS

In view of the conclusions reached and taking into consideration the safety actions taken during the course of the safety investigation,

Moby S.p.A. is recommended to:

- 02/2017_R1** Ensure that it addresses the safety-critical periods of dry-docking, irrespective of the validity of Statutory certificates.