Report of the investigation into Mooring breakout causing gangway fall from quayside

On board

BLACK WATCH

at Bilbao
on
29th October 2008

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Abbreviations Used In This Report

AB	Able Seaman
BL	Breaking Strain
ºC	Degrees Celsius
ECR	Engine Control Room
GPS	Global Positioning System
GT	Gross Tonnage
IMO I	International Maritime Organisation
ISM	International Safety Management
KN	Kilo Newton’s
Kts	Knots are Nautical Miles per hour
ºT and ºG	Degrees True and degrees Gyro
LT	Local Time
m, m^3, cm	Metres, cubic metres, centimetres
NM	Nautical Miles (1nm=1852 metres)
NTM	Notice to Mariners
OOW	Officer of the Watch
ST	Ships Time
t	Tonnes where (1t=1000kg)
UTC	Coordinated Universal Time
VDR	Voyage Data Recorder

1 SUMMARY

1.1 The cruise vessel BLACK WATCH was berthed at Gexto Pier In Bilbao on 29th October 2008 when in the forenoon watch the winds began to increase and become gusting. The vessel's master took action to improve the mooring pattern forward - the end of the vessel taking greatest impact of the North Westerly wind – but at approximately 14:15 ship's time (UTC + 1) an exceptionally large gust peaking to 50 knots, accompanied by a shift of wind direction to North caused an increase of pitching and rolling movement of the vessel and parting of moorings forward. All of the forward moorings parted with the exception of two lines, one of them a breast line on a drum the other a spring line on bitts that was not contributing to lateral restraint. The brake on the drum rendered to the extreme force and although these remaining lines did not part they were unable to hold the vessel alongside.

1.2 As the vessel's bow swung away from the berth the gangway fell from the quayside and a passenger and AB on the gangway were projected into the seas below. A second passenger who was close to the end of the gangway also fell into the sea.

1.3 Two other passengers on shore were struck by parting rope tails but sustained only minor injuries. There was potential for very serious injury that was fortunately avoided.

1.4 With three persons in the water the vessel's staff responded by throwing life rings to the casualties in the water and preparing to launch the Man-overboard (rescue) Boat. The life rings served to keep casualties afloat until assistance arrived in the form of a harbour boat, which was fast enough to suspend the launching of the vessel's own boat. Further life rings were thrown by shore staff from the pier. One of the casualties – an elderly female – was unconscious. She was kept afloat by the AB.

1.5 The passengers were rescued first and attended to by paramedics ashore before being taken to hospital. The AB was rescued subsequently and after medical checks returned to work on board the vessel. The passengers struck by lines were attended to by ship's medical staff. All have, at time of writing, made full recovery.

1.6 After casualties were removed from the water the vessel was manoeuvred alongside with the assistance of tugs, also by using her own thrusters forward.

1.7 The vessel sailed from Bilbao at 17:54 on 29th October for Honfleur in France after which her next port of call was Dover in UK, where this preliminary enquiry was carried out on 1st November 2008 in Dover.

2 PARTICULARS OF VESSEL

2.1 “BLACK WATCH” is a Passenger Cruise Ship registered at Nassau, Bahamas. The vessel has the following principal particulars:

- Official Number - 8000293
- Call Sign - C6RS5
- IMO Number - 7108930
- Length overall - 205.46 metres
- Breadth - 25.2 metres
- Gross Tonnage - 28613 tons
- Net Tonnage - 11854 tons

2.2 The vessel is powered by four MAN/B&W main engines developing a total of 13240 kW driving two shafts with controllable pitch propellers on each. The vessel is also equipped with two 450kW bow thrusters in tunnels.

2.3 The vessel carries passengers only.

2.4 The vessel was built in 1972 at STX Finland yard in Helsinki and was formerly named ROYAL VIKING STAR (to 1991),WESTWARD (to 1994) and STAR ODDYSEY.(to 1996) At the time of the incident she was owned by Black Watch Cruise Limited and managed by Fred Olsen Cruise Lines, with technical management provided by Fred Olsen Marine Services.

2.5 The vessel was first registered under the Bahamas Flag in 2001 and was entered with Det Norske Veritas Classification Society. At the time she complied with the all statutory and international requirements and certification.

2.6 "BLACK WATCH" was last subjected to a Bahamas Maritime Authority Annual Inspection at the Port of Valetta on 14th April 2008. Observations were made that referred to administrative issues, one of which concerned testing of fire detection systems and the posting of No Smoking signs at the paint locker.

2.7 The vessel had been subjected to Port State Control inspections over the previous year at the Ports of Boston in USA and Auckland in New Zealand, the most recent of which – Auckland - occurred on 22nd February 2008. There are no relevant findings and no outstanding deficiencies from either of these inspections.

3 NARRATIVE OF EVENTS

3.1 All times noted in this narrative are given in the style of the standard 24 hour clock without additional annotation and as local time in the port of Bilbao, which was UTC+1. Other timing is noted in brackets where it differs from this standard. The year to which all references to date relate is 2008.

3.2 A subsequent examination of the vessel's VDR recordings has confirmed detail of the witnesses as being accurate. The voice recordings on the bridge and the vessel's heading were indicative of a very rapid escalation of events.

3.3 The weather at the time of the incident was exceptional from the prevailing conditions of the earlier watch (8 – 12) during which the wind had been from the north west at strength 4 to 5 (Beaufort). At the time of the incident the wind strength had increased to 40 to 50 knots (recorded in the log book as 8 Beaufort but this is an average figure for the hour concerned). The direction of the wind remained from the North West until the time of the incident but then veered to a new direction from the north.

3.4 The tide was flooding at the time of the incident. High Water (Springs) was due to occur at 16:18. At Gexto Pier this meant that a current would have been flowing between the caissons supporting the pier taking the vessel away from the pier and placing the moorings under tension. The half tide conditions at the time would have meant the current was likely to be at its maximum. During berthing on the ebb the vessel had noted a tidal effect across the end of the pier. (see Appendix II)

3.5 Mooring patterns were the same as those used by the Fred Olsen vessel BOUDICCA during an earlier stay at the same berth. BOUDICCA and BLACK WATCH are vessels of similar size and windage characteristics. (See Appendix I for mooring patterns)

3.6 Whilst the tidal current would have influenced the vessel's position after breakout the indications in the evidence, reinforced by VDR recorded events, was that the sudden increase in wind strength was the principal cause of the breakout.

3.7 The wind force was first observed to be gusting at approximately 10:00. Subsequent to that time action was taken, which was not logged, but was estimated by the Master to be at about 11:00 and by the 2nd Officer as 10:30. Moorings forward were adjusted using ship's staff on shore. The two headlines (one WINCHLINE (68.4 tonnes BL) and one Karat Maxi (78.4 tonnes BL)) were shifted to a position further aft converting them into breastlines. This was done to create an improved lateral resistance to the increasing wind force that was shifting to a broader angle on the beam.

3.8 At 12:00 the 2nd Officer, on watch on the bridge noted the wind speed to be increasing and at approximately 14:15 he noted it rose to 40 knots. The increase was intense and sudden enough to cause the vessel to heel and roll, which was noticed in the ship's management office by the Master and other officers working on administration there. The Master noted the occurrence as a squall that changed the wind direction from North West to north – broad on the beam of the vessel, making the angle of interception effectively 90 degrees. The VDR recorder showed the heading to be 277 at this stage.

3.9 At this time the Master also heard sounds which he recognised as the ropes tightening under extreme tension.

3.10 The Chief Officer was in the lower store with crewmembers supervising the moving of paint in the store when, as he and the crew left the store, they heard a loud bang above them. The store was below the forward mooring deck.

3.11 As the Chief Officer left the store hearing the loud bang he heard on the internal radio a message from the 2nd Officer indicating that a mooring rope forward had parted. He could tell from the tone of the 2nd Officer's voice that a critical situation was developing so he went quickly to the bridge, arriving shortly after the Master.

3.12 At the same time the Master had concluded in the office with the Chief Engineer that it was time to start engines and thrusters and both he and the Chief Engineer left for their respective stations – the bridge and the engine control room.

3.13 When the Master arrived on the bridge a few seconds later he noted that the 2nd Officer already had matters in hand, having alerted the engine control room for immediate availability of engines and thrusters, but he was also attempting to call him (the Master), the Chief Officer and the Safety Officer. As soon as he (the Master) appreciated that an emergency was developing he ordered the crew to go immediately to their mooring stations, using the public address (All Ship) system. Evidence of the VDR recording indicates this to have been shortly before 14:12. The situation developed very quickly and most people reacted before these communications reached them. These actions were recorded in the log book as occurring at 14:16 – the time at which the VDR recording indicated that the vessel called the Port Control to inform them of the serious events that had developed. Within the 4 minutes the vessel had completely broken free forward and was now held with the exception of two ropes forward, by the after moorings. (see below). The VDR recording showed a rapid change of heading from 277 at 14:12 to 227 at 14:14. The sound recording also indicated a sudden increase in wind noise immediately before this.

3.14 On his way to the bridge the Chief Officer heard the Security Officer calling "man-overboard" on the internal radio.

3.15 Among the emergency procedures invoked was an order to clear the gangway, which was immediately acted upon but one elderly female passenger was unable to move to safety.

3.16 At the gangway, the Security Officer noted the vessel was moving off the berth when he was alerted by creaking noises from the gangway. He stopped what he was doing on checking passengers in and out by swipe-card and noted that the elderly female passenger was on the gangway. The passenger was about 3 metres inboard of the outer end. The AB on duty at the shore end of the gangway was assisting the passenger.

3.17 The Security Officer, realising that the gangway was sliding towards the edge of the quay shouted to the passenger and AB to make quicker progress towards the shore.

3.18 The vessel's bow moved away from the quayside very quickly. VDR records indicated the heading began swinging from the alongside 277° very soon after 14:12 and had swung through 50° to port by 14:14. After moorings remained mostly intact.

3.19 The gangway outer end quickly reached the edge of the quay, at which point the end dropped and the elderly female passenger and the AB assisting her were projected into the water. A second passenger close to the end of the gangway also fell into the water. This event would have occurred during the two minutes recorded by the VDR above between 14:12 and 14:14.

3.20 After the gangway was hanging in the water from the shell door and the three persons were in the water the Security Officer threw the life ring from the gangway entrance into the water close to the casualties. A second life ring was thrown from the pier.

3.21 The Security Officer saw the casualties in the water and called to his colleague at the gangway entrance to get more life rings and throw them into the water but the vessel was swinging away from the casualties fast. Eventually the vessel settled on a South heading and the gangway entrance was a considerable distance from the scene.

3.22 The 2nd Officer on the bridge noticed a yellow jacket in the water and quickly realised there was a person overboard. At the gangway the same alert was concurrently taking place and that area was reacting to the emergency.

3.23 The Chief Officer, having arrived on the bridge took up station on the starboard bridge wing and saw people in the water.

3.24 The evidence suggests that the first broken mooring escalated to multiple moorings but the witnesses did not testify to seeing subsequent ropes parting. The fact that the vessel moved off the berth verifies that this was the case and subsequently the parted ropes were floating in the water.

3.25 The same applied to the broken lines aft. The master noticed two parted ropes in the water as he was about to manoeuvre the vessel back alongside. This caused him to suspend any operations with the main engines for fear of fouling the ropes.

3.26 The Chief Officer, on seeing people in the water gave orders for the ship’s man-overboard boat to be mobilised. This was carried out immediately and the boat swung out by 14:18 but prompt attendance of police, pilot or coastguard boats overtook events and the ship’s boat was not launched.

3.27 As the bow of the vessel moved off the berth the Master, who was now on the bridge and in command, gave the order for the (starboard) anchor to be let go.

3.28 The Chief Officer on the bridge heard the Master give an order to drop the (starboard) anchor but was uncertain whether he repeated the order to the crew. The order to drop the anchor was audible on the VDR recording at 14:13:18. The order was quickly countermanded by the Master; again this was audible on the VDR recording at 14:13:22. He later testified that he realised that to do so may prolong the wind pressure on the side of the vessel and cause moorings to part aft.

3.29 The Chief Officer could also be heard on the VDR recording at 14:14:02 shouting (from the bridge wing) to the bosun forward not to drop the anchor. In a tense moment it was detected that the bosun had not heard the master’s countermand and was about to execute the original order.

3.30 Soon after these events the bow of the vessel was lying sufficiently off the shore to be taking up a position of equilibrium with the wind pressure, the stern remaining attached to the shore. Eventually the heading settled at 90 degrees off the line of the berth. At 14:18 the VDR recording included a discussion between the master and other officers including the aft mooring station about whether the after ropes were holding by which time the heading was indicating the equilibrium position.

3.31 The Chief Engineer went to the engine control room (ECR) and found that systems were already being activated by the two 4th Engineers and the Electrician on duty in the ECR as a result of the early action of the 2nd Officer, engines were started but soon after one pair were clutched in to be used they were disconnected following the signal from the bridge that the water was not clear due to the presence of broken ropes in the water. The thrusters however were started and used.

3.32 As the vessel swung off the berth the 2nd Officer on the bridge noted a tug passing and called it on VHF Channel 12 (port operations) to request assistance. The tug responded and stood by on the port side of the vessel. He had already alerted pilots and port control at 14:18.

3.33 At 14:20 the medical team were alerted to attend the gangway. At the same time the tug alerted by the 2nd officer was pushing on the port side.

3.34 The pilot boat (according to the testimony of the 2nd Officer) proceeded towards the three casualties in the water and the 2nd Officer noticed that it was heading towards one of the floating broken mooring lines, whereupon he alerted the boat by VHF Channel 12 and the boat took avoiding action, arriving at the casualties soon after.

3.35 The pilot boat had a freeboard that was too high for effective recovery of casualties from the water so a line was passed to the casualties (probably the AB as the others were injured or unconscious). Further assistance arrived soon after with boats of suitable freeboard for recovery of those in the water.

3.36 The vessel was eventually ready to move back alongside, the water having been cleared of casualties and the broken rope tails. Casualties were, according to the log, picked up at 14:25

3.37 The pilot boarded at 14:46 and, with assistance of the original tug on the port side the vessel was manoeuvred alongside in the original position using her thrusters. The gangway, which was still attached to the vessel at its inboard end was hanging down the side of the vessel but the master was able to position the vessel with the gangway between the fenders, which prevented it becoming jammed or damaged.

3.38 A crane arrived on the pier and lifted the gangway clear at 15:28.

3.39 At 15:36 two additional tugs were made fast, one on the after centre lead and one on the port bow. A third tug remained pushing on the port side.

3.40 The vessel was moved off the south side of the pier at 15:52 and moved round to the north side. The vessel was turned so as to pointing east, instead of the original west and this enabled the replacement gangway to be positioned at the starboard shell door, unchanged from the original arrangement except that a shore supplied gangway was used.

3.41 At 16:12 the vessel was all fast with the replacement gangway in position. Passenger boarding resumed.

3.42 Two additional passengers who were on shore at the time of the incident reported with minor injuries in the form of bruising to their lower legs caused by contact with broken ropes. These passengers described their understanding of the situation to the Safety Officer in his report. They kept clear of the gangway, seeing that it was moving towards the edge of the pier. They also described the male passenger who fell to the water as standing on the platform at the end of the gangway.

4 ANALYSIS

4.1 It is clear that the initiating event that escalated to the gangway accident was the reaction of the vessel to the sudden gust of wind at 14:15. The moorings would probably have been under tension from the force of the flood tide beneath the pier but there would not have been any sudden changes in this force.

4.2 It has been calculated using an established wind pressure formula[1] that the load exerted by a 40 knot wind on the beam as it was in this case would be approximately 1735.38 KN or 176.96 tonnes. At 50 knots, which was momentarily experienced at the time of the incident the load increases to 2711.53KN or 276.50tonnes

The formula is:

$$P_w = C_w(A_w \times \sin^2 y) + (B_w \times \cos^2 y) \times V_w^2/1600$$

In which:

P_w is the Wind pressure in KiloNewtons;
C_w is the Wind force Coefficient, which varies according to whether the wind is bow on, stern on or beam on. In this case it is taken as beam on at a value of 1.3;
A_w is the lateral projected area of the ship above water in m^2;
y is the angle of the wind direction to the ships centreline;
B_w is front area of the ship above water line m^2; and
V_w is the wind velocity.

The denominator 1600 is a constant applicable to the density of air at sea level.

4.3 The mooring pattern used in Bilbao had, according to the master's report to the company, been used before, not only on BLACK WATCH but also on a sister vessel BOUDICCA. The forward breastlines were passed across to the opposite side of the pier to improve the lead by a shallower angle of depression to the shore and thus reduce both loading and chafing forces.

4.4 The mooring pattern (see Appendix I) of 2 headlines, 3 breastlines and 2 springs forward and similarly, 2 stern lines, 3 breastlines and 2 springs aft was made up of high strength ropes. All ropes were manufactured by Scanropes. Most were 64mm Karat MAXI 8 strand plaited ropes with a nominal breaking load of 78.4 tonnes. One at each end was a 60mm Karat WINCHLINE 6 strand right hand lay rope with a nominal[2] breaking load of 68.4 tonnes. The WINCHLINEs were

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[1] Formula Taken from Port Designer's Handbook By Carl A. Thoresen

[2] "Nominal" Breaking loads refer to the figures extracted from the rope certificates held on board for all ropes in the vessel's outfit.

on storage drums that are also used for hauling. The drums are braked. The MAXI ropes were all loose, either turned up on bitts or left turned on capstans forward or winch drums aft. The ropes that were left in this way were each "backed up" by turns on a nearby set of bitts.

4.5 The resulting modified mooring plan forward created a situation in which 5 "breast" ropes were taking the majority of the lateral wind load. These ropes were 4 Karat MAXI (78.4 tonnes) and one WINCHLINE (68.4 tonnes). The springs would have been taking very little load initially as they are designed for longitudinal restraint.

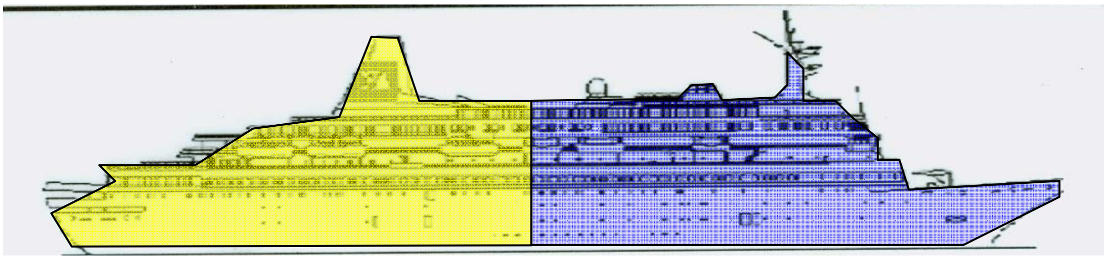


Figure 4.5: Profile of vessel showing approximation of topside areas in forward (blue) and after (yellow) sectors either side of approximated centroid of total area.

The total nominal static load strength of the forward breast ropes (undamaged) would have been approximately 382 tonnes. This strength would be reduced by depression out of the horizontal and deflection at fairleads but in the case of the forward ropes the depression angle was smaller than it was with the after ropes. The forward ropes had been led to the opposite side of the pier to create a better lead. Assuming therefore that symmetry distributed the wind pressure approximately evenly between forward and after sectors (see figure 4.5), the forward five (breast) ropes would be taking a load of approximately 89 tonnes at 40 knots but this would have risen to 138 tonnes during the gust at the time of the incident. The springs would not initially be taking any load. This is considerably less than the combined nominal strengths of the ropes.

4.6 The pier would interrupt the wind force on the side of the vessel but this has been ignored as the pier is fully exposed with no superstructures and this assumption creates a resultant that is worse than the reality – it errs on the side of safety.

4.7 The tidal forces on the hull would be dependent on the blockage factor of the vessel including under-keel clearance and the vessel's draught was approximately half the depth of water. The blockage factor would be minimal but would have been fairly constant for the period spanning the incident.

4.8 Information obtained from a ferry master trading regularly into Bilbao with local pilotage certification has indicated that tidal streams in the region of the Gexto Pier are not considered significant during the flood and only slightly so during the ebb. The same source also indicated that in strong North westerly winds a swell runs into the harbour along the axis of the main channel, which is close to the position of Gexto Pier. This swell could account for some of the movement on the BLACK WATCH described by the master. It could be a contributory factor leading to chafe on the ropes immediately before the incident.

4.9 KARAT Maxi is a composite synthetic fibre rope using two distinctly different types of synthetic fibres for its composition. One of the fibres - Estalon® is a buoyant material, while the other – Polyester – is extremely strong but not particularly buoyant. The combination produces a rope that is easily handled because of its lightness and buoyancy but has the strength characteristics of a Nylon or Polyester rope, which is approximately 150% as strong as more conventional lighter ropes (usually Polypropylene).

4.10 How the fibres are arranged is determined by a number of factors but one of them would probably be resistance to chafe. Scanropes – the rope manufacturers - could probably provide more detailed information on this aspect of the ropes' characteristics.

4.11 The practice of leaving ropes on drum ends is debatable. Cases have been reported where axles have yielded to extreme bending moment imposed by a rope on the drum but the occurrence is very rare and is often associated with the even more contentious practice of applying "locking hitches" at the drum-ends. Bitts have also been known to fail, usually at their welded connection to the deck. Many new vessels, mostly tankers and bulk carriers have bitts that are tested and marked with their working load but older vessels of the vintage of BLACK WATCH are unlikely to be provided for in this way.

4.12 The practice of drum-end securing of ropes could be questioned. Difficulties of achieving tension with no slack using stoppers and bitts could be one reason seamen use this method of securing. Converse to any negative argument however is that with the rope on the drum-end it is more likely to be taking strain and contributing to the securing of the vessel. In relation to readiness for tension adjustment this arrangement compares to ropes on storage/hauling drums like the ones to which the WINCHLINEs are fitted on BLACK WATCH but would depend on a slippage factor to prevent damage to equipment such as is possible by limited turns on the drum.

4.13 BLACK WATCH has a limited number of fairleads on the mooring decks and these are relatively small. Most fairleads seen at the time of the preliminary enquiry were smoothed by friction with ropes. Some were slightly abraded, possibly by contact with tugs' towing lines. The condition of the ropes seen at the same time (which were the same (repaired) ropes as were in use at the time of the incident) was fair but some had noticeable chafe damage to their outer layers. This will inevitably be reducing their overall strength but with each plaited rope starting with a nominal breaking load of 78.4 tonnes there should be ample reserve strength in the ropes.

4.14 The strength of ropes will decrease as they are passed round sharp angles and the fairleads on BLACK WATCH being relatively small will increase this likelihood. The added effects of chafe through friction on abraded surfaces of the fairleads can add to the reduction of strength still further. But the vessel is fitted with fairleads that are specifically designed for ropes of this size and has been trading for many years without incident.

4.15 Each rope that parted did so in the vicinity of the fairlead, strongly suggesting that this was the point of maximum stress on the rope. This is not unexpected as it is the section of rope that is subject to the smallest radius. The smaller the radius, the greater the weakening of the rope until ultimately the radius becomes a cutting edge. Manufacturers should be able to provide more detailed data on minimum recommended radii.

4.16 BLACK WATCH, because of the limited number of fairleads, often uses multiples of ropes through a single fairlead. Whilst not strictly in accordance with any design mooring plan the practice may actually relieve frictional stress on at least some of the ropes. Instead of bearing on a hard steel surface the multiple ropes sharing a single fairlead will be bearing partially on the hard steel of the fairlead and partially the outer layers of the other rope or ropes, which are soft and yielding by comparison. The fibres will have a lower coefficient of friction than the steel. They will therefore act like an anti-chafe device.

4.17 The decision by the Master to move the headlines further aft to present a broader angle on the ropes would have substantially increased the lateral restraint of the mooring layout. One of the ropes moved was a WINCHLINE. The design of this 6 stranded rope is similar to a wire rope and a characteristic of the design is a greater resistance to extension when compared to 8 stranded plaited ropes. The WINCHLINE was also stored on a drum, which also served as its hauling drum.

4.18 It is noted that the forward WINCHLINE is one of the ropes that did not part. The control of the rope is largely dependent on the effectiveness of the brake on the drum, which it is known yielded under load during the incident. This in turn is dependent on the maintenance of the machinery and its regularity. The record of maintenance showed this winch brake to be within date of the annual check in the planned maintenance system. It was near to the end of that period, the check next being due on 19th November.

4.19 Whilst the yielding of the WINCHLINE brake almost certainly prevented the rope parting, it also allowed the bow to be blown offshore. Only one of the two WINCHLINEs was in use. It had a nominal strength of 68.4 tonnes. The estimated load at the forward end of the vessel was approximately 89 tonnes. It remains an unknown if the second WINCHLINE, if deployed in the mooring pattern, could have checked the breakout. Nominally the combined strengths would have been almost 137 tonnes but it seems doubtful, even at peak performance that the winch brake drums could have provided much more that 20 to 30 tonnes of resistance each, so the drift offshore still would seem inevitable. The single WINCHLINE rope was left carrying almost the entire load of the forward mooring system, all but one of the other ropes having parted. The other remaining unbroken rope – a KARAT Maxi backspring – was reported to have come under extreme tension as the bow moved away from the pier, slipping on the bitts as it did so but finally jumping off the bitts, leaving the WINCHLINE as the sole remaining forward mooring rope carrying any load. The spring did not part.

4.20 Whilst the rendering of the brake on the WINCHLINE allowed the bow to swing away from the shore it did retain a method of hauling the vessel back alongside, albeit with assistance from the thrusters and tugs. Had the rope parted, or had any part of the winch and its attachments to the hull failed other hazards could have arisen. As it was escalation had already created a critical situation at the gangway and since this was a serious threat to life, it now took precedence.

4.21 By moving the headlines further aft the Master did indeed provide a greater lateral constraint but the lead of the ropes through the fairleads would have been passing around a sharper angle. This would have introduced a stress concentration at the fairlead that with the original leads of the two headlines would otherwise have been fairly low, the ropes originally following a line of minimal, almost non-existent deviation. Whether the more oblique angle of the ropes as longer headlines would have imposed sufficient force to part the rope has not been assessed. It is fairly certain however that extension of the longer rope would have allowed a similar moving off the berth when the wind forces increased as they did. The master's decision to shorten the lead therefore is consistent with good seamanship. He had to assume that the fairlead design was sufficient to allow the angle now imposed in the rope without causing sufficient damage to part the rope.

4.22 The broken ends of the ropes were examined during the Preliminary Inquiry. Figure 4.22 shows a typical sample. The strands have all parted at approximately the same position longitudinally, indicating a rapid parting. This is further reinforced by the concentrated fusing of the central (yellow) strands, also visible in the figure, which indicates an extreme concentration of stress at this point prior to failure. The most likely cause of such failure is probably the shock loadings imposed immediately prior to the incident when the vessel began pitching and heeling. Whilst there is long term chafe damage visible on the vessel's outfit of ropes, this is not so severe that there is discontinuity of the main strands.

Figure 4.22: Above: Outer (blue) and inner (yellow and white) fibres have parted at the same position. Together with the fusing apparent on the inner fibres indications are that the parting of the rope depicted was very rapid.

4.23 The reconstruction of events strongly suggests that after the first rope had parted, the others at first took up the strain but as the tension increased and as each rope took a progressively greater load the remaining ropes parted with the exception of the WINCHLINE and the back spring forward. More detailed analysis is not possible. After the initial rope parting the subsequent events were not witnessed. There was already intense activity in activating the vessel in readiness for the impending consequences, which there is no doubt, the ship's staff recognised as serious.

4.24 VDR records indicate a very rapid escalation of events. Based on the heading recording the period during which ropes were parting probably spanned a maximum of two minutes between 14:12 and 14:14. The evidence of the broken rope (Figure 4.22) supports this conclusion.

4.25 The above scenario created two principal hazards when breakout occurred:

- The parting ropes represent an impact hazard to personnel in way of their alignment, both on-board and ashore, as the stored energy of the rope is discharged in the spring-back; and

- The release of tension on the moorings allows the vessel to drift off the berth thus becoming a causal factor in escalation introducing other hazards due to the vessel's new positioning.

4.26 The first hazard manifested itself only peripherally when the two passengers on shore were struck by rope ends. It is unlikely that they were in the main path or their injuries would have been much more serious. They sustained minor bruising, when broken bones or worse could have been the result if in direct line with the rope end on impact. Nevertheless the hazard deserves attention.

4.27 The second hazard manifested itself at the gangway as it was dragged towards the quay edge, finally falling to hang vertically down the vessel's side from the shell door where it remained firmly attached. Unfortunately this attitude cannot support personnel on the gangway.

4.28 Other secondary hazards could have occurred as an escalation of mooring breakout. Most common of these would be collision (with passing vessels), contact with another fixed object or grounding. None of these were experienced on this occasion.

4.29 The safety management system (SMS) on board BLACK WATCH incorporates a planned maintenance (PM) system, as well as a number of pre-arrival and pre-sailing checks that are comprehensive. The PM system for ropes includes regular checks and the filing of certificates and these have been seen to be in place according to the system. The ability to match individual ropes with their certificates however is lost once the ropes are in service as there are no identifying marks. To an extent the ropes could be identified by their position in the vessel but this is only truly reliable with ropes that are permanently stored in those positions or if the ropes are carefully monitored for position from the point where they enter service. Only the WINCHLINEs, on BLACK WATCH can be traced in this way. The remaining loose ropes will inevitably become mixed so an audit trail ceases to exist.

4.30 The gangway was rigged in a fashion that is very traditional custom and practice, i.e. hooked over the fish plate at the vessel's side but also attached by lashings. In the area of the shell door there is evidence of mechanical connection (lugs and pins) but the Master advised that these were for an earlier system. The lugs were not used in the current gangway arrangement which is of a different pattern to the one for which the lugs were constructed. Instead the inboard end of the gangway is secured by ropes to eyebolts that are strongly attached to the hull. The evidence of the incident is testimony to the fact that this method of securing was adequate as both sides of the gangway remained attached at the inner-end connection to the vessel.

4.31 The outer end of the gangway is carried on a platform with wheels that is in turn connected to the gangway. This platform is also connected through a linkage to each step in the gangway. The steps are designed to rotate about the horizontal axis synchronously with the bottom platform thus providing a series of stable level steps for passengers to ascend rather than the more traditional "chicken house" ramp - a pattern that has all but disappeared on vessels such as cruise ships. The gangway was provided with substantially rigid side rails, which would help people who are unaccustomed to traversing the inevitable sloping surface. The gangway was comprehensively provided with nets to prevent falling through between the side rails. None of these precautions however could prevent the gangway from falling from the quay edge as it did during the escalation of events at the time when the vessel moved away during breakout. The wheeled platform supporting its outer end was itself dependent on being on the quay surface to provide that support. (see Appendix III)

4.32 The regular clientele of the BLACK WATCH includes a large proportion of passengers who are more senior in years. Most are fairly active but less so than younger people. Some are less mobile and a few are often classed as disabled but the vessel operates systems of management that cater well for such people. Lack of agility was clearly a factor in the accident that occurred in Bilbao when the female passenger was unable to move. This was despite the intense attention of the gangway AB trying to assist her. Alternatively or additionally, a strong sense of fear may have caused the passenger(s) on or adjacent to the gangway to "freeze" and become immobile. The elderly female passenger and possibly the slightly less elderly male passenger at the outer end of the gangway were too slow to clear the gangway in the few seconds that it took to reach the quay edge. This was the reason both passengers fell to the water, the principal causal factor being the lack of support from the gangway as it fell to a vertical attitude alongside the vessel. The AB fell with them due to his insistence on trying to move them clear, staying with the female as he did so.

4.33 Further escalation occurred in the water due to the need for buoyant support. The life ring initially thrown from the gangway door together with the swimming of the AB to unite it with the male passenger strongly mitigated further deterioration of the situation, the remaining hazard being hypothermia. As for the female, she was unconscious and the AB's efforts to support her, whilst obtaining support himself from a life ring undoubtedly prevented her from sinking beneath the surface. The AB's presence therefore was a strongly mitigating factor in the hazards that befell the passengers but it was insufficient to prevent the fall to the water in the first place.

4.34 The fall to the water, in circumstances such as above cannot be prevented by the traditional arrangement of gangways relying as they do on support from the quay surface. In the event that such support is removed the outer end of the system collapses. Given that the practice has been widely used for many years there is a danger in assuming that nothing more can be done. That assumption however is flawed and could easily be challenged.

4.35 If the vessel no longer remains alongside, the position of the gangway on firm ground is no longer guaranteed. The position of the vessel alongside is normally assured by a robust mooring system but as this incident has shown there is a probability above zero, albeit still very remote, that can lead by escalation of events to the situation where the gangway is no longer supported by the shore. The consequences of such an event can be shown to involve serious injury or fatality. In the Bilbao incident the female passenger narrowly escaped becoming a fatality by the additional mitigation of the AB in the water. He was able to actively intervene and keep her afloat, which, because she was unconscious and seen to be sinking could not have been done by her alone. This is not a mitigation that should be relied upon. Any consequence that involves fatality, as long as probability of the situation remains above zero moves the resulting risk into what normal risk management would regard as an intolerable zone. Even if the likelihood of the mooring breakout was not appreciated before the incident it cannot be ignored now that such a near miss has occurred.

4.36 Life rings, whilst offering good buoyancy do rely on the assumption that casualties are able to help themselves. The presence of the AB at the gangway did in fact provide a more active intervention, which clearly changed the course of events on this occasion, but even an AB, trained as he is, is still subject to hypothermia effects if, as he did on this occasion, he enters the water. There is strong evidence to show that the AB extended himself exceptionally without which the female passenger may not have been kept at the surface.

4.37 The near miss experienced by the two passengers on shore who were struck by the broken ropes, was fortuitously not serious. Had the passengers been standing closer to the breaking ropes it is possible they could have been seriously injured or worse. Mooring ropes can store an enormous amount of energy, in this case up to 78 tonnes of tension. If released when the rope parts, the resulting projectile of the rope end would strike any person standing in its path with potentially lethal force. Mooring accidents are not unknown in which, usually ships' crews or shore mooring gangs have been very seriously injured and some have even involved fatality. The dangers of recoiling ropes are known to be potentially high risk.

5 CONCLUSIONS

5.1 Without detailed scientific and forensic analysis, it is impossible to determine precisely why the first moorings parted. The extreme weather and particularly its sudden intensification is the most likely principal causal factor. In the circumstances despite an established assessment process and/or safeguards, mooring breakout still occurred.

5.2 Sea conditions at the time and their effect on movement of the vessel could have contributed towards chafe before the incident, which is a possible cause of weakening of the otherwise strong ropes. Account of this possibility was taken by the Master in his earlier action to improve the leads of the forward ropes.

5.3 The existing system of management of ropes, although comprehensive, suffers the problem of losing the audit trail due to lack of identification against certification. The management of their ongoing condition is thereby dependent on local analysis at each mooring event. It could be more systematically part of the vessel's management and maintenance procedures with a more specific method of identifying each rope individually.(see Recommendations)

5.4 The gangway support system for circumstances where the vessel's own gangway is used is currently a system involving a single point of failure when support is lost at the outboard end in the event of the vessel moving off the berth. In view of the fact that the system is specifically provided for the safe access of personnel to the vessel this situation should not be accepted as inevitable since a consequence of a collapse could very easily be fatality or serious injury. Instead, some method of providing back-up support of the outer as well as the inner end of the gangway should be sought and introduced.(see Recommendations).

5.5 The vessel's systems of contingency planning worked well and the performance of ships' staff was commendable. The realisation however that despite this, a critical situation developed leads to the conclusion that more could be done to further improve the management of risk. In this case, the mooring breakout and the gangway's traditional arrangements allowed the situation that resulted in the accident.

5.6 The presence of the AB at the gangway was a proactive safety measure but the speed of the events and the immobility of the passenger he was assisting resulted in him becoming a casualty himself. Fortunately for the passenger, the AB's presence in the water, together with the rapid deployment of life-rings meant that she was afforded support where it might otherwise have been lacking.

5.7 The authorities in Bilbao performed well in the emergency. Rapid support was available for the vessel and suitable craft were quickly in attendance to effect recovery of persons from the water. Even though the vessel's rescue boat was mobilised, the necessity for its launching was overtaken by events. The standards of the vessel's rescue boat drill are in no way criticised. Standards of seamanship aboard the patrolling craft already afloat, in particular the Guardia Civil RIB, were sufficient to prevent further catastrophe.

5.8 Paramedics ashore operated efficiently and were able to revive the female casualty and set her and the male passenger on a path to recovery that was completed by medical facilities in the city.

5.9 Above all, the actions of the AB at the gangway can only be described as selfless and courageous. He stayed with the female casualty when he knew the gangway was going to collapse beneath them. When in the water, he kept her afloat when she was unconscious. After she was recovered from the water by the Guardia Civil the AB remained in the water so that a rapid transfer to paramedic assistance ashore could be effected for her. His actions were probably the most significant contribution towards saving the lady's life.

5.10 The lesser known near miss of two passengers on shore being struck by parting ropes is important. The fact that injuries were minor could possibly allow the occurrence to be eclipsed by the much more prominent in-water event. The possibility remains however that passengers and others could be exposed to potentially lethal dangers in mooring systems when ashore.

5.11 Where the personnel on the piers are exposed because there are no sheltered walkways, as is the case at the Gexto Pier in Bilbao there remains a high risk hazard that should be mitigated. Clearly this is not the responsibility of the vessel.

5.12 When ashore passengers are in the care of local tour operators or responsible for themselves but they are still contractually attached to the vessel by the organised tour that is the cruise. The Gexto Pier at Bilbao appears very bare (see Appendix II). There are no terminal buildings or walkways that could offer shelter from potentially dangerous encounters such as the rope recoil hazard identified in this case. Many other piers may be similar.

5.13 No mooring arrangement should be in place without the master having first approved it. In the event of a rope parting it could be deemed to have involved the vessel. Responsibility for injuries on shore might also be claimed to be at least shared by the vessel but it is unreasonable to expect the master to have had any influence on the exposed design of a pier. (See also recommendations).

6 RECOMMENDATIONS

6.1 **Rope management:** This may be one area in which a rope, identified or otherwise as damaged due to wear and tear is not able to be isolated without being completely removed from service, a procedure that is possible only for a limited number of ropes if the stock on board is not completely duplicated. Duplication would normally be considered an unreasonable expense. The task of mitigation however is not impossible (see below).

6.2 In addition to the good seamanship practice of inspecting all ropes prior to deployment, a system of identification could be introduced. Without it the certificates held on board are meaningless if the ropes to which they refer cannot be identified. Manufacturers are able to place identifying marks on ropes, one method being the shrinking on of sleeves close to the eye splice of ropes (on both ends); the sleeves can enclose the serial number of the rope that also appears on the certificate. Another method is to attach robustly constructed tags at each end with identification marks permanently engraved, again matching the serial number on the certificate. In either method, the rope's individual maintenance can thus be traced. If the rope parts and loses the section of the rope fitted with the sleeve or tag, the opposite end still remains. If this too is lost, it is still possible to mark the rope with some individual marking.

6.3 Another method of marking is colour coded whippings that use different colour lacing around the eye splice. Colours could be single or multiple combinations that should then be indicated on the certificate for the rope. An added safeguard would be for the whipping to be sewn into the rope.

6.4 The maintenance record should include information such as the overall condition of the rope, specific damage and its severity, repairs such as shortening and re-splicing and rotation of position to share wear and tear between ropes. This enables more efficient planning of renewals and allows for effective audit of the vessel's maintenance regime for mooring ropes.

6.5 When assessing mooring decks those responsible for newbuilding or refit design approval should consider a range of typical mooring arrangements to provide for better protection of ropes.

6.6 The condition of ropes and the adverse effects that chafe might have on their overall strength should, in combination with the identification requirement identified in 6.2, be a principal part of the maintenance system for the ropes.

Action point: A system of rope identification against certification and the PM System has now been introduced on company vessels.

6.7 **Shore facilities:** Protection of passengers while ashore should always be given prominence by collaborating with shore authorities and operators to provide sheltered protection from moorings and other hazards (such as overhead loads where machinery may be in use). Covered walkways, sheltered transport or clearly marked safe zones that are well clear of hazards should take precedence in deciding the relative safety of any berth where vessels disembark their passengers. Detailed consideration of the suitability of certain piers and quaysides for the passage of passengers ashore could be an enhancement to their overall safety for the full extent of the cruise. This however is a responsibility of the shore authority so an industry solution by dialogue between providers' and users' representative bodies would be the most appropriate action to take to address this issue.

6.8 **Gangway:** The simplest mitigation for the principal hazard of the falling gangway already exists in commonly operated lifting practices elsewhere, such as in construction and in the offshore industry. The principle is evident in lifting policy in these industries and in some cases in legislation, some of it affecting ships in certain territories regardless of flag. The principle is that personnel should never be lifted in any apparatus that is not robustly protected from falling. Elevators for example have more than one supporting wire. In the offshore industry personnel baskets are equipped with safety strops to guard against the highly unlikely possibility of failure of the primary lifting apparatus. Essentially, the single point of failure is eliminated. When a gangway is supported permanently from one end only (the vessel), the other (outboard) end, being temporarily supported only by the surface upon which it is resting (the quay), it could be regarded as a single point of failure in the unlikely but proven possible circumstance where the resting surface is removed, i.e. when the gangway is pulled off due to its attachment to the vessel now adrift.

6.9 Mitigation against this single point of failure should be sought. In shore mechanised gangways it already exists in the support system that holds the gangway up regardless of the presence of the vessel. The ship's gangway however does not operate in the same way – but in some cases it could.

6.10 Most gangways are lifted into position on bridles that support them horizontally until rested upon the vessel's hull connection and the shore. In most cases the bridles are then disconnected. If these bridles were retained, or if the outer end were connected to topping lifts supported from a higher deck, even if the vessel moved off the berth the gangway would not fall any further than the topping lift or bridle would permit in taking the load. Any personnel on the gangway could remain there. More importantly they would still have a deck underfoot that would enable them to make progress to a place of safety inboard. See Appendix III. This arrangement however would have limitations. Certain gangways associated with passenger vessels may not be able to be realistically supported in this way.

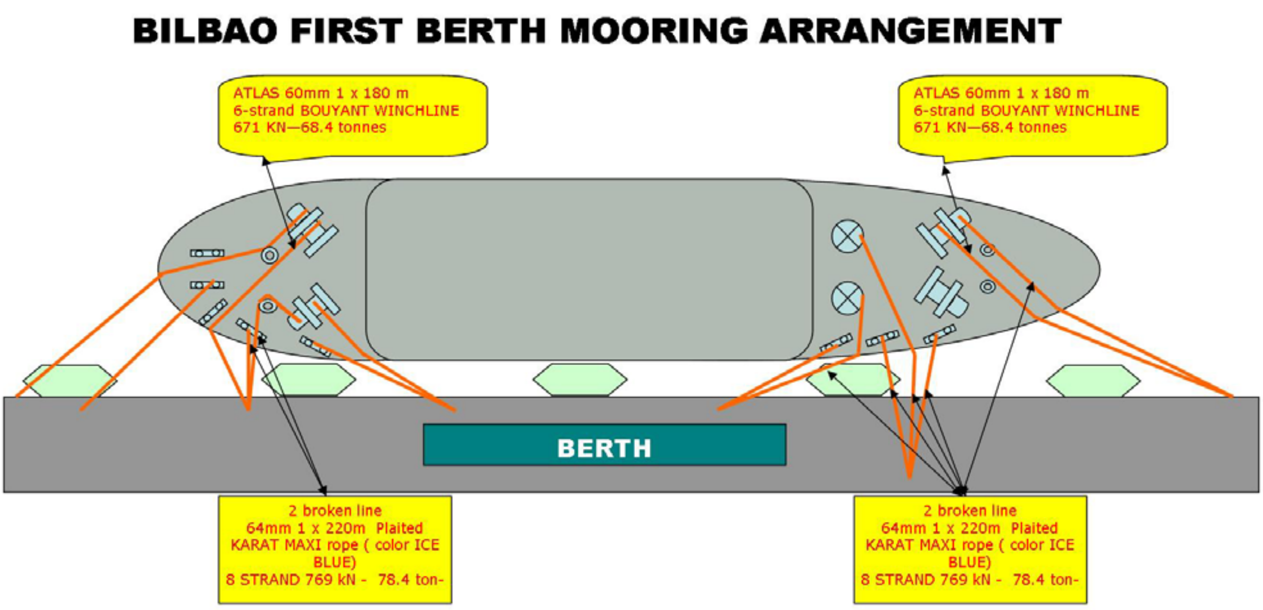
6.11 Ideally, if it were possible, such an arrangement should be adjustable from the gangway position, which is constantly manned, so as to take up or slack back to keep the outer end of the gangway in contact with the surface upon which it is resting. In an emergency, the topping suspension arrangement could be available for rapidly taking up any slack before the outer end loses its support and to lift the gangway to a more level attitude. Where platforms are attached that control the attitude of the steps on the gangway, the attitude of the platform should also be protected against rotating out of a level attitude.

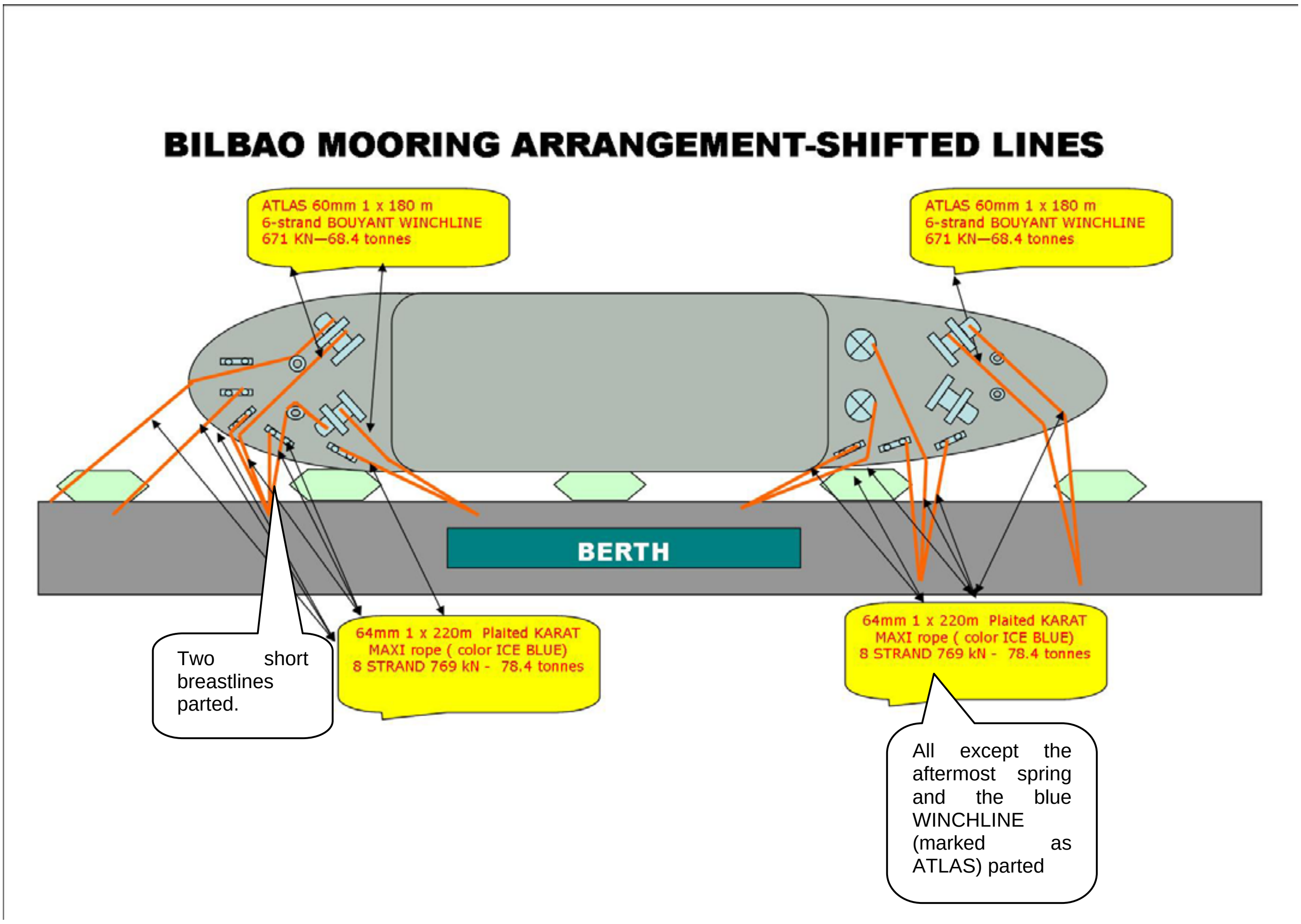
6.12 In cases where shipboard support of the gangway is impractical an alternative solution should be sought. Supported shore gangways are one solution but may not always be available. When not available the remaining alternative is limited to a robust intervention system similar to the AB attendance that was in use on BLACK WATCH but more focused on rapid removal of personnel from the place of danger.

6.13 Any intervention system being operated by personnel should be provided with the earliest possible warning of the need to initiate action. One system could be the monitoring of the vessel/shore gap such that any significant increase could be detected. An alarm linked to such a device should be placed in the key monitoring stations including the gangway shell door(s), the Bridge and the Engine Control Room. The system could use low or high technology but should be subject to testing and calibration within the PM system on a regular (every port) basis.

6.14 The experience gained in this incident should be used to review all safety and rescue procedures, regardless of whether they may be traditional such as the gangway arrangements. The ISM Code calls for continuing improvement as hazards are identified in incident analysis and risk management procedures.

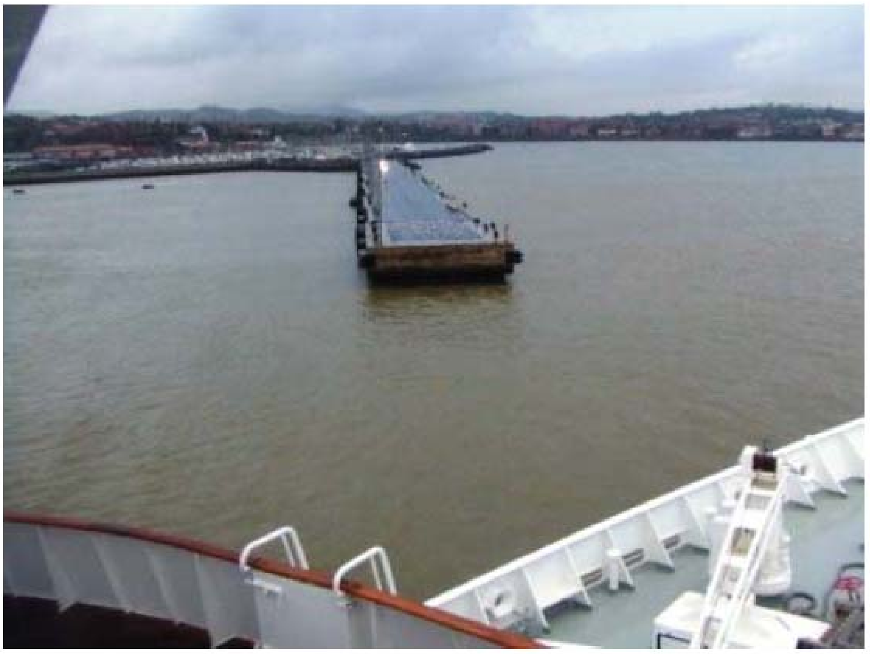
APPENDIX I


BILBAO FIRST BERTH MOORING ARRANGEMENT
ATLAS 60mm 1 x 180 m
6-strand BOUYANT WINCHLINE
671 KN—68.4 tonnes
ATLAS 60mm 1 x 180 m
6-strand BOUYANT WINCHLINE
671 KN—68.4 tonnes
BERTH
2 broken line
64mm 1 x 220m Plaited
KARAT MAXI rope (color ICE
BLUE)
8 STRAND 769 kN - 78.4 ton-
2 broken line
64mm 1 x 220m Plaited
KARAT MAXI rope (color ICE
BLUE)
8 STRAND 769 kN - 78.4 ton-


BILBAO MOORING ARRANGEMENT-SHIFTED LINES
ATLAS 60mm 1 x 180 m
6-strand BOUYANT WINCHLINE
671 KN—68.4 tonnes
ATLAS 60mm 1 x 180 m
6-strand BOUYANT WINCHLINE
671 KN—68.4 tonnes
BERTH
64mm 1 x 220m Plaited KARAT
MAXI rope (color ICE BLUE)
8 STRAND 769 kN - 78.4 tonnes
64mm 1 x 220m Plaited KARAT
MAXI rope (color ICE BLUE)
8 STRAND 769 kN - 78.4 tonnes
Two short breastlines parted.
All except the aftermost spring and the blue WINCHLINE (marked as ATLAS) parted

APPENDIX II

GEXTO PIER



Gexto pier, cruise berth.

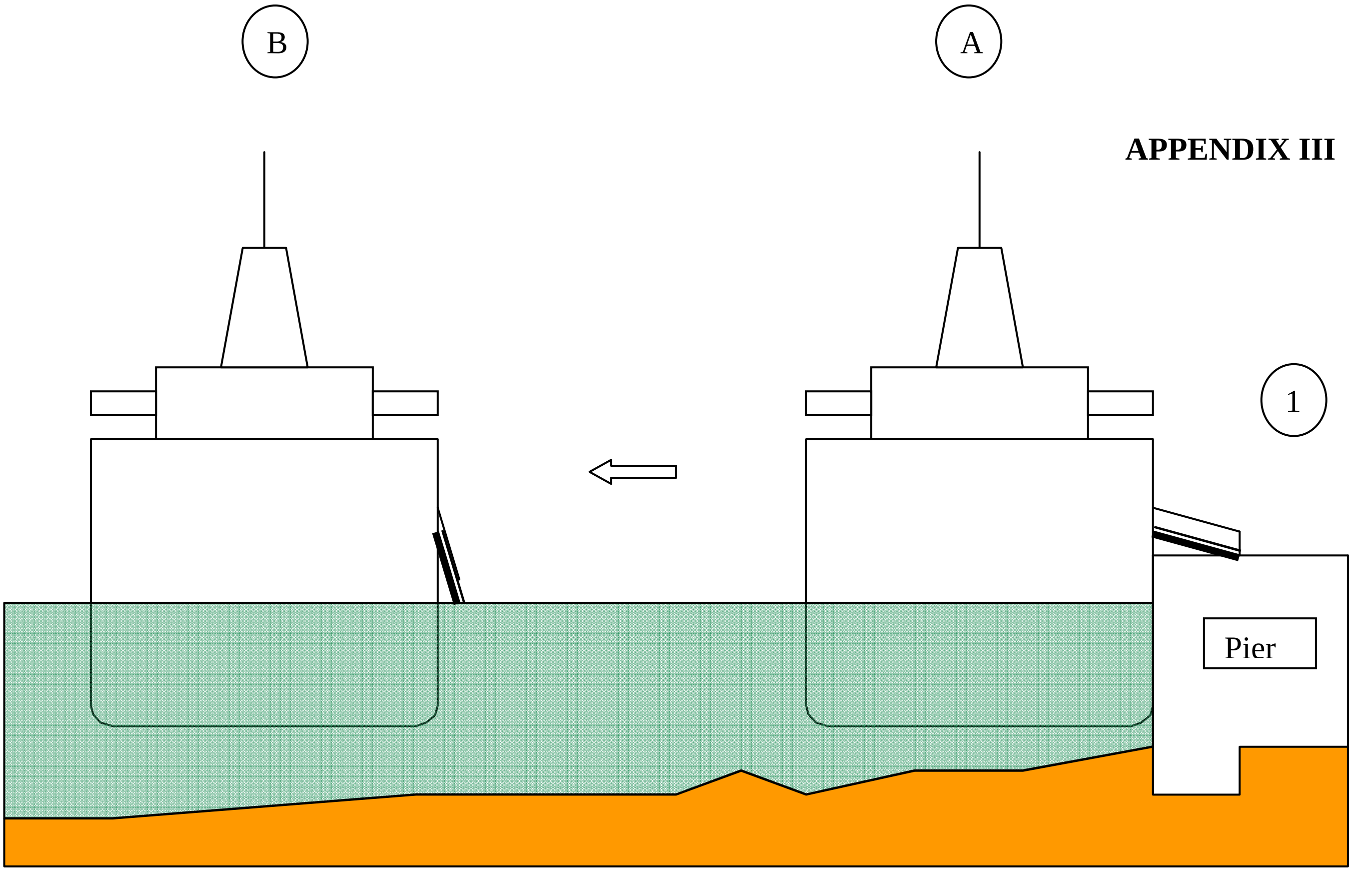
ISPS compliant,

locator code: ESBIO-0040

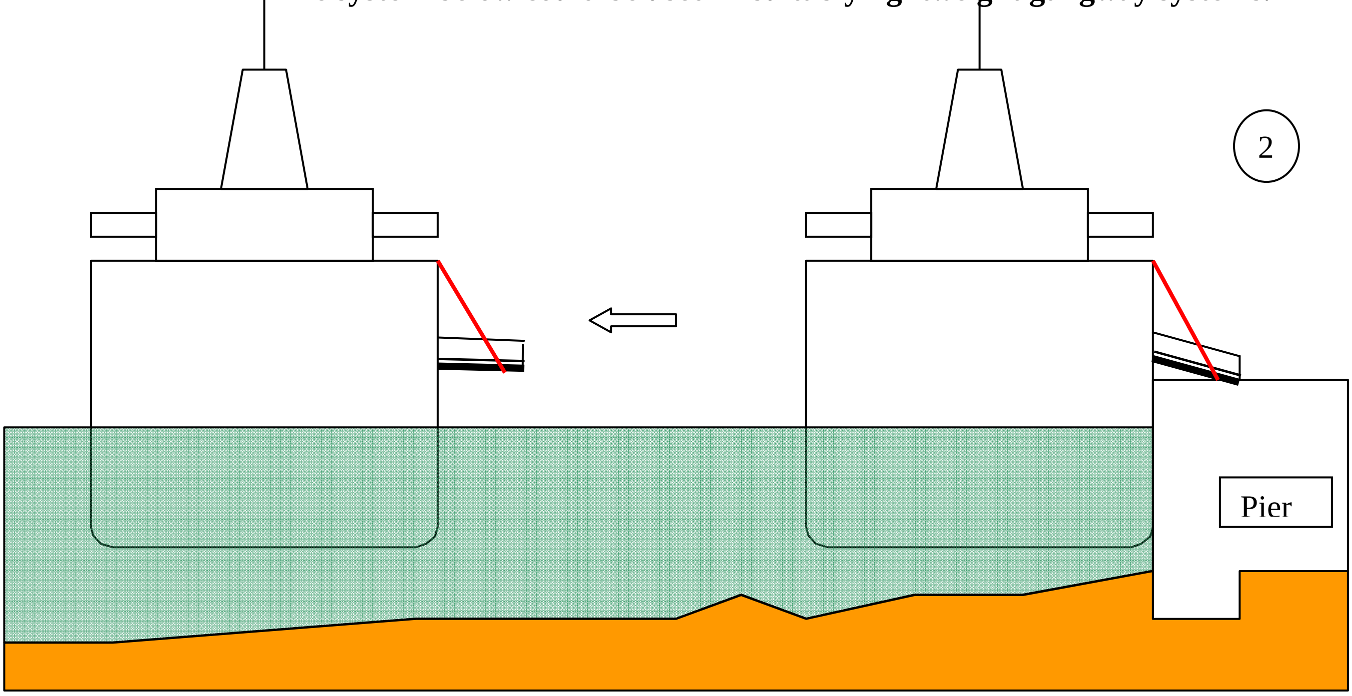
Note the current setting out from the river.

The vessel swung off the south side of the berth prior to berthing when the above photographs were taken. These show the construction of the berth. They also show that the ship’s staff were aware of the tidal current - at this stage ebbing - flowing through the pier.

APPENDIX III



The system below could be used in suitably lightweight gangway systems.



Position A: Vessel alongside pier with ship’s brow gangway rigged in style of custom and practice (Scenario 1)
Position B: Vessel after separation from pier with brow gangway still attached, scenario 1 by inboard end only and therefore hanging vertically, and scenario 2, with additional topping support at outer end. (marked in red) This could also be provided by crane and bridle.
N.B. Topping support in scenario 2B has been raised to level gangway so as to remove hazard of falling for personnel on gangway at time.
It is likely that, many existing gangway designs will be too heavy in construction for this arrangement in which case an operational intervention system should be introduced in conjunction with a vessel/shore gap monitoring system and alarm.

APPENDIX IV

VDR OUTPUT

Output from the vessels Voyage Data Recorder made available the following Radar images that are indicative of the sequence of events. The electronically generated chart is not sufficiently up to date to include the Gexto Pier. The images also include overlaid IAS data. The Gexto Pier has been inserted for the purposes of this report in red. Its position is approximate.

Figure App.IV.1

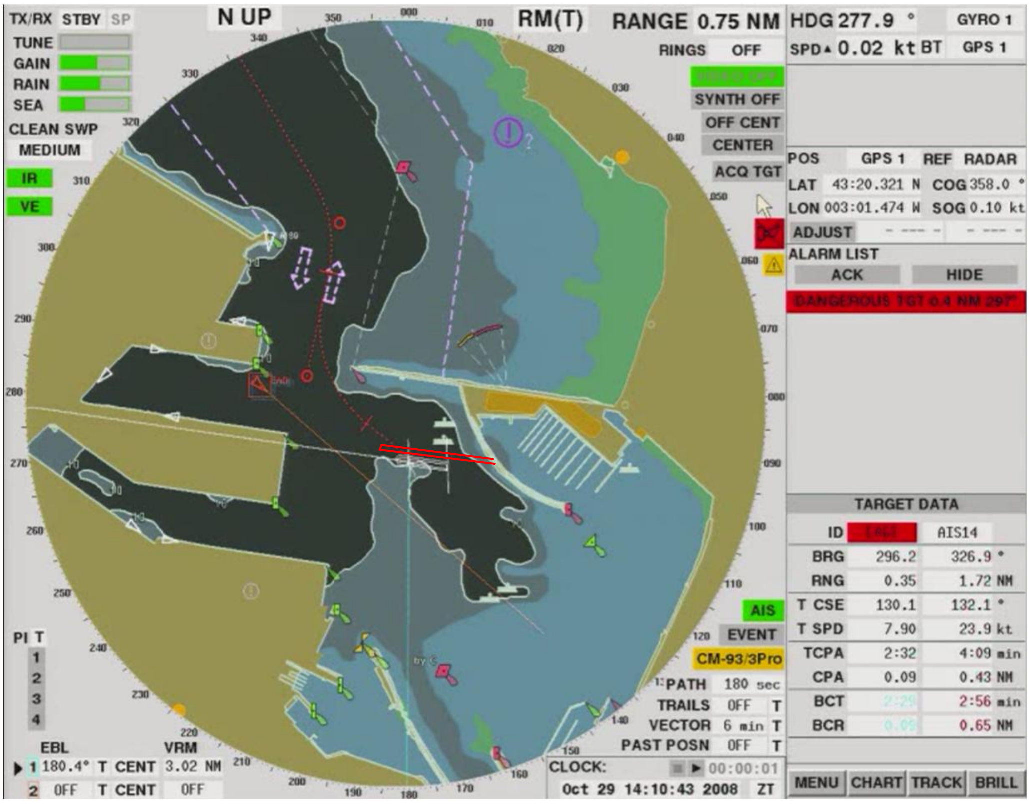


Figure App.IV.1

Radar/AIS/ECS display. Heading is 277.9. i.e. alongside pier.

Time: 14:10:43

The vessel is alongside the berth (superimposed in red above – not part of the original recording).

Figure App.IV.2

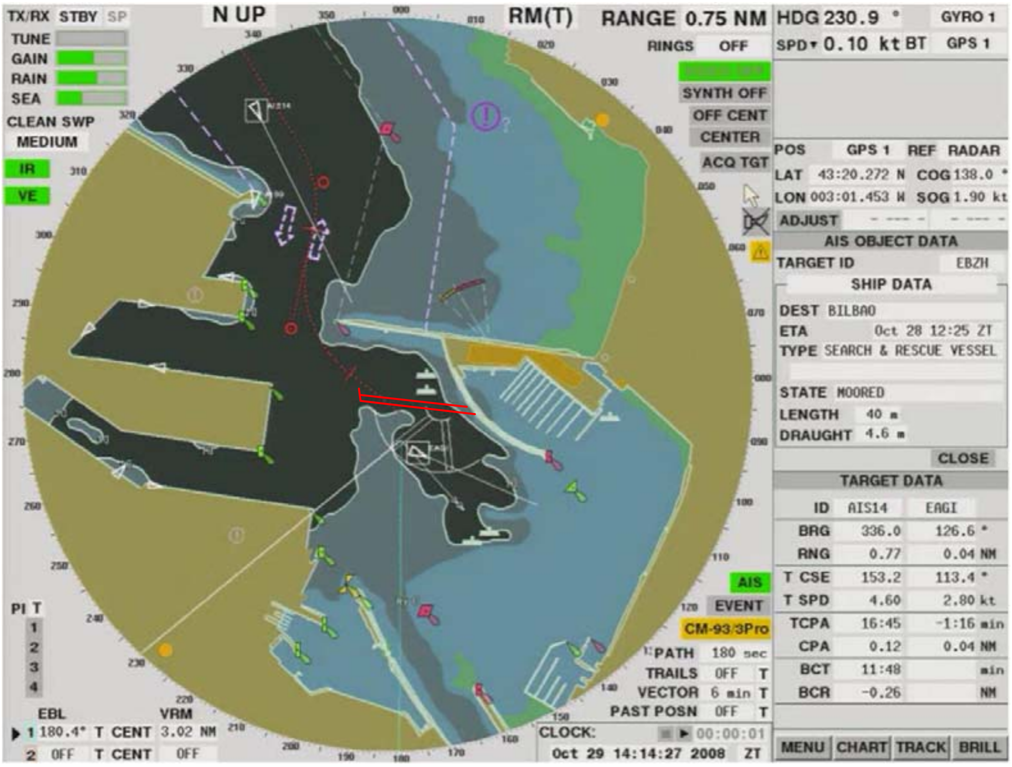


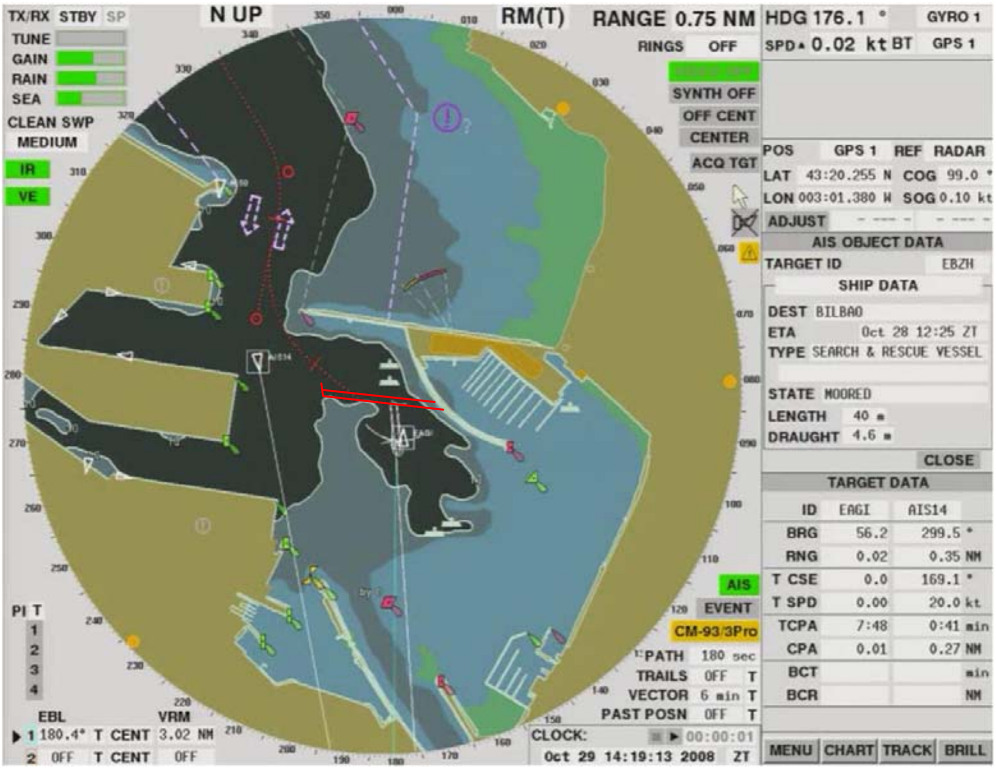
Figure App.IV.2

Radar/AIS/ECS display. Heading is 230.9. i.e. transient between moored and equilibrium positions.

Time: 14:14:27

The vessel has broken adrift forward and is pivoting on the after moorings.

Figure App.IV.3



Radar/AIS/ ECS display. Heading is 176.1. i.e. in equilibrium downwind (and tide)

Time: 14:19:13

The vessel is heading almost due South and is in equilibrium, attached by the stern moorings.