Notes, Observations and Findings Regarding Ro-Ro Passenger Vessel ESTONIA

Background and Introduction

In September 28, 1994, the ro-ro passenger vessel MV ESTONIA capsized and sank on her journey from Tallinn to Stockholm with the loss of 852 souls. A Joint Accident Investigation Commission (JAIC, consisting of representatives from Estonia, Finland and Sweden) published a part-report in April 1995 and the final report in December 1997. Both the report itself and circumstances close to the accident have been questioned ever since, and alternative explanations, including sabotage and criminal actions, have arisen and been discussed.

In 2020, new footage was published, showing until then unknown damage on the hull of the vessel. Hence, a preliminary assessment[1] was initiated by the Estonian Safety Investigation Bureau (OJK) in its role as flag state, with both the Safety Investigation Authority, Finland (OTKES), and Swedish Accident Investigation Authority (SHK) participating as coastal and substantially interested states respectively. The aim of the preliminary assessment has been to investigate whether the newly discovered damage on the hull has originated on the surface (thus influencing the accident and the sinking process) or when the vessel hit the bottom, and to determine whether the JAIC investigation needs to be reopened.

Parallel to the investigative work, the ambition has also been to deal with uncertainties and straighten question marks that have appeared in connection to this accident. This paper is part of this ambition. Due to this ambition, the content in this paper appears diverse and covers very different subjects, from construction of the front bulkhead to the question if trafficking occurred.

[1] A legal term describing a state of marine accident investigation.

1. Construction Status of the Front Bulkhead

1.1 Legal Requirements on Passenger Vessel Constructions

A vessel of the type of MV ESTONIA should have a hull beneath the bulkhead deck divided into watertight compartments and be able to stay afloat even with two of them damaged and flooded. In the forward part, there should be a watertight collision bulkhead up to the bulkhead deck (on MV ESTONIA deck 2).[2]

The vessel had an operable forward opening, i.e., the bow visor, which is not considered to be part of the full-strength hull. Hence, some water ingress into the visor could be accepted. Instead, the forward weathertight part of the hull above the bulkhead deck consisted of a forward car ramp and bulkhead at the side on both starboard and port side (front bulkhead).

According to SOLAS-legislation, applied to MV ESTONIA, the collision bulkhead should be prolonged weathertight up to the deck above. The prolonged collision bulkhead should be placed within certain distances aft from the forward perpendicular.[3] (See Fig. 1.1.)

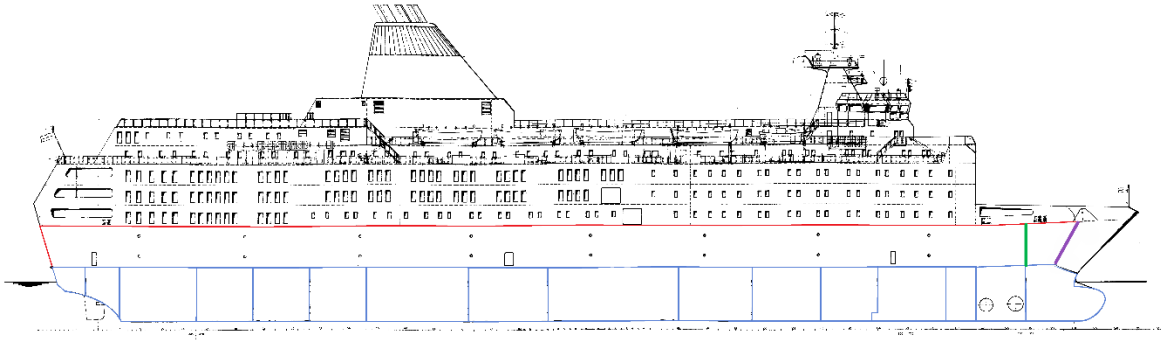

Fig. 1.1. As the vessel should have been built if no exemptions had been applied. Blue indicate watertight hull and bulkheads, red and purple indicate weathertight hull, where purple is also car ramp, and green indicate the extended weathertight forepeak bulkhead (collision bulkhead).

However, the legislation made exemptions possible with the condition that the trade of the vessel should not exceed 20M from nearest land.[4] In the case of MV ESTONIA this resulted in the weathertight front bulkhead (including the car ramp) having a dual function, and also being the weathertight collision bulkhead. This was as she was supposed to be built if she was built in accordance to legislation and accepted exemptions (see Fig. 1.2).

[2] SOLAS 74 Chapter II-1 Part B, Regulation 9.
[3] SOLAS 74 Chapter II-1 Part B, Regulation 9.
[4] SOLAS 74 Chapter II-1 Part A, Regulation 1.

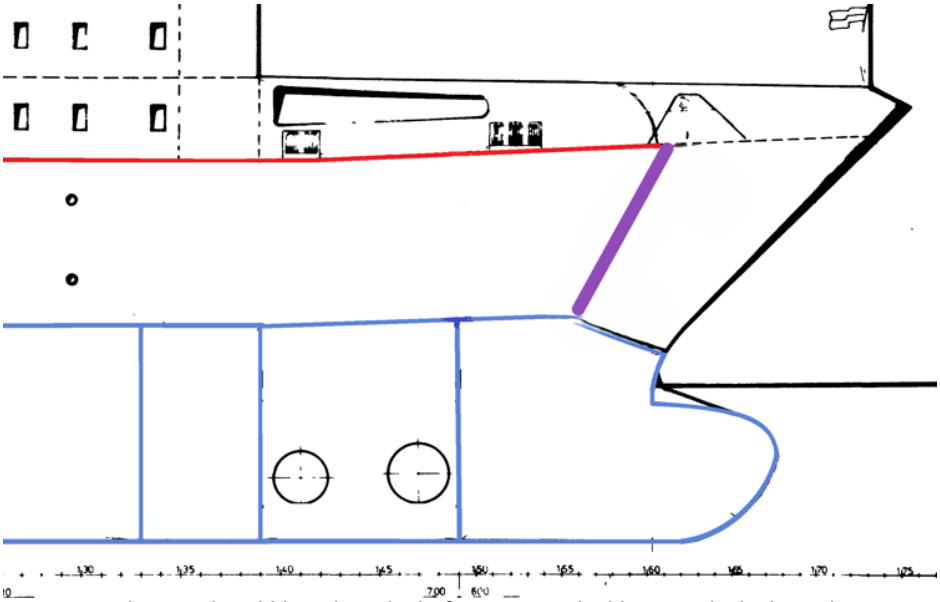

Fig. 1.2. As the vessel could have been built if exemptions had been applied. Blue indicate watertight hull and bulkheads, red weathertight hull, and purple indicate weathertight front bulkhead (also car ramp). Given the exemption from extended weathertight forepeak bulkhead, the trade area should have been restricted to 20M from nearest land. The exemption should have been noted in vessel's certificate.

1.2 MV ESTONIA Front Bulkhead as Found

Footage of the vessel shows openings for hoisting/lowering and locking arrangements through the front bulkhead on both sides of the car ramp. Shipyard drawings of this part say that the front bulkhead should be to some extent tight (in German "wasserdicht").

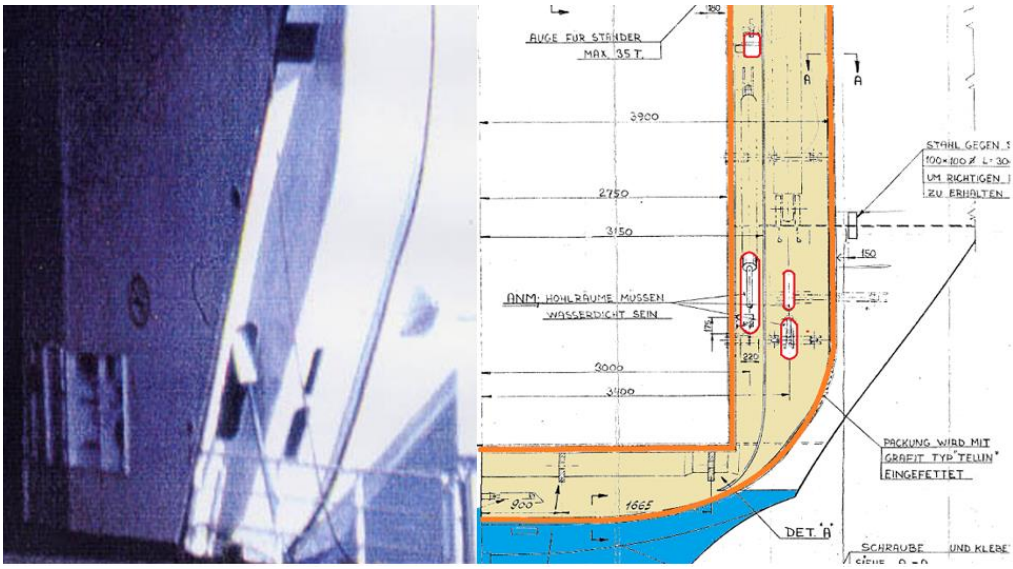

Fig. 1.3. The left picture shows four openings in the front bulkhead on port between the sealings for the visor and the ramp (inside of the visor sealing, but outside of the ramp sealing). This means that if there is any water inside the visor, it may pass through the openings into the space behind (port wing house). The drawing on the right shows sealings (in amber) the openings (in red) and the note that it should be tight ("ANM: Hohlräume müssen wasserdicht sein"). The same circumstances apply for starboard side. Coloring of the drawing is made by SHK. Both picture and drawing are cropped.

This requirement could be upheld by the bulkhead to both wing houses. Footage from the diving operations in summer 2023, however, show that the doors into the wing houses are grille doors, i.e., they do not uphold the standards of either the hull or the bulkhead.

Fig. 1.4. Door from car deck to port wing house. This type of door is on drawings called “Drahttür”, which is German for grille door. Image from ROV- film made in July 2023.

This means that, in case there would be much water inside the visor, there actually would be free entrance for water ingress from the bow visor. Water could pass through the front bulkhead openings into the wing-houses, between the anchor chain lockers and the outside hull board. From there it could continue down to the wing house area aft of the chain locker. It could then be possible to continue through the grille door to car deck, or via the opening of the ramp/visor maneuver stand. Another possible way for water to ingress would be through potential leak at the bottom corner of the ramp.

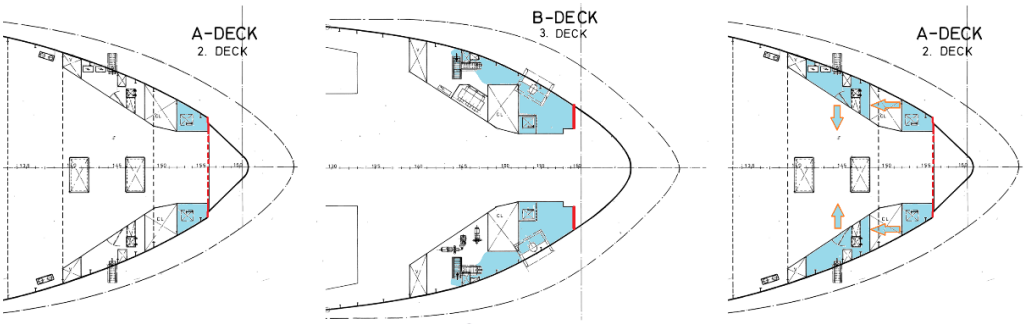

Fig. 1.5. Scheme for possible water ingress from inside the visor to car deck. Water flow through the openings and fill the area on deck 2 fore of the anchor chain locker (image left), then reaches the area between the chain locker and outer hull board on deck 3 (image middle), and eventually flow down to deck 2 aft of the chain locker and through the grille door (image right).

1.3 Witness Statements

A crew member from MV ESTONIA's previous trade between Sweden and Finland has stated that there were problems from time to time with water ingress into the bow visor.[5] Hence, it was important to keep the sealing in good condition. Still, it could happen that water came all the way to car deck. Consequently, it could happen that water, raising to the maneuver stand for operation of the ramp and visor, caused electrical short-circuit. According to this witness, the visor sealing was put in place by bolts (he had himself put the bolts in place) but has noted that parts of the sealing is now missing. His conclusion is that this cannot have happened during the accident since the bolts are still in place, as can be seen from footage.

The existence of bolts is confirmed by the manufacturer's manual. However, it cannot be definitely determined whether the bolts have been replaced without any sealing in place (which the witness claims) or if the sealing has been ripped of due to the accident though the bolts have been in place.

Fig. 1.6. The picture shows both a screw to keep the sealing in place as well as that the visor sealing is missing . The picture is from footage made in October 1994.

[5] Interviewed by SHK in August 2024.

There is information that a Swedish pilot, has claimed he saw water on car deck at one time as he passed the car deck.[6] There are also other statements claiming the same observation. According to these statements, it seems to have been water on car deck, not escaping via the vessel's scuppers[7].

1.4 Conclusions

It should be noted that the bow visor was not a part of the hull per se, and consequently did not need the same tightness as the bow ramp. It can be confirmed that there was a possibility for water, under certain weather conditions, accessing the bow visor. This in turn allowed potential water ingress through the front bulkhead in different ways, and eventually into the car deck. This may be an explanation to witness statements, that are saying there was water on car deck from time to time.

A consequence of these findings is that the vessel MV ESTONIA never had a fully weathertight front bulkhead with ability to resist water ingress (indicated in purple in Fig. 1.7). This is obviously not according to drawings or legislation at the time she was built.

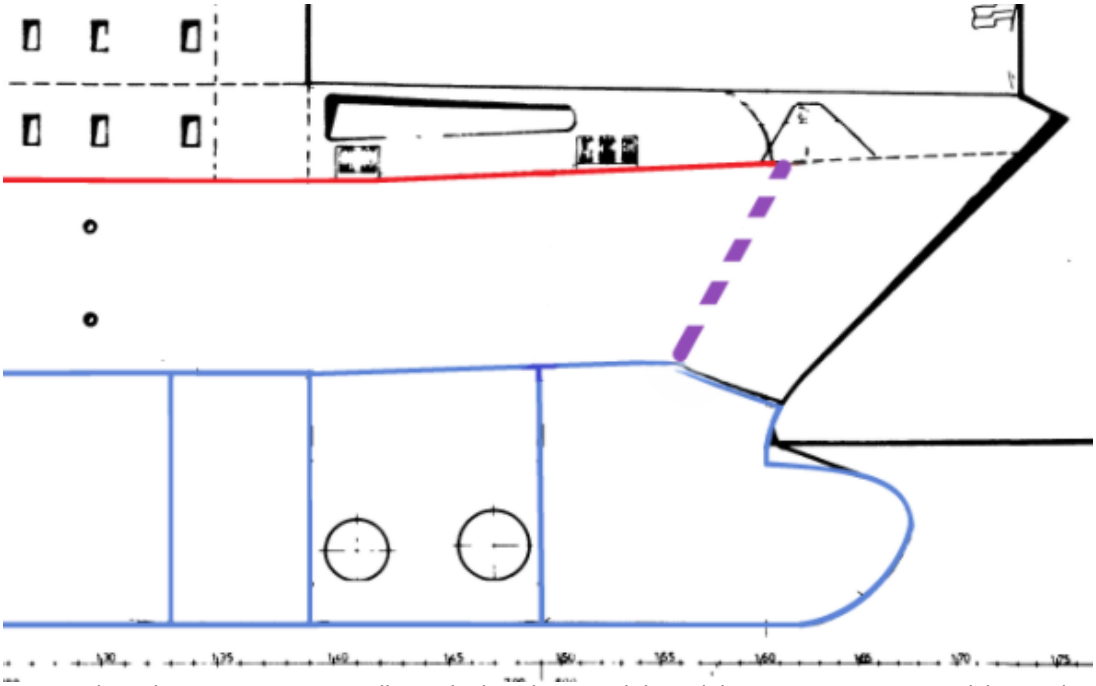

Fig. 1.7 This is how MV ESTONIA actually was built and operated through her time in service since delivery. Blue indicate watertight hull and bulkheads, red weathertight hull. The purple front bulkhead was neither fully weathertight nor watertight.

[6] This witness statement has not been confirmed.

[7] Scuppers are a type of water outlet, situated along the sides of e.g., a car deck. These can be either closed or open. They may also be clogged by rubbish. The lower ends are situated a couple of meters above water surface.

It could be discussed whether the vessel in this aspect was seaworthy. However, since a statement of seaworthiness was made in January 2023[8], any additional statement is superfluous.

It should be noted that the flaws of the front bulkhead had no influence at all on the accident 28 September 1994. Compared to a fully opened car deck ramp, the openings in the front bulkhead have to be regarded as minor.

2. Crew Actions to Meet Adverse Weather

2.1 Portholes on Car Deck

On deck 2 and 3 (the main and hoistable car decks) there were portholes[9], each of them equipped with a deadlight[10]. The lowest port holes are thus situated some meters above water line. The function of a deadlight is to be clamped over the porthole to secure it in adverse weather. The hoistable car decks were not in use this journey.

Fig. 2.1. Images from footage made in summer 2023. Left a porthole on deck 2 where the deadlight is not clamped, and right is a clamped deadlight, securing a porthole on deck 3.

Footage made in the summer of 2023 shows that some of these portholes are secured, and some not secured. This means that the crew obviously did not take any consequent action to secure the portholes by clamping the deadlights. This is, on the other hand, not considered to have had any impact on the cause or the outcome of the accident.

[8] See Intermediate Report of the Preliminary Assessment of MV Estonia, Tallinn 2023, Appendix B.
[9] Porthole is a circular window in a hull of a vessel.
[10] Deadlight is a hinged metal cover to be clamped over a porthole.

2.2 Hatch Bow-Thruster Room

During the summer of 2023 footage from the car deck showed that the port side hatch to the bow-thruster room is open. It cannot be determined whether the hatch was open during the voyage, or if it was closed and later opened as a consequence of the vessel hitting the seabed. Nevertheless, it has to be concluded that the latches of the hatch were not secured enough to keep the hatch closed. This hatch was on port side (i.e., the upper, “dry” end of the vessel) and status of the starboard side hatch is not known. If the hatch was already open when the accident occurred, this may have contributed to the water ingress in the specific watertight compartment below.

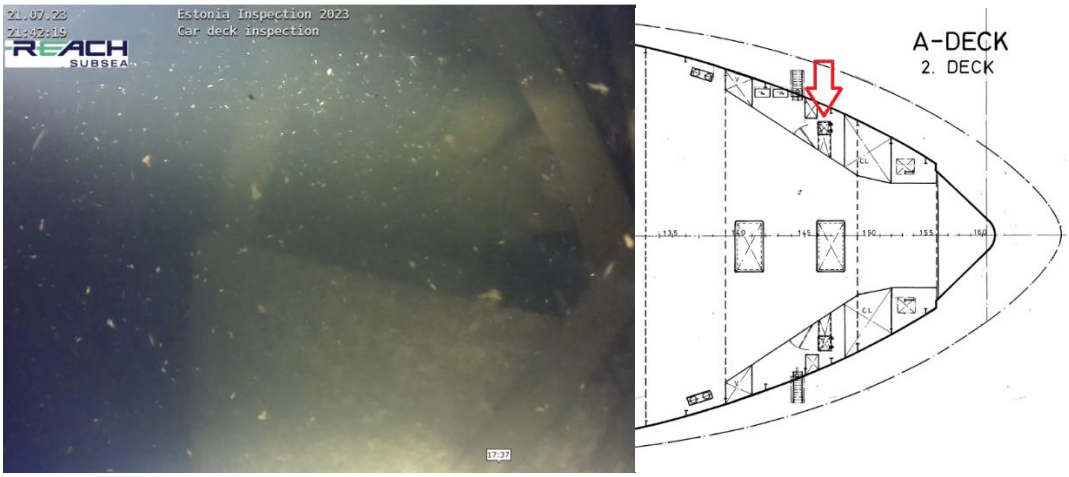

Fig. 2.2. Picture on the left is from car deck footage, made in summer 2023 and shows the open hatch to bow-thruster room on port side. The ROV is at the time maneuvered up-side-down. The image to the right shows a drawing where the hatch is marked with a red arrow.

2.3 Bow Visor Manual Lockings

In addition to the three hydraulic lockings, there were two manual side lockings for the bow visor on MV ESTONIA. These were not included in daily routines, and there were no instructions for their use. Hence, they were not regarded as part of the operational locking system (JAIC 15.6). In the vessel’s manual they were described as spare.

It has via technical calculations been concluded that the force added, if these additional manual lockings had been activated, had not been enough to keep the visor in place during the weather conditions prevalent at the time and with the same speed.

It has, however, not been possible to make calculations to find out what speed reduction, in combination with the activation of the manual lockings, had been enough to keep the visor in place.

2.4 Conclusions

There is nothing indicating or suggesting that any extra-ordinary activity to prevent damage or accidents due to the coming weather situation was made on MV ESTONIA on her last journey, except for the speed reduction. The available evidence indicates that several other such activities could have been made, but were not.

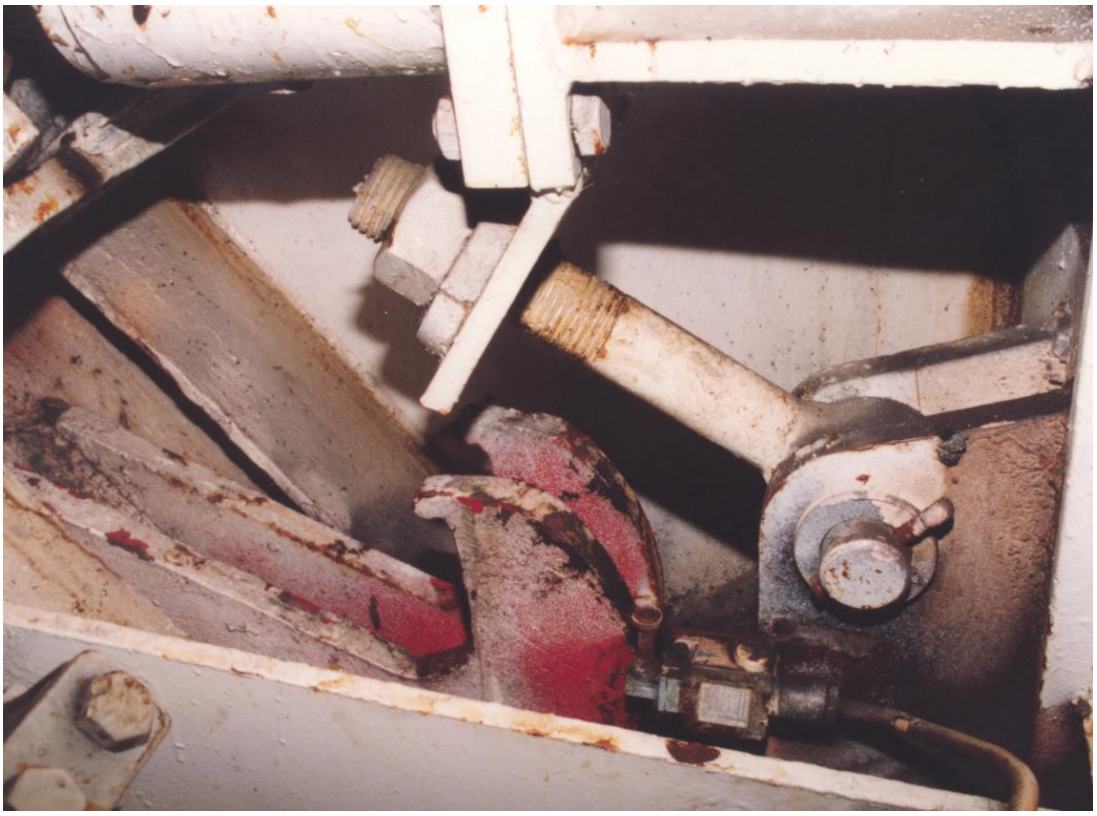

Fig. 2.3. The image shows one of the visor manual lockings on MARE BALTICUM. The vessel had a similar construction as MV ESTONIA. The sensor seen on bottom of picture is not part of the manual locking. Image from Swedish National Archive (taken 7 November 1995 by JAIC).

3. Other Observations

3.1 Bow Ramp Locking not in Locked Position

During the surveys in 2021-2022 at the wreck site, it was found that the lower ramp locking on port side of the hull was not in locked position (i.e., not fully extended). This confirms footage from 1994, and is mentioned in the JAIC report (JAIC 8.6.5, 15.8 and 13.4). The mating part on the ramp is still on the ramp, though partly twisted open, wearing less damage than the other three. This confirms that the lower bow ramp locking on port side was not fully, but partly, engaged when the ramp was forced open. All the four lockings were hydraulically operated.

According to the JAIC report, problems in having the lower port side bow ramp locking in fully extended position occurred from time to time. The standard procedure was then to pull the locking in again, and make another try. Normally, this procedure was sufficient (JAIC 3.3.5).

If this locking had not been fully extended when the vessel left Tallinn, the indication would not have shown green light, and the vessel should not have departed. However, it cannot be ruled out that the locking has moved inwards during the ramp breaking-open process (JAIC 13.2.3).

Fig. 3.1. The picture is from photogrammetry in 2022 and shows the both bow-ramp lockings on port side, hull part. The lower is not in fully extended position. A diver estimated in 1994 the degree of extension to "1.5 inches" (some 3 cm) instead of the full length, about 15 cm. If this was the circumstance when leaving Tallinn, a green light would not have shown on the indication panel at departure.

3.2 Broken Mooring Line and Potential Damage to the Forward Car Deck Ramp

A couple of witnesses have stated that during a cargo operation in Tallinn one of the forward mooring lines broke because a list emerged. The reason this was mentioned was the witnesses' concern that the situation may have caused damage to the ramp. One of the witnesses claims that the situation should have occurred in August 1994.

A former crew member has witnessed and confirms such a situation in which he took part. This situation had occurred the previous winter, however, and not in August 1994. Due to a special occasion onboard, there was not enough manning on car deck during discharging. This led to the vessel being unbalanced, thus listing and breaking the forward breast line. The discharging was stopped, the ramp lifted, and the vessel moored back into position. Then discharging could continue after the ramp was lowered again. No damage to the ramp was discovered, and no report was written. However, the former crew member recalls that the responsible officer was warned by the captain.

Even though the ramp itself could not move that much, the radial spherical bearing used (according to drawings GE 100 ES SKF) allowed oblique up to 7° and the design instruction from drawings allowing movements up to 2 mm. Hence, it seems unlikely that the occurrence would have caused any substantial damage to the hinges or the ramp.

3.2.1 Conclusions

There had been some issues with the lower port side bow ramp locking. In addition, a future need of corrective action due to play in the ramp hinges (JAIC 3.3.6) had been defined, and it cannot be ruled out that the hinges to the bow ramp was very close, or even had passed, its technical lifetime. However, since the bow ramp obviously was in fair operational status, and found locked and battened down at the time of the accident, it can be ascertained that the status of the bow ramp hinges had no influence to neither the cause nor the outcome of the accident.

It is therefore unlikely that the occurrence with the broken breast line caused any substantial damage to the ramp.

3.3 Were Mattresses Used for Sealing?

It has been stated that mattresses or blankets were used for compensating a leaking rubber sealing from time to time. A possible explanation to these rumours may be the anticipation that the port side bow ramp hinge was damaged and that there is footage showing mattresses, blankets and different types of clothes in the area after the accident.

However, except from the obvious inefficiency in using such a method, there is restricted access to the zone in question to manually put things there. The lower side parts are very difficult to reach due to a built-up edge on both sides of the ramp (Fig. 3.3 and 3.6). The ramp railings on top of the built-up edge efficiently obstruct access to the sealing area. Hence, it would be dangerous to act in this area while the ramp is closing.

Fig. 3.2. Footage from ROV-film made in 1994, showing the outer port side bow ramp hinge, and a subject made of fabrics (possibly a jacket).

The bottom part of the sealing, running just below car deck level in the area between the car deck itself and the ramp, is situated beneath seven steel flaps, fastened by hinges to the ramp. The flaps are constructed to rest to the car deck in whatever position of the ramp by its own weight (which is estimated to ca 50 kg each). Thus, they are foldable for maintenance access. When the ramp was brought up, four flaps, counting from port side, were still attached to the ramp (Fig. 3.5). Taking into consideration the weight of the flaps and the risks to lift these while closing the ramp, it has to be considered very unlikely that such an operation has taken place.

The existence of fabric material in the area may instead be explained by the existence of the vessel's dirty-linen container close by, as well as content of cars and trucks being moved around during the accident. All floating objects would gather in the uppermost part of the hold, which would be the port lower corner of the ramp, considering the position of the vessel when sunk.

Fig. 3.3. As can be seen from this picture, there is a built-up edge at the side of the ramp, coming close to the bulkhead. Above the edge, the ramp railing hinders access to the area between edge and hull. At the bottom of the ramp, a flap can be seen. The flaps may be folded up to reach the area below for maintenance. The picture is from the vessel MARE BALTICUM, which was constructed in the same way as MV ESTONIA.

Fig. 3.4. Linen container on MV ESTONIA, seen from close to the bow ramp, looking aft. Dirty linen were thrown from upper decks into the container through a shaft. Image: www.estline.ee © Evi Järvelaid.

3.3.1 Conclusions

The conclusion is that no material was put in between the bow ramp and the hull while closing.

Fig. 3.5. The car deck bow ramp, port side to the right (the ramp is up-side-down on the picture). Four flaps are still connected to the ramp, hanging in their hinges. The picture is cropped.

3.4 Were Sledgehammers Used for Closing and Opening of Ramp Lockings?

According to witness statements, crew members are said to occasionally have used sledgehammer when operating the bow ramp lockings.

The placing of the car deck bow ramp lockings was inside the wing houses. Thus, it is not possible to see or reach the lockings from the car deck. This makes it impossible for any passenger to witness such an operation (see Fig. 3.3, which shows the white bulkhead of the port wing house, which contain the lockings). An alternative explanation, according to a statement from a former crew member, could be that the passenger witnesses have seen crew members using wooden mallet to free the visor and ramp from ice, and mistaken these for sledgehammers.

However, even though it would cause a loud noise through the vessel, it would not be impossible to use a sledgehammer on the ramp upbuilt edge to cause vibrations to facilitate the movements of an obstructing locking pin.

Fig. 3.6. The picture shows bow ramp lower locking, seen from car deck. The locking itself is inside the wing house (on the other side of the white painted hull). When locked, the locking pin is hydraulically pushed (to the right in the picture) into the yellow housing and to unlock, the locking pin is to be hydraulically pulled out (to the left). This shows that it is not possible to hit the locking from car deck. However, it would be possible to hit the yellow housing into which the locking pin is to be pushed or pulled, having the vibrations to facilitate the movement of the locking pin. The picture is from the vessel MARE BALTICUM. Compare to Fig. 3.3 above.

3.5 Were the Retrieval Hooks in Operation?

Footage made of the vessel as it rests on the seabed clearly shows that both retrieval hooks were in place when the bow ramp was torn open. This is confirmed by the examination of the bow ramp after it was brought up, since damage on the brackets, both sides of the ramp, indicate damage caused by strong forces.[11] Both hooks have been pulled out, thus broke, and are lost.

No indication of any flaw concerning the hooks has been noted, though a former crew member has stated that it had happened that the hooks had to be repaired. It cannot be ruled out that the repair weld has reduced the strength of the hooks.

It should be mentioned that the placing of the hooks was inside the wing houses on each side of the car deck bow entrance, and were thus not visible from the car deck. To reach the hooks one had to enter the wing house, climb up to deck 3, and then pass between the anchor chain locker and the outside hull board.

[11] Element Materials Technology AB TEK24-0010.

3.6 How Did the Railings Come Off?

All bow ramp railings have come off the ramp, and have been found on different sites around the vessel. One of these has been salvaged. Examination of the attachment points of the ramp and the broken end of the brought-up piece of railing confirm that no machine tool or cutting has been used for them to separate.[12] Instead, it is assessed that they have separated as a consequence of the accident, being caught by the ramp locking pins, being in extended position, and torn loose (see Fig. 3.1 and 3.7).

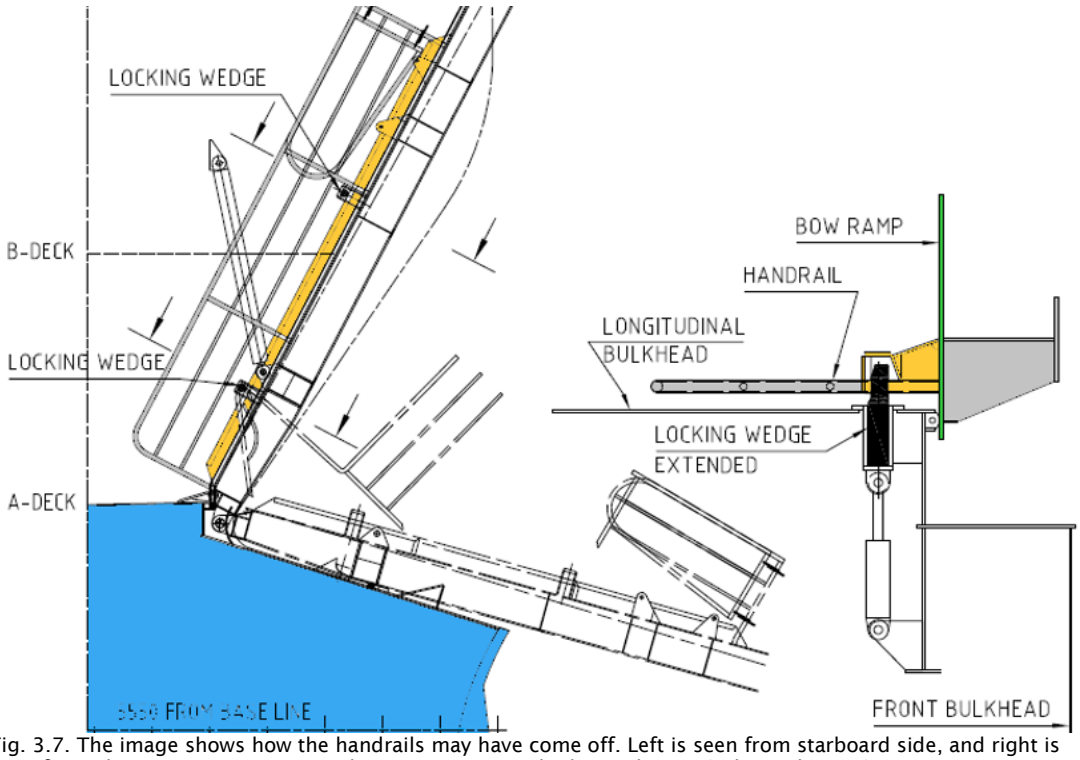

Fig. 3.7. The image shows how the handrails may have come off. Left is seen from starboard side, and right is seen from above. Image: Jan-Ove Carlsson, CAD 17 Handrail Detachment (coloring by SHK).

3.7 Sensors to Atlantic Hydraulic Locking

The bow visor bottom locking (the Atlantic locking) was equipped with a position indicator with magnetic sensors. The indication resulted in a light signal on the manoeuvre stand on deck 2. This signal was, however, not seen on the bridge. If the indicator arrangement did not give green light at the manoeuvre stand, there was a visual check made by the vessel's electrician from inside the visor. If the locking was found in place, the vessel could still depart.

During the diving operations in 1994, the magnetic sensors for the bottom locking could not be found. However, the empty ends of the sensor cables were found nearby. Since the sensor mounting bracket was undamaged, it appears like the

[12] Element Materials Technology AB TEK24-0010.

sensors had been removed before the accident. This is denied by the company. It cannot be ruled out that the sensors were ripped off during the accident (JAIC 13.2.3). During the diving operations in 1994, loose end cables, which are supposed to be the two bow visor sensor cables, are cut by a diver. The exact reason for this is not known.

Fig 3.8. Images from footage made in December 1994. Left shows two loose end cables very close to remains of the bottom locking on the hull. Right shows the hand of a diver cutting cables in the same area. Videos 6555 and 6571 respectively.

3.8 Provision Hatch on Deck 2

Aft on car deck, there was a provision hatch (Fig. 3.9). The hatch was covered at sides, but had a door aft. The hatch was used to bring containers with supplies onboard.

One witness, being a crew member on the vessel for previous owner, has stated that this provision hatch was complicated to close and that it could happen that the hatch was not closed all the time when it should be. On the other hand, the witness has no knowledge about how this hatch was handled by the new management.

There is no footage available or any other means to confirm the status of this hatch.

3.8.1 Conclusions

There is no available information to confirm the status of the provision hatch. If it was left open, or went open during the sinking process, this would have accelerated the process, and the opposite: was it closed and properly secured, it

would have prevented water to ingress into the area below. However, during the circumstances it can be concluded that it could not have prevented the accident from occurring.

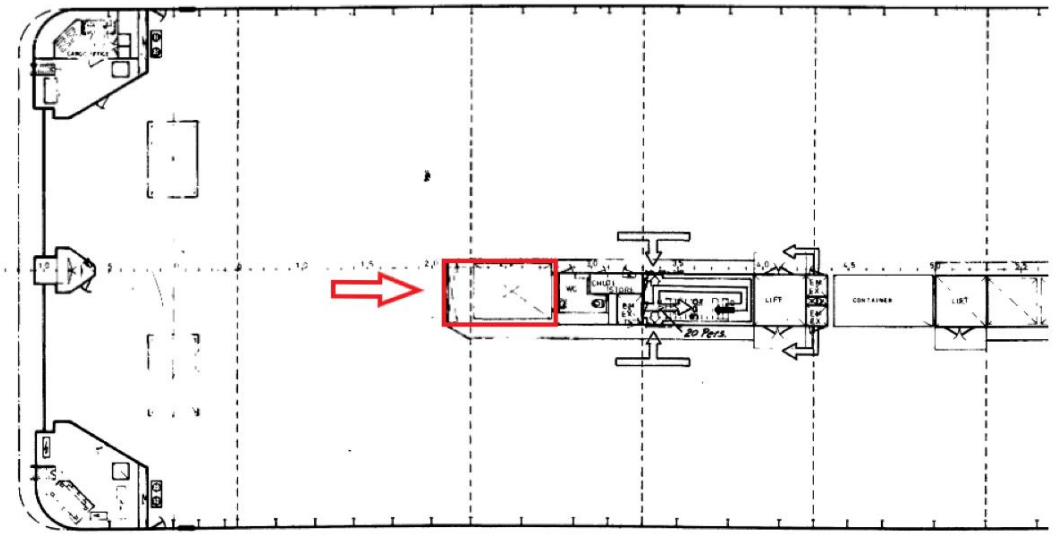

Fig. 3.9. Provision hatch on aft part of car deck, showed in red.

3.9 Locking Bolt Not Preserved

The bow visor was salvaged on 18 November 1994. On this were still parts of the bottom locking, i.e., the bottom locking lug. This was damaged, but not failed. (Fig. 3.10).

Fig. 3.10 and Fig. 3.11. Fig. 3.10 (left) shows the bottom locking lug on the visor. Fig. 3.11 (right) shows the failed bottom lock lugs from the hull, as found in February 2025. Image left: JAIC 8.10.

During diving operations in 1994, some details from the vessel were cut out and brought to surface. Amongst these were matching parts of the visor hydraulic bottom locking arrangement, i.e., the bottom locking lugs, mounted on the vessel's hull (Fig. 3.11), and the bottom locking bolt (Fig. 3.12), which was examined.

Fig. 3.12. The bottom locking bolt as found in footage from 1994. Bottom left, the failed matching lugs, mounted on the vessel's hull, can be seen. Image: JAIC Fig. 8.15.

The examination of the arrangement showed that the locking bolt was fully extended, i.e., in an engaged position. The piston rod was bent upwards, and the hydraulic hoses were still connected. The examination of the bolt showed that the bolt was straight with a diameter of about 78 mm. Only a slight variation was measured at the contact area between the bolt and the visor lug. No other damage to the bolt was noted. (JAIC 8.6.1). The failure of the bottom locking lugs, mounted on the vessel's hull, indicates that the part of the bottom locking that failed was the lugs, mounted on the vessel's hull.

The bolt was not preserved, as explained by JAIC due to some practical reasons.

3.9.1 Conclusions

The fact that the locking bolt was not preserved was unfortunate, but more of transparency reasons than technical. The bolt itself had not failed nor contributed to the accident. The failing parts were instead the bottom locking lugs, mounted on the vessel's hull, which were salvaged and thoroughly examined.

3.10 Was Human Trafficking On-Going?

In one of the interviews with survivors it has been suggested that human trafficking was on-going on MV ESTONIA on her last journey.

One other witness has stated that on one occasion in February 1994 (the exact date is mentioned and related to a personal event) a number of refugees from an Asian country had escaped from a trailer. The journey on that specific occasion was delayed, waiting for a decision on whether the vessel should return to Tallinn or continue. This statement is considered to be reliable since the witness was directly involved in the occurrence.

3.10.1 Conclusions

There have been refugees smuggled onboard MV ESTONIA at least once, but long before the last journey. Nothing indicates that such smuggling occurred, or did not occur, on her last voyage. However, there is no connection between refugee smuggling and the loss of MV ESTONIA on 28 September 1994.

Jörgen Zachau
Investigator-in-Charge

On behalf of
Ohutusjuurdluse Keskus/Estonian Safety Investigation Bureau, Tallinn, Estonia
Statens haverikommission/Swedish Accident Investigation Authority, Stockholm, Sweden

Safety Investigation Authority, Finland (SIAF) has seen the document prior to its publication and has no further comments.