Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Federal Higher Authority subordinated to the Ministry of Transport
and Digital Infrastructure

Investigation Report 86/13

Very Serious Marine Casualty

Fatal accident of the entrance to the port of Figueira da Foz, Portugal on the training craft SY MERI TUULI on 10 April 2013

8 August 2014

The investigation was conducted in conformity with the Law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Law - SUG) of 16 June 2002, amended most recently by Article 1 of 22 November 2011, BGBl. (Federal Law Gazette) I p. 2279.

According to said Law, the sole objective of this investigation is to prevent future accidents and malfunctions. This investigation does not serve to ascertain fault, liability or claims (Article 9(2) SUG).

This report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to Article 34(4) SUG.

The German text shall prevail in the interpretation of this investigation report.

Issued by:
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1 Summary

At 0830[1] on 10 April 2013, the X-Yachts 442 German training craft, Sailing Yacht MERI TUULI, sailed out of Peniche in Portugal with five crew members. Her destination was Figueira da Foz. The distance and speed calculated for the voyage were 55 nm and 8 kts respectively, meaning the time of arrival would have been at about 1630 in the afternoon in high tide. The MERI TUULI did not reach her berth in the port of destination. After the sails were struck, she abruptly heeled south-west of the northern jetty, roughly on the 10 m line, at 1641 due to groundswell probably to port on the waterline when she broached and lost her ability to steer because of a steep aft wave of 5-6 m in height. The mast broke and four crew members fell overboard in the process. A police officer and a crew member died in a semi-rigid inflatable dinghy that capsized during the rescue operation, after two crew members of the MERI TUULI had already been recovered.

[1] Unless stated otherwise all times shown in this report are West European Summer Time (WEST = UTC + 1).

2 FACTUAL INFORMATION

2.1 Photo

Fig. 1: Photo of the ship by the sailing school

2.2 Ship particulars

Name of vessel:	MERI TUULI
Type of vessel:	Sailing craft
Nationality/Flag:	Germany
Port of registry:	Heiligenhafen
Call sign:	DIJC2
Owner:	Sailing school, Nordtoern & Well Sailing, Hamburg
Year built:	2001
Shipyard/Yard number:	X-Yachts Haderslev, X-442 No 85
Length overall:	13.48 m
Breadth overall:	4.15 m
Draught (max.):	2.10 m
Engine rating:	37.5 kW
Main engine:	Yanmar
Hull material:	Glass-fibre reinforced plastic (GRP)

2.3 Voyage particulars

Port of departure:	Peniche
Port of call:	Figueira da Foz
Type of voyage:	Other shipping, international
Manning:	Skipper
Draught at time of accident:	2.10 m
Number of passengers:	4

2.4 Marine casualty or incident information

Type of marine casualty/incident:	Very serious marine casualty, abrupt heel
Date, time:	10/04/2013, 1641
Location:	Figueira da Foz
Latitude/Longitude:	φ 40°08.7'N λ 008°52.6'W
Ship operation and voyage segment:	Approach
Place on board:	Cockpit
Human factors:	Yes
Consequences (for people, ship, cargo, the environment and other)	Two fatalities, considerable damage to the boat none

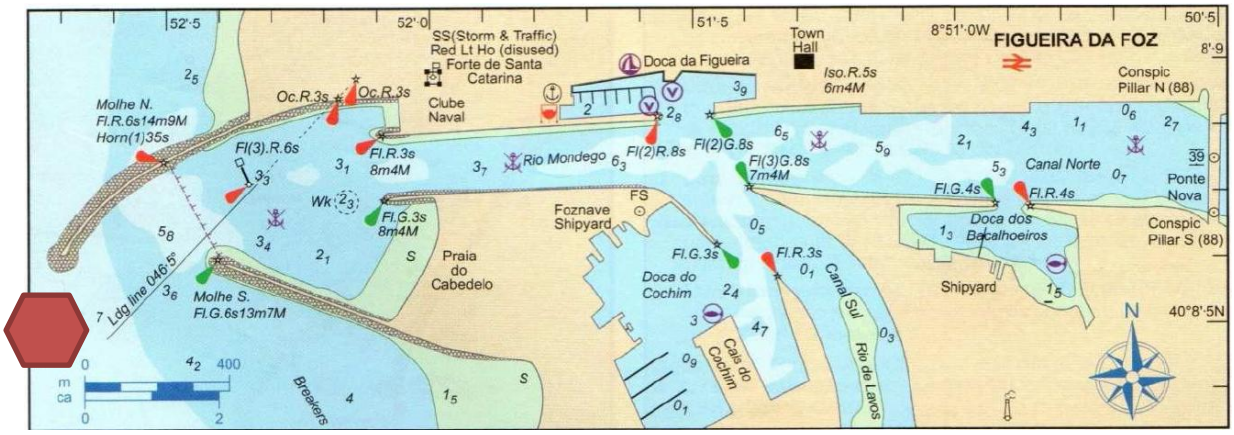


Fig. 2: Reeds Nautical Almanac 2013, scene of the accident

2.5 Shore authority involvement and emergency response

Agencies involved:	MRCC Lisbon, Instituto de Socorros a Naufragos (ISN, Portuguese search and rescue service), harbour master, police, fire brigade, coast guard (UCC-GNR), civil protection service, outpatient department (INEM), hospital
Resources used:	Helicopter, rescue cruiser PATRAO MOISES MACATRAO, police boat PAPA NOS, ambulance
Action taken:	Crew rescued from the water, primary care
Results achieved:	One police officer and one crew member lost their lives, six injured

3 COURSE OF THE ACCIDENT AND INVESTIGATION

At 0830 on 10 April 2013, the German training craft, Sailing Yacht MERI TUULI, sailed out of Peniche in Portugal with five crew members. Her destination was Figueira da Foz. The distance and speed calculated for the voyage were 55 nm and 8 kts respectively, meaning the time of arrival would have been at about 1630 in the afternoon in high tide. The MERI TUULI did not reach her berth in the port of destination. After the sails were struck, she abruptly heeled south-west of the northern jetty because of groundswell, probably to port, approximately on the 10 m line at 1641. The mast broke and four crew members fell overboard in the process. A police officer and a crew member died in a semi-rigid inflatable dinghy that capsized during the rescue operation after two crew members of the MERI TUULI had already been recovered. Furthermore, four crew members and two police officers were injured and required medical treatment.

3.1 Course of the accident

The crew's voyage began on 6 April 2013 in Lagos/Portugal and was set to finish on 13 April 2013 in Leixões. The ports scheduled prior to the destination were Sines, Cascais, Peniche, and Figueira da Foz. Alongside the skipper, three experienced sailors were on board. The skipper and the subsequent deceased were in possession of the German Sailing Association's (DSV) recreational offshore skipper licence (Sporthochseeschifferschein - SHS), the British Royal Yachting Association's RYA Yachtmaster Offshore, and the LRC radio certificate (Long Range Certificate). Another crew member held the DSV's coastal vessel skipper's licence (Sportküstenschifferschein - SKS), and one other crew member had about 120 weeks of sailing experience on craft between 28 and 44' but no certificate of competency. All were experienced offshore and had met in Hamburg before the sailing trip to plan the voyage. The distance was 330 nm in total. The legs were to be no more than 50-70 nm. That was coupled with 7 kts. Reportedly, the skipper last sailed the Portuguese coast three years ago.

On 9 April 2013, one day before departure in the port of Peniche, the harbour master of the marina informed the skipper of the MERI TUULI about the expected weather conditions during the voyage to Figueira da Foz. At the same time, he handed over a weather chart from WINDGURU[2], pointed to the particular dangers during the approach, and advised that Figueira da Foz be avoided in high waves. Moderate to fresh south-westerly winds were forecast between Cabo Carvoeiro (west of Peniche) and River Minho (north of Porto), which would gradually increase and possibly freshen up to Bft 7 in the night the further north one sails. Reportedly, visibility was good and swell would initially come from the north-west with wave heights of 3-4 m and later from the west with wave heights of 4-5 m. Due to the weather situation, it was announced in the navigational warning (No 835/2013) that the port of Figueira da Foz was closed to vessels of less than 35 m.

[2] Windguru (http://www.windguru.cz/de) is a specialised weather forecast service for windsurfers, kitesurfers, and other users. The forecasts are based on weather models. Windguru is able to provide forecasts for every area of the world. The forecasts on the Windguru site are not official weather reports. Windguru was designed to assist users in forecasting.

The harbour master was reportedly not aware of this warning. The MERI TUULI's port of destination was entered as Leixões in the Latitude 32 system (acquisition system of the Portuguese authorities for ship movements).

The TIME BANDIT, a British sailing yacht that intended to depart for Figueira da Foz with the MERI TUULI on the following morning, was moored in the same marina at Peniche. Both yachts sailed in a northerly direction along the Portuguese coast for several days and were familiar with one another. The crew of the TIME BANDIT reported that the waves in Peniche crashed onto the jetty on the night before departure. They were long, had a height of 3-4 m, and broke in a daunting surf in shallow water. In February 2011, surf reportedly washed over the British yacht WATERWAVE in similar conditions at Povoa de Varsim (north of Porto) during the approach. There were two fatalities. The monthly British magazine Yacht reported on it. The BSU is not aware of the extent to which knowledge of the sea conditions was shared between the yachts.

The local weather report was obtained on the MERI TUULI via ZYGRIB[3] and the general weather situation via Germany's National Meteorological Service (DWD) on 10 April 2013 prior to leaving port. This indicated that the route was situated between a high and low pressure system with atmospheric pressure of 1015 hPa. The degree of cloud coverage was reportedly 6/8 to 7/8 and there was occasional drizzle. A southerly wind of 3-5 Bft prevailed. The wind was expected to be weaker along the coast. Increasing wind was forecast for the night. The swell was specified at 3 m in height from the north-west with a wave period of 15 s. Visibility was reportedly good to moderate. A north-westerly 2-3 m swell was observed off the jetty in Peniche. The crew was briefed and informed about the situation. The option of Leixões as a port of destination was allowed for in the event of Figueira da Foz not being accessible. This was to be clarified by radio with the port authorities during the voyage. A night voyage was necessary for the voyage to Leixões and a navigational watch was assigned accordingly, i.e. the night watch, consisting of two people, was to rest during the day.

The MERI TUULI cast off at 0830. The mainsail was set in the port of Peniche. The foresail was set shortly after leaving port and the engine was turned off at about 0840. They initially sailed on an upwind course and then on a beam reach course north of the island of Berlenga. At 0930, they sailed on a general course of 34° towards Figueira da Foz. The foresail was unsteady and struck shortly after. After that, the MERI TUULI sailed at a speed of 7 kts in good sailing weather and an aft current. A GPS and waypoints were used for navigation with two nautical chart plotters, as well as electronic nautical charts from Navionics. Imray yachting chart sets were also on board.

[3] ZYGRIB is a free software package that uses the GRIB format of global meteorological institutions to transfer weather data and display the same on a workplace computer. The weather forecast can be carried out directly from the program. Connection to the Internet is not essential. The GRIB file can also be transferred via a modem.

The electronic wind indicator was faulty. The TIME BANDIT, which set sail shortly after, was behind the MERI TUULI.

Fig. 3: Departure from Peniche, Cabo Carvoeiro (08:53 camera time)

The mood on board was reportedly good and pancakes were fried during the trip. The subsequent casualty was primarily at the helm for the day watch, while the other crew members also provided relief by steering the craft or performed other tasks. There was no compulsion to adhere to the planned route. Only the time frame should be correct. Selection of the ports of call was based on the weather conditions. The port used for the next crew change was also flexible and not prescribed by the sailing school. About 2.5 to 3 hours and 18 nm off the approach to Figueira da Foz, the later casualty and the skipper tried to reach the harbour master (also the one at the marina) on VHF channels 8, 11 and 16. The frequencies were specified in Reeds 2013. FORTE SANTA CATARINA (three times on channel 8), FIGUEIRA DA FOZ PORT (three times on channels 11 and 16 respectively), and CAPIMARFOZ (3 times on channel 16) were reportedly chosen for the calls. The TIME BANDIT, which in the meantime had been visible astern on several occasions and was sailing parallel to the coast with butterfly rigging, was called on channel 16 at 1416. A conversation was then held on channel 6 between the TIME BANDIT and the later casualty, as well as another crew member of the MERI TUULI. The crew of the TIME BANDIT was concerned about the swell and urged caution. They also wanted to call at Figueira da Foz. Information about any signals or communication with the port (or even a port closure) was not mentioned. Visibility deteriorated and there was drizzle in the air about 2 nm off the jetties. A decision was taken to call at Figueira da Foz on the MERI TUULI.

The mainsail was struck and the engine started at about 1610 some 1 nm south-west of the port entrance. The possible maximum speed reportedly stood at 6-8 kts. The subsequent casualty was at the helm and the skipper at the mast to strike the sails. Breaking waves and surf were visible west of the northern jetty and east of the southern jetty near the beach.

It was calmer in between in the area of the port entrance. The skipper decided to first pass the northern jetty and then approach the calmer area of the entrance from the north-west with the swell. He advised that it would be choppy and wet. The swell reportedly stood at about 2-2.5 m in height. Apart from that, high tide was a good time to enter. The crew was wearing lifejackets with integrated crotch straps and those employed on the deck were to secure themselves using lines and the D-rings. In fact, only one crew member was properly secured. In the case of the others, it is unclear whether the crotch straps were closed and how the lifelines were fastened. At least one crew member had not donned the crotch strap and the life line since they would have obstructed him. All the crew members were in the cockpit and the skipper was at the helm shortly before the entrance. According to the statements, a 2-2.5 and 5-6 m-high aft wave washed over the cockpit of MERLI TUULI, causing four crew members to fall overboard. The mast broke and remained lying on the port side. The MERI TUULI was now situated about 100 m south-south-east of the northern jetty. It is unclear whether the MERI TUULI heeled to port or starboard in the breaking wave. One crew member reported to port, one crewmember to starboard and another crewmember was not sure of the side, while from the shore starboard was reported at 1635, reportedly causing the mast to break when it struck the water surface about 400 m south of the northern jetty.

All the lifejackets worn by the people in the water inflated and opened. The subsequently injured crew member reportedly held onto the port side of the MERI TUULI. The skipper was reportedly first caught in the drag of the running rigging and initially unable to surface. His thigh was reportedly bruised and the position of the lifejacket twisted at his head. The force of the water reportedly pulled off his trousers. He swam to the MERI TUULI and met a fellow sailor without a lifejacket floating in oilskins. He was reportedly responsive and since it was not apparent that he required any immediate help, the skipper ultimately swam on and reached the stern of the MERI TUULI. Only later did it transpire that the drifting person had a chip fracture in the upper left arm. One crew member was on board. He was to deploy the bathing ladder at the stern. Using considerable force, it was possible to lower the buckled bathing ladder into the water. The skipper managed to board and gave instructions to get the case with the distress signals from the locker seat. In the meantime, the skipper made a line ready to guide the sailor suspended overboard to the stern. He then fired a red flare and helped to release a female sailor in the cockpit from her twisted lifejacket, which was constricting her head and neck. It was not possible to get the fellow sailor on board at the stern. He was secured with a second line. The skipper then opened the inflatable liferaft's bracket
The liferaft fell overboard and immediately drifted away from the craft without having inflated. There was no connection to the MERI TUULI because the attachment was suspended on the stern pulpit, which had broken off. One crew member was reportedly about 300 m away from the MERI TUULI in the direction of southern jetty. The lifejacket had also parted in this case, but it was possible to hold it onto the body. The water appeared to be relatively calm and it was possible to swim to the southern jetty.

The red flare was sighted on the TIME BANDIT.

This yacht was also en route to Figueira da Foz behind the MERI TUULI, but called in on VHF channel 14 shortly before and was advised the port was closed. Consequently, the crew decided not to call at the port. They transmitted a mayday relay message because of the flare.

About 20 minutes later, a rescue cruiser and a semi-rigid open inflatable dinghy with two outboard engines approached the MERI TUULI. The closed rescue cruiser, the PATRAO MOISES MACATRAO, first rescued the two people drifting in the water, one with and the other without a lifejacket. The skipper attempted to give a new lifejacket to the crew member secured at the stern. However, the jacket drifted off. Instead of the lifejacket, the casualty was able to grasp a lifebuoy from the police boat PAPA NOS and was pulled on board via her stern. Meanwhile, the skipper donned a pair of trousers in the superstructure and made the emergency tiller ready. He then started the engine. After a short thrust, the running rigging suspended in the water blocked the screw, meaning the engine had to be stopped again. The PAPA NOS then returned to collect another person, also without a lifejacket. The MERI TUULI was to be taken in tow by the rescue cruiser.

Fig. 4: Blocked screw

The intended towline was located beneath the headsail and fenders stowed in the forepeak. Therefore, the skipper decided to use a mooring line, which he drew through both front cleats. At that moment, he saw the PAPA NOS – vertical on a wave at about 1.5 m some 400 m away from the Praia do Cabedelo beach – pitchpole. Afterwards the inflatable dinghy drifted bottom-up to the beach. The capsize caused three police officers and two rescued crew members from the MERI TUULI to fall overboard. The skipper apparently held onto the boat line attached outside with his lifejacket. Another police officer held onto the stern of the PAPA NOS with a crew member from the MERI TUULI and assisted with a lifebuoy drifting in the water.

The other crew member of the MERI TUULI was alongside in the vicinity of the capsized craft. Rescuing them was now the priority. The skipper disrupted his recovery preparations, donned a new lifejacket in the cabin and went on deck. The PATRAO MOISES MACATRAO arrived just after that and collected a police officer drifting in the water, as well as the skipper. She then sailed back towards the beach in the surf zone to rescue more people. The rescue attempt was then aborted close to the shore because of the low depth and breaking waves without rescuing anyone else from the water. The PATRAO MOISES MACATRAO first sailed further seawards to make additional observations and then back to port, where the survivors were transferred to paramedics at the berth of the Instituto de Socorros a Naufragos (ISN, Portuguese search and rescue service). After that, they were taken to the district hospital at Figueira da Foz. The PATRAO MOISES MACATRAO then sailed back to the scene of the accident. When it was clear that the other survivors were on the beach, the rescue cruiser sailed back to her berth and finished the mission at 1845.

Fig. 5: Drifting MERI TUULI

Fig. 6: PATRAO M. MACATRAO mission

Of the survivors from the capsized PAPA NOS, one crew member from the MERI TUULI and the PAPA NOS managed to survive by drifting to the southern beach of Figueira da Foz on the surf. The skipper of the PAPA NOS with a non-inflated lifejacket and another crew member from the MERI TUULI without a lifejacket were found dead on the beach. According to observations made, the survivors were generally two to three metres away from the craft and gave the impression that they were conscious. After primary care and attempts to resuscitate two people, they were taken to a nearby hospital by ambulance. The PAPA NOS and MERI TUULI were washed onto the Praia do Cabedelo beach south of the Figueira da Foz port entrance.

Fig. 7: MERI TUULI grounded

Fig. 8: PAPA NOS grounded

3.2 Investigation

The Lisbon-based Office of Prevention and Investigation of Maritime Accidents (gpiam) published an investigation report on the very serious marine casualty involving the MERI TUULI in October 2013. This report can be downloaded at http://www.gpiam.mamaot.gov.pt/images/Relatorios_Tecnicos/022013_MERI_TUULI.pdf. Due to new findings made during the BSU's visit to the gpiam and the police authorities in Figueira da Foz between 4 and 6 December 2013, as well as the survey of the MERI TUULI by the BSU after she was moved to Germany on 31 July 2014, it was decided to resume the investigation with regard to outstanding issues relating to the accident involving the MERI TUULI.

The MERI TUULI only exhibited minor damage above the waterline during the survey at Teerhofinsel in Bad Schwartau on 30 July 2013. The loss of the mast and the entire standing rigging, as well as the destroyed railing only caused minor damage to the shell. Similarly, no significant damage was evident on the underwater hull, except for the steering gear. The keel-hull connection was intact. The wheel was buckled and the emergency tiller's arm had broken off. The interior of the yacht had already been cleared up and cleaned. There was practically no equipment left. The electronic system was destroyed by water ingress, even though the companionway with washboards and sliding hatch were reportedly closed in the surf zone on the day of the accident. However, the hatch reportedly opened a little before the starboard side grounded on the beach and the upper washboard fell out, meaning water could enter. The rigging was reportedly replaced about a year ago and as new.

Equipment on the MERI TUULI:

Navigation
Furuno GP32 GPS with GPA 017 antenna mounted on the stern pulpit, Raytheon Pathfinder RI80C radar system, Raytheon ST60 display for echo sounder, Raytheon ST60 display for speed log, AIS Technilan CSB 200 Class B transponder, Geonav nautical chart plotter, on-board computer with navigation program, Navionics 46XG electronic nautical chart set for western Europe. Binoculars, magnetic compass, hand bearing compass, mobile phone

Radio
Cobra Marine MRF80 VHF-DSC system, MRD-80 short wave receiver for weather and NAVTEX, on-board computer with Wetterwelt software, Sailor Iridium satellite phone with email, McMurdo S4 Rescue Sart

Small craft charts
Imray C48, C49, C50

Sailing directions
Reeds 2013, Imray 2005 and 2011 Atlantic Spain and Portugal, tide tables for 2013, Radio Regulations for 2013, other

Life-saving appliances

Eight Kadematic Nova 275 AHR lifejackets with crotch strap, eight lifebelts, two lifebuoys with light/line, two MOB marker buoys, one heaving line, BFA Marine inflatable liferaft for eight people, four fire extinguishers, two fire blankets, EPIRB buoy, radar transponders, Walden recovery net and tackle, flares (12 red paraflares, four hand flares, and two smoke signals)

During the BSU's visit to the Portuguese investigation authority, the GPIAM, in Lisbon on 4 December 2013 and to the police authority in Figueira da Foz on 5 December 2013 with the former harbour master, the following findings were made:

- Exact position of the accident:

  Only one track exported from the ECS of the MERI TUULI exists. The nautical chart (Imray) used was revised; however, the latest issue was not on board.

  ECS with current Navionics charts and charted with extended northern jetty was used for navigation. According to the radar recordings, the accident happened at 1641 on 10 April 2013 just south-west of the northern jetty outside the calm zone.

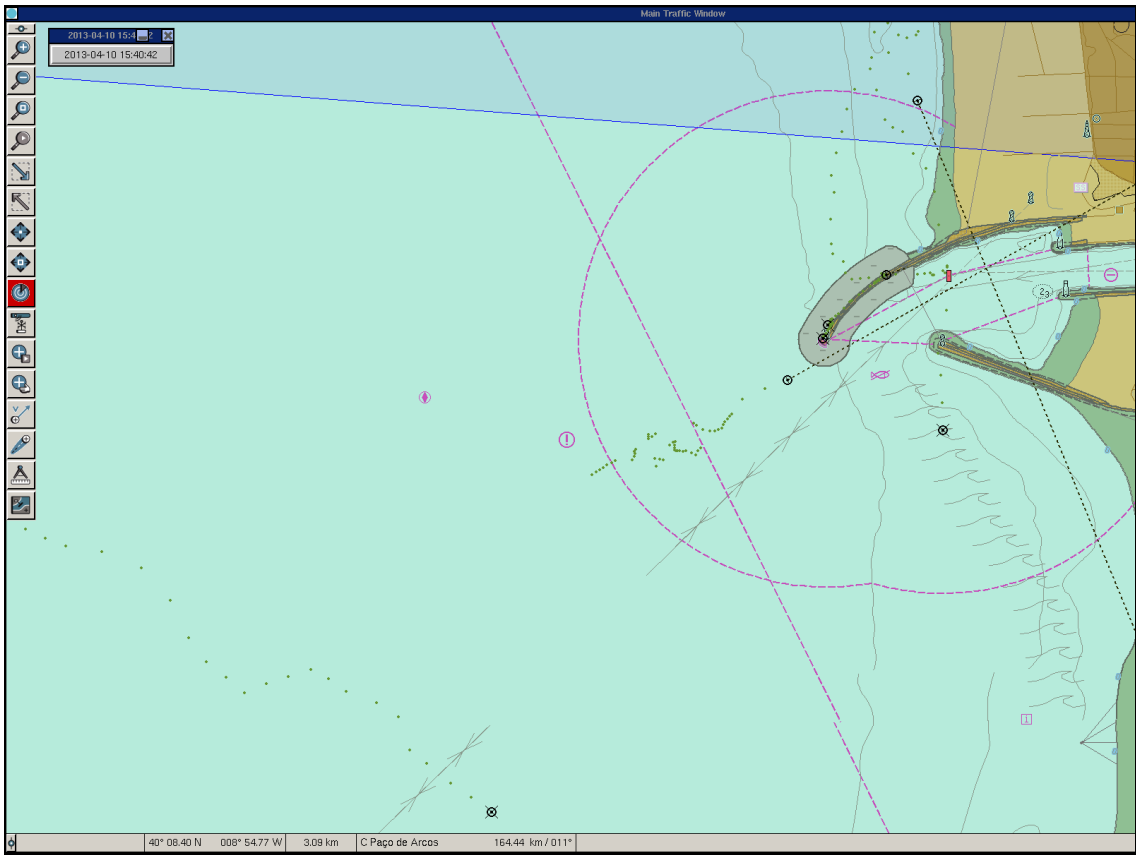


Fig. 9: Radar recordings at the time of the accident (1641)

The sketch prepared by the sailing school, Nordtoern & Well Sailing, which overlays a Navionics nautical chart, shows the possible positions of where the sail was struck and the accident. This indicates that the MERI TUULI was located in the zone protected by the jetties. The scene of the accident was presumably closer to the northern jetty, in the unsheltered area (s. figure 9).

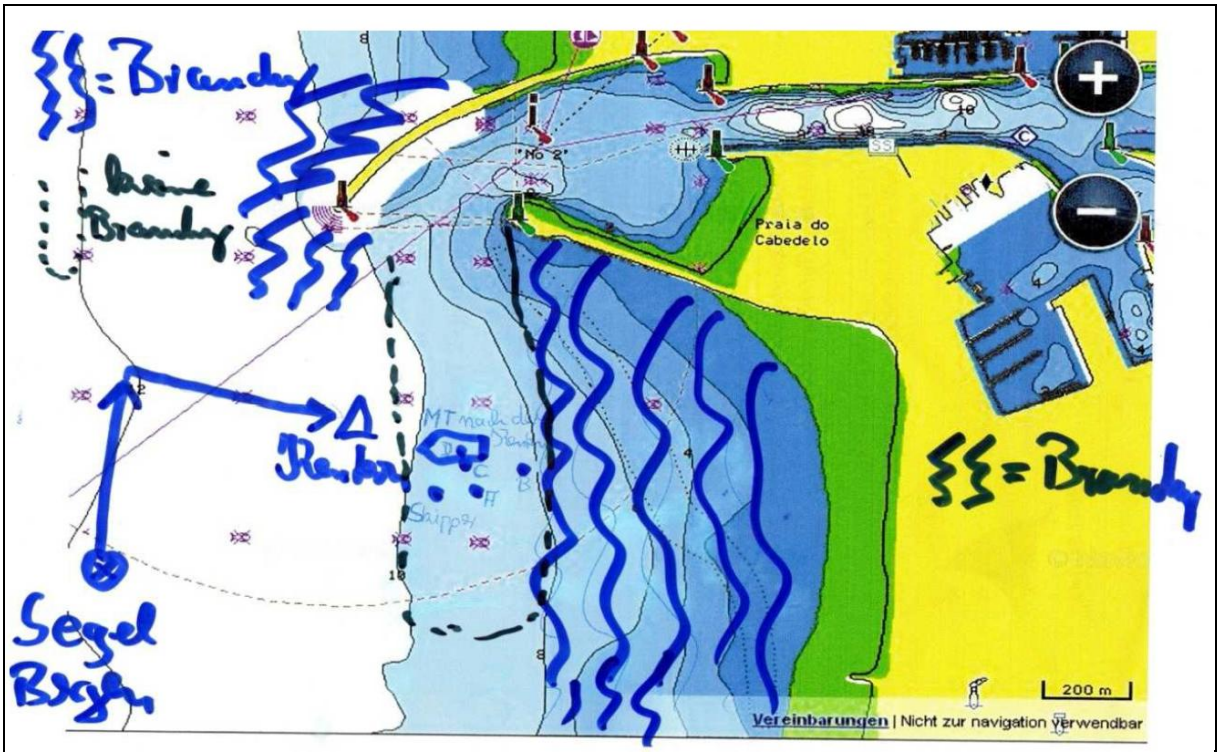


Fig. 10: Sketch by Well Sailing

- Course of the accident (explanation of the capsize, mast had ground contact?):
  The mainsail was struck about 1 nm south-west of the northern jetty (s. figure 18, end of the recorded track). In the process, it is normal to turn to the windsea. Afterwards the MERI TUULI had to turn using the engine with the sea approaching from aft to move into the entrance. A north-easterly course alteration would then be necessary at the entrance. The MERI TUULI was probably struck by groundswell on the bar and heeled rapidly to the side between roughly 40 and 60° – the maximum righting moment according to the righting lever arm curve – in the process. A knockdown (sudden rolling motion on the surface of the water) is also conceivable. The hull's range of stability without superstructure, equipment and rigging is 115°. All those present considered ground contact by

the mast unlikely ([...] the mast hit the bottom and broke [sic], see GPIAM investigation report).
Shrouds probably broke due to water shock and transverse acceleration, causing the mast to fall on the port side. Four crew members fell overboard.

- Chaotic wave image (cross sea) at the time of the accident:
  North-west, 5-6 m, sea breaking heavily. The calm zone is located to the south of the entrance approx. on the 10 m contour line.

- Striking the mainsail:
  Precise statements do not exist. The crew testified in the presence of a translator of the German embassy and the gpiam in the police station Figueira da Foz.

- Statements about visibility:
  About 2-3 nm.

- Information concerning the closure of the port, visual signs and radio reports:
  The information provided in the sailing directions (Reeds, Imray) are reportedly wrong. They are shown correctly in the Portuguese port manual.

- Statements about the response to the radio call by MERI TUULI to the marina:
  There are radio recordings on VHF 16. Reportedly, nothing was heard in the harbour master's office (probably too far away). The MERI TUULI called the station CAPIMARFOZ. VTS Lisbon recorded the conversations.

- It is claimed in the GPIAM investigation report that the AIS and NAVTEX were switched off. It is unclear whether and how that is substantiated.
  VTS Lisbon does not record AIS data from Figueira da Foz. Inasmuch, there is no evidence, unless from other vessels. According to the statement made by the crew the AIS was said to have been switched on and tested with another vessel. The AIS-positions of the MERI TUULI were reportedly displayed through Marine

Traffic[4]. It had also been connected to the same cutout with the GPS-receiver. A failure was said to have been unlikely.

The navigational warnings on NAVTEX were probably not observed.

- Harbour master's office:

  A new harbour master has now been employed. The office also carries out police duties. It reports to the Ministry of Defence (Ministerio da Defesa Nacional, Marinha – Autoridade Maritima Nacional, Comando Local Policia Maritima, Figueira da Foz). The port authority and pilots have their own building and are independent from an organisational perspective. Based in Lisbon, the vessel traffic service (VTS) records ship movements and VHF traffic. The SAR station has a helicopter and is located north of Figueira da Foz. The rescue cruiser PATRAO MOISES MACATRAO is located in the port. The maritime police has a semi-rigid lifeboat, the PAPA NOS. She is equipped with two 250 HP Suzuki outboard engines and has been in the service of the Capitania do Porto da Figueira da Foz since June 2010. Her length, breadth and draught are 10 m, 3.2 m and 0.55 m respectively. There is also the fire brigade. With the exception of pilots and the port authority, every agency was involved in the rescue operation.

[4] Marine Traffic is a service developed as an academic project by the Aegean University of Greece (University of the Aegean) for the publicly display of worldwide AIS data. Upon request by the Federal Bureau of Maritime Casualty Investigation of 25 June 2014 at vessel tracker, a private AIS service in Hamburg, vessel tracker advised of the fact that the last AIS data of MERI TUULI was recorded on 7 April 2013 in Lagos and 8 April 2013 in Sines.

- Channels:

  There are the stations Marina da Figueira da Foz (VHF 8, 16), Figueira da Foz Pilots (VHF 14, 16), Capimarfoz (VHF 8, 16), and Polimarfoz (VHF 11, 16). The last two stations refer to the harbour master and the police station, which are in the same building. There is evidence to show that the MERI TUULI called on channel 16 Capimarfoz. That call went unanswered. It is possible that the MERI TUULI was too far away for the transmitting power.

- Santa Catarina signal mast:

  The signal mast is located on a historic building on the northern side of the port entrance, which is protected by jetties. The site is surrounded by houses. A road passes outside.

  A small park with sandy beach is in front. The signal mast was not visible to the naked eye from the southern jetty. The signals are shown incorrectly in the sailing directions of Reeds and Imray. The following would be correct if the entire port was closed: Day signal: two parallel high black balls. Night signal: four fixed vertical lights in the colours green, red, green, red. Partial closure for vessels up to 35 m in length: Day signal: one high black ball. Night signal: three fixed vertical lights in the colours green, red, green. Partial closure for vessels up to 11 m in length: Day signal: one semi-high black ball. Night signal: three flashing vertical lights in the colours red, green, red. The ball's diameter is 50 cm.

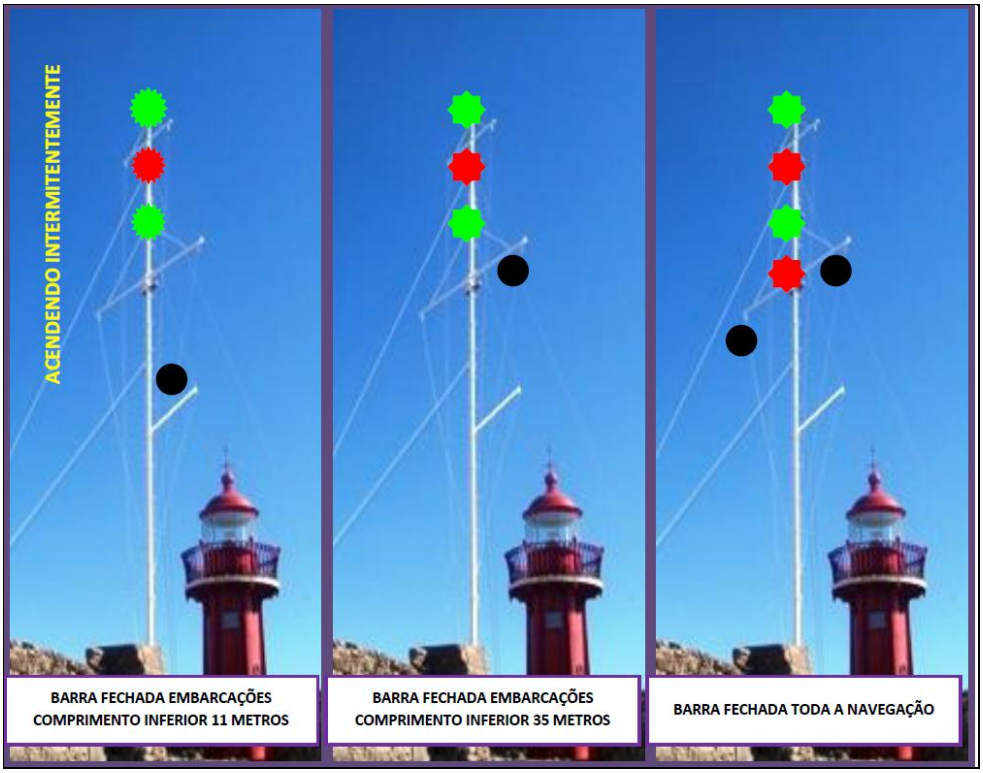


Fig. 11: Santa Catarina signal mast

- Scene of the accident on the southern beach:

  A campsite with beach follows immediately after the southern jetty. Two wavesurfers were in the water. The sea was calm with a light swell of 2 m. On the day of the accident, the rescue operation was filmed and photographed. This material was copied for the BSU. A bar where heavily breaking groundswell can form is located off the jetty.

Weather report by the DWD

On Tuesday 9 April 2013, wave interference formed west of the Azores on an air mass boundary, which intensified. On the day of the accident, 10 April, it evolved into the low pressure system 'JOEL', which was positioned north-west off the Iberian Peninsula with core pressure of slightly below 1000 hPa on the morning of the accident. It was settled within a larger low pressure system with 990 hPa over the East Atlantic. The warm front of 'JOEL' ran up to the Atlantic coast of Portugal; the cold front stretched west from the core across the Atlantic. 'JOEL' reportedly reached the north-west region of France in the evening **(see surface weather map**). The region in which the accident occurred was located within a brisk south-westerly air current. The observation data for the region around Figueira da Foz indicate a south-westerly wind. Average measurements were 24 to 27 knots (6 Bft) in the coastal area and more than 30 knots (7 Bft) in places on the open water. There were also gusts of 1 to 2 Bft above the mean wind because of the widespread unstable air mass with scattered showers. In the enclosed shipping forecasts of the French national weather service, 'Meteo France' (Porto and Sao Vicente region), and the British national weather service 'UK Met Office', 5 to 6 (7 in places) was

forecast for the south-west of the region in which the accident occurred and scattered showers were possible. The French speak of an approaching north-westerly swell in respect of both the Porto sea area and Sao Vicente. **The figures (swell and wind sea)** show the expected wind and sea conditions. 6 Bft and a significant wave height of 3.5 to 4 m were calculated for the time of the accident. At the same time, the level of swell was 3 to 4 m from the north-west. There was light rain in places and it must have been mostly overcast at the time of the accident. Visibility was somewhat restricted, partly due to precipitation. This was also addressed in the forecasts. Air temperature stood at 16 degrees. Moreover, water temperatures of 14 degrees were measured. Predicted wind speeds were very consistent with the wind speeds actually measured. Here, wave heights of 3.5 m with south-westerly mean winds of 6 Bft were predicted for the time of the accident. The wind sea and swell are shown in the **figures**. It is striking here that a west-north-west swell of 3 to 4 m could be expected at the time of the accident.

The attached time series comprising ECMWF modelling data shows the chronological sequence of wind and waves in three-hour time intervals off the entrance to Figueira da Foz.

Time series

Date	Time	DD	kBFT/kts	Bft	Wind Sea	Swell	Temp
Wed 10/04/13	00 utc	S	14	4	SSW 0.2m 3s	WNW 3.1m 12s	14°C
Wed 10/04/13	03 utc	SSW	18	5	SW 0.6m 3s	WNW 3.3m 13s	14°C
Wed 10/04/13	06 utc	SSW	19	5	SW 0.9m 4s	WNW 3.3m 13s	14°C
Wed 10/04/13	09 utc	SSW	20	5+	SW 1.1m 4s	WNW 3.3m 13s	15°C
Wed 10/04/13	12 utc	SSW	23	6- / 30 7	SW 1.4m 4s	WNW 3.2m 13s	15°C
Wed 10/04/13	15 utc	SSW	23	6- / 30 7	SW 1.5m 5s	WNW 3.1m 13s	15°C
Wed 10/04/13	18 utc	SSW	23	6- / 29 7-	SW 1.5m 5s	WNW 3.1m 12s	15°C
Wed 10/04/13	21 utc	SW	21	5+ / 28 7-	SW 1.2m 5s	WNW 3.1m 12s	15°C
Thu 11/04/13	00 utc	SSW	23	6- / 31 7	SSW 1.3m 5s	WNW 3.1m 12s	15°C

Fig. 12: ECMWF spectral analysis

The swell exhibited values of 3.3 m from west-north-west. At 1.5 m, the wind sea caused by the south-westerly wind of 6 Bft was significantly lower. A chaotic wave pattern was caused by the overlay of wind sea and swell. The swell was not severe in the deep Atlantic. However, the waves neared the sea floor (groundswell) when they converged with shallower water. In the case in question, a relatively high west-north-west swell converged with shallower water.

Waves move slower in shallow water than in deep water. As compared to deep water, they can reach twice the height there.

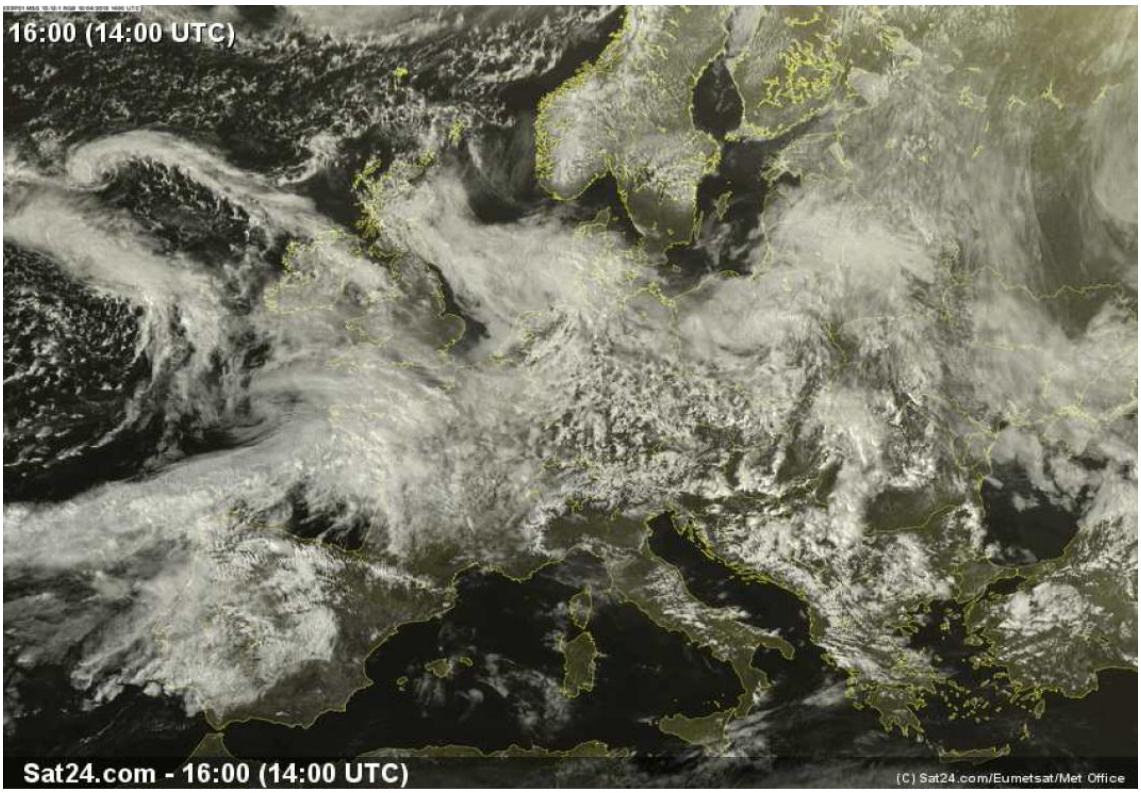


Fig. 13: Satellite image

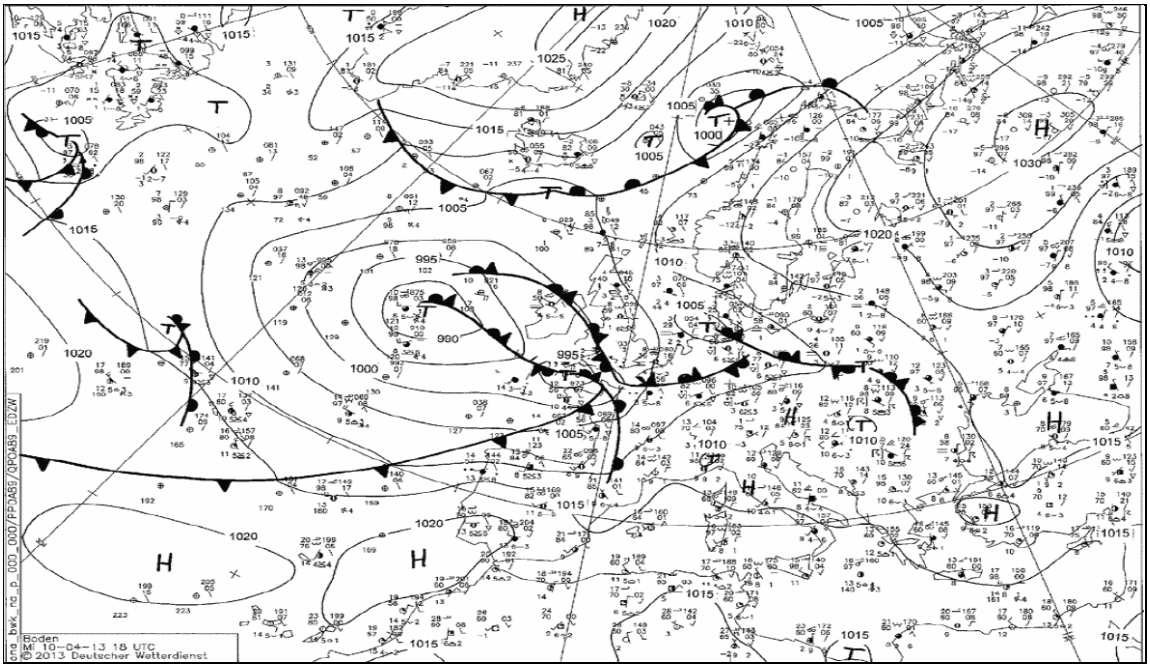
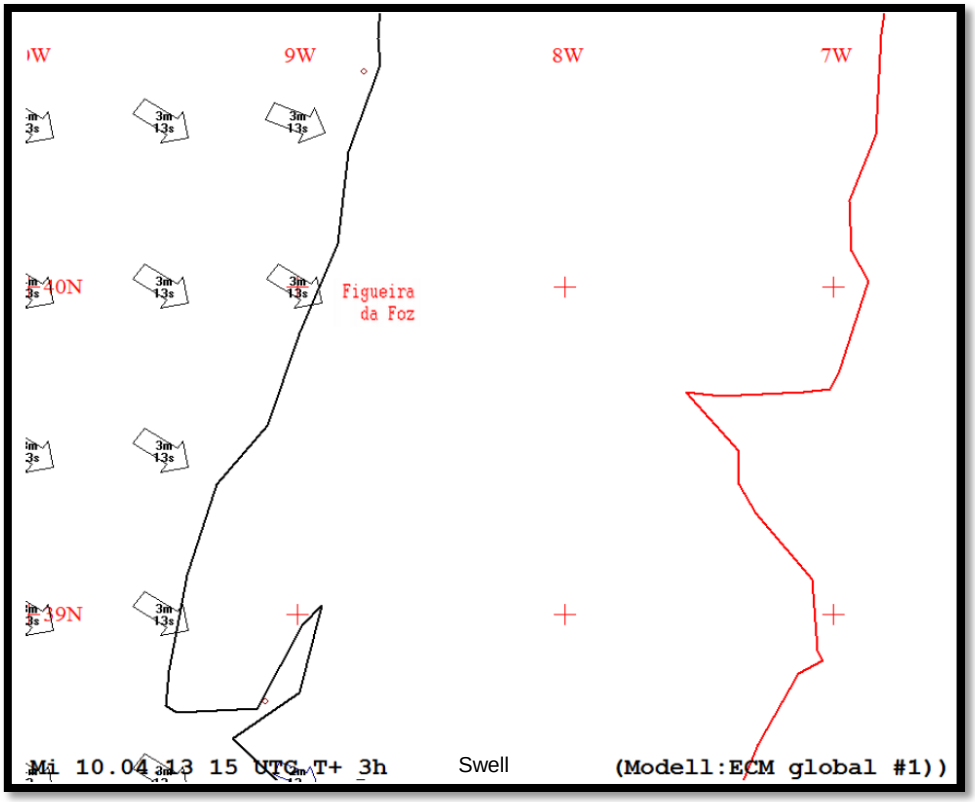


Fig. 14: Surface weather map



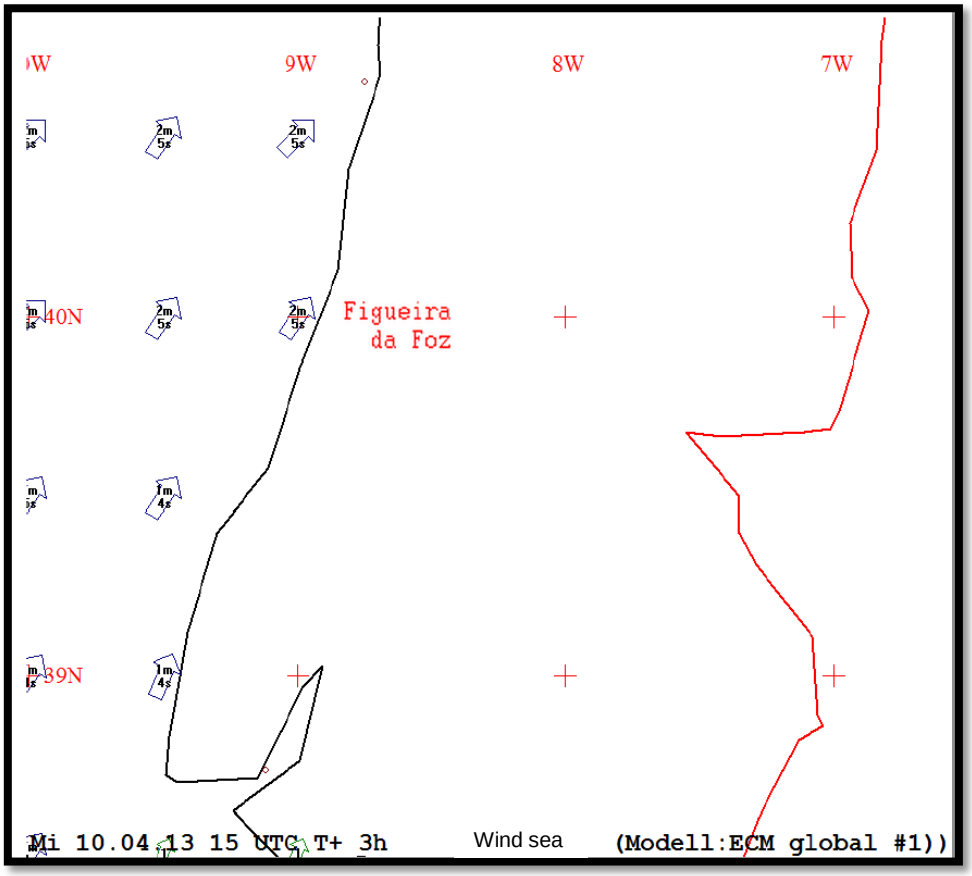


Fig. 15: Swell and wind sea

Assessment of capsizing, stability, and transverse forces by TU Harburg (Hamburg-Harburg University of Technology) and the BSU

The craft broached to and while broaching the mast struck the water.

This does not concern an actual capsizing issue because of a lack of stability, but a manoeuvring problem. The rudder loses its effectiveness because of the wave, the ship broaches to, and such considerable roll moments occur while broaching that the ship may capsize.

The broaching cannot be calculated using existing methods of calculation. However, it is likely that as with other accidents on the Iberian coast, the accident involving the MERI TUULI happened in a similar manner. The people need not necessarily have fallen out due to the transverse acceleration. It is likely that would also happen statically at about 90° (knockdown). [5]

When the ship heels at just over 115° (the first zero-crossing position of the righting lever arm curve of the yacht's range of stability), then the ship has a stable equilibrium position at 180° and would then also heel there. Presumably, the ship would then have also flooded. If the mast then breaks as well, then the heeling moment drops and the ship would right herself again.

[5] See video on the Internet of the marine casualty and knockdown of a BAVARIA 38 yacht at the entrance of Zumaia, Spain, in February 2014.

4 ANALYSIS

Radio traffic, NAVTEX, AIS

The radio traffic on VHF channel 16 was recorded by Antenna Candeiroz and Antenna Figueira da Foz on channel 16. After that, the MERI TUULI called the station Capimarfoz three times at 1408. The call went unanswered. The MERI TUULI called the TIME BANDIT at 1416 and 1417. They then communicated on VHF channel 6. However, this was not recorded by the official shore stations.

Start	Duration	Called party	Calling party	Filename	Description	DTMF	protected	Storage	Line name	Channel name
2013-04-10 13:07:46	13			P01VCS08_L64945278.mp3			no	B		MRCCCand2
2013-04-10 13:07:46	14			P01VCS08_L64945274.mp3			no	B		MRCCCand1
2013-04-10 13:16:16	21			P01VCS08_L64945408.mp3			no	B		MRCCCand2
2013-04-10 13:16:16	13			P01VCS08_L64945406.mp3			no	B		MRCCFreit1
2013-04-10 13:17:01	10			P01VCS08_L64945432.mp3			no	B		MRCCFreit2
2013-04-10 13:17:23	10			P01VCS08_L64945447.mp3			no	B		MRCCCand1
2013-04-10 13:17:27	6			P01VCS08_L64945450.mp3			no	B		MRCCFreit2

Fig. 16: VHF, channel 16, Antenna Candeiroz, times in UTC

At 1658 after sighting a red flare, the TIME BANDIT sent a mayday relay message on VHF channel 16 stating the following:

Mayday relay (three times)
This is your Time Bandit (three times)
Clear scene in the approaches to Figueira da Foz Harbour

Communication was then established with MRCC Lisbon and the rescue operation, coordinated by the harbour master at Figueira da Foz (as on-scene commander), started.

Start	Duration	Called party	Calling party	Filename	Description	DTMF	protected	Storage	Line name	Channel name
2013-04-10 16:07:24	11			P01VCS08_L64948588.mp3	figueira		no	B		MRCCCand1
2013-04-10 16:06:50	13			P01VCS08_L64948578.mp3	figueira foz		no	B		MRCCCand1
2013-04-10 16:05:41	8			P01VCS08_L64948552.mp3	figueira foz		no	B		MRCCCand1
2013-04-10 16:05:09	29			P01VCS08_L64948545.mp3	figueira foz		no	B		MRCCCand1
2013-04-10 16:02:43	13			P01VCS08_L64948481.mp3	figueira foz		no	B		MRCCCand1
2013-04-10 16:01:47	48			P01VCS08_L64948465.mp3	figueira foz		no	B		MRCCCand1
2013-04-10 16:01:26	9			P01VCS08_L64948458.mp3	figueira foz		no	B		MRCCCand1
2013-04-10 16:01:11	13			P01VCS08_L64948438.mp3	figueira foz		no	B		MRCCCand1
2013-04-10 15:59:57	45			P01VCS08_L64948408.mp3	figueira foz		no	B		MRCCCand1
2013-04-10 15:59:32	24			P01VCS08_L64948395.mp3	figueira foz		no	B		MRCCCand1
2013-04-10 15:58:35	23			P01VCS08_L64948372.mp3	figueira foz		no	B		MRCCCand1

Fig. 17: VHF, channel 16, Antenna Candeiroz, times in UTC

The crew of the MERI TUULI indicated that the stations Figueira da Foz Port on VHF channels 11 and 16 and Forte Santa Catarina[6] on VHF channel 8 were each called three times at ab

[6] Note: Santa Catarina is merely a signal station (see 11), not a radio station.

out 1340. The distance to the port of destination was about 18 nm. It is possible that the transmitting power was not sufficient to be received by Antenna Figueira da Foz. The BSU is not in possession of recordings of this radio traffic.

The following navigational warning was broadcast over NAVTEX[7] at 2219 on 9 April. It was applicable for two days and reported that the port of Figueira da Foz was closed to vessels of less than 35 m in length.

Navigational warning

RA85
MONSANTORADIO
092119 UTC APR 13
NAV. WARNING NO 835/13
PORTUGAL-CONTINENTAL PORTUGAL-
WEST COAST-FIGUEIRA DA FOZ
HARBOUR ENTRANCE CLOSED TO
VESSELS UNDER 35 METRES LENGTH
NAVIGATIONAL WARNING NO 834/13
CANCELLED
NNNN

Cancel date: 11-Apr-2013

On the MERI TUULI, it was reportedly common practise to start the NAVTEX receiver during the voyage, so that only current reports are generated and long repetitions prevented. However, the report on the closure of the port was not seen on board. The filter set on the receiver to limit the data is not known.

The AIS (Universal Shipborne Automatic Identification System) is used by ships to acquire the identity, current voyage data and manoeuvring of other ships also equipped with this system. The Class B AIS on the MERI TUULI is switched on together with the navigation equipment. The MMSI No / Name of ship / Call sign / Type of ship / Position of GPS antenna / Position of ship / SOG (speed over ground) / COG (course over ground) / UTC date and time / GPS antenna type / PA (position accuracy) are transmitted.

[7] NAVTEX provides shipping with navigational and meteorological warnings, meteorological forecasts, as well as other urgent information. The warnings are made for all ships via an automated display or printout from a dedicated receiver. NAVTEX transmissions have an intended maximum range of about 400 nautical miles. The NAVTEX manual (official notice of the Ship Safety Division (BG Verkehr)) recommends that receivers be switched on no later than 12 hours before departure or preferably at all times. The memory, which cannot be erased by the user, is designed for at least 200 reports with an average length of 500 characters. The oldest must be overwritten by the new report when the memory is full.

The transmitting power is two watts. The MERI TUULI's AIS data were not recorded by any port authority.

Nautical charts and sailing directions

According to the MERI TUULI's carriage list, Navionics electronic charts operated with a nautical chart plotter and on-board computer with navigation software from Fugawi, as well as small craft charts from Imray for the west coast of the Iberian Peninsula were on board. The extended northern jetty at Figueira da Foz was already plotted on the electronic nautical chart. The track of the MERI TUULI is also shown at intervals of 1 nm. The plot finishes about 1 nm south-west of the plotted pilot transfer point. There was a fault after that. Presumably, the GPS antenna was damaged. Therefore, the plot is incomplete.

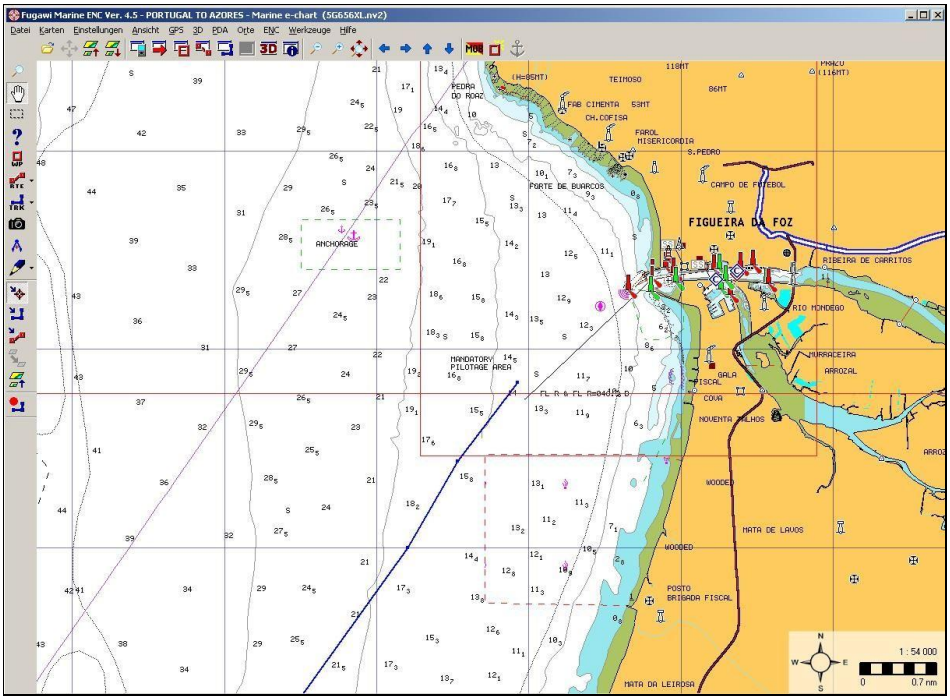


Fig. 18: Plot of Fugawi-Navionics nautical chart

The extended jetty was not plotted on the Imray C49 chart, edition: 2005, reference system: WGS 84, scale: 1:350000 with the port map for Figueira da Foz, scale: 1:15000. The depth areas at the entrance differ from those in the official British Nautical Chart 3228. Here, only the 10 and 5 m contours are plotted in the area of the entrance without bar. The latest edition of C49 dates back to March 2012. The survey for the official Figueira da Foz nautical chart is from the year 2005 (reference system: ED 50). The GPS receiver would have to be set to ED 50 or the position adjusted to WGS 84 (0.07' south and 0.09' west in this case). The lighthouses at the entrance are faint on the aerial photo. The Santa Catarina signal mast is not visible.

The northerly lighthouse on the jetty is incorrectly plotted in Reeds Nautical Almanac 2013 (see Fig. 2) and the charted depths correspond with the Imray chart (Edition 2005).

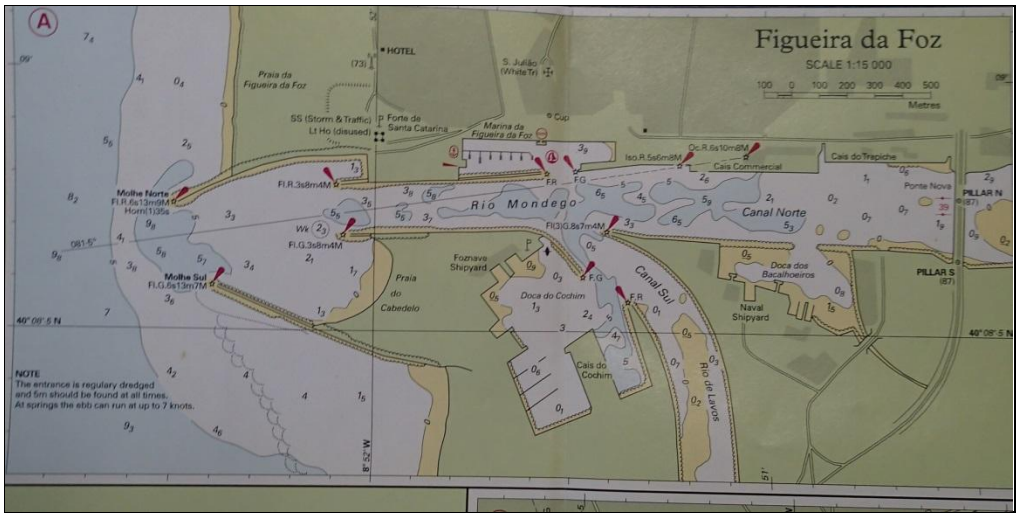


Fig. 19: Copyright: Imray Nautical Chart C49, 2005, Edition 2005

Fig. 20: Copyright: portugalfotografiaaerea.blogspot.com

Lifejackets

The inflatable lifejackets used on the MERI TUULI had a volume of buoyancy of 275 newton and were also equipped with spray hood and crotch strap.

The abdominal belt has a D-ring to the left and right of the buckle. A lifeline to the craft with shock absorbers (fall arrest line) was not on board. This would soften the load during a fall to about 6 kN for the person and the energy induced by the fall is converted into a plastic deformation in the fall arrest line. It is unclear how the lifejackets were donned by the crew and how they were secured to the craft. One crew member suffered a shoulder fracture, the others who fell overboard bruises.

Fig. 21: 275 newton lifejacket

Fig. 22: Spray hood

Fig. 23: Crotch strap

Fig. 24: Tattered lifejacket

A breaking load test by the manufacturer revealed that the damage at the torn seams occurred at a force of 3.21 kN (327 kg) if only one D-ring was connected with the lifeline. If two D-rings were connected, then the chest strap would not tear until 11kN (1,120 kg).

Sailing school, Nordtoern & Well Sailing

The sailing school has now existed for 20 years. During this period, it has built up a reputation due to training sailing students and skippers, as well as its practical ISAF safety training courses[8] and lectures on emergency situations and medical assistance, in particular. Man overboard manoeuvres with rescue slings and recovery nets, projects like SARRRAH[9] (careful horizontal recovery and treatment of hypothermic people for better chances of survival), and sailing trips with experienced skippers are among the range of services. In the process, the sailing school does not just assess the knowledge necessary for recreational craft licence tests gained within the school environment, but also places special emphasis on practical exercises and new methods, such as PSOOBAK.[10]

Stability and capsizing

The BSU assesses the MERI TUULI's range of stability to be up to 120° during the accident. This assessment is based on a stability calculation for X-442 yachts, which shows righting levers up to 115° in the case of a hull without superstructure and equipment. The maximum righting levers are in the area of 40° to 60° in this case. The range of stability would increase because of the superstructure and decrease again because of the sails (roller-furling foresail). An inclining test was dispensed with because the range of stability would be within the range estimated by the BSU.

The risk of recreational yachts capsizing[11] due to crossing waves that are steep, high or breaking is high. Inasmuch, breaking waves should be avoided and the wave pattern continuously monitored. If the wave height is 55% of the hull length, about 7.5 m in the case of the MERI TUULI, then they could not withstand capsizing for a sustained period. If the wave height is 35% of the hull length, about 4.5 m in the case of the MERI TUULI, then all recreational yachts would heel to 130°. These rules of thumb determined by the Wolfson Unit at the University of Southampton using model tests are good guidelines.

[8] International Sailing Federation. It recommends that skippers and sailors attend certified courses for man overboard manoeuvres, search and rescue, assistance in a distress situation, hypothermia, SAR procedures, weather forecasts, liferaft and lifejackets, fire prevention and firefighting, use of fire extinguishers and fire blankets, cardiovascular resuscitation and primary care, communication equipment (VHF and GMDSS), pyrotechnic distress signals and distress radio beacons/EPIRBs, care and maintenance of safety equipment, storm sail, leak prevention, damage control and repair, as well as heavy weather and sea anchor every five years.

[9] Search and Rescue, Resuscitation and Rewarming in Accidental Hypothermia, www.sarrrah.de

[10] PSOOBAK comes from the aviation sector and is a method of solving dangerous situations jointly. It is a German abbreviation, which translated into English stands for understand problem, immediate action, gather options, assess options, decision making, execute, control. In practise, it means that the skipper does not make decisions autonomously, but performs a risk assessment with the involvement of the crew, which leads to a decision.

[11] Capsize is understood to mean a heel of 90°.

It must be remembered that recreational yachts are not designed as self-righting craft, meaning they would drift in an inverted position when capsizing. Moreover, the shape of the keel must be considered in waves that are steep for a sustained period. Model tests have shown that on a wave slope steering and controlling full keel shapes is more stable than fin keel shapes.[12] It is easier to keep the sea abaft the beam. As soon as the course bears away, the hull turns broadside to the breaking wave.

The BSU does not believe the MERI TUULI rolled over[13], as indicated by Portugal's GPIAM investigation report. The crew spoke of a 2-2.5 and 5-6 m, respectively, steep aft wave that broke over the craft. It is likely that the mast broke in the process and remained lying on the port side. The MERI TUULI did not necessarily heel over onto her side, nor did her mast necessarily reach into the water, in the process. The high roll moments and the wave breaking over them were the cause of the four crew members washed overboard. Thereby a crew member had broken an arm at the winch, and the mast and the railing with bathing ladder were damaged. The crew member who remained on board was permanently connected with a lifeline and the craft.

[12] See 'An Investigation into the Stability of Sailing Yachts in Large Breaking Waves', A. Claughton, P. Handley, January 1984, University of Southampton, Department of Ship Science, Faculty of Engineering and Applied Science

[13] Roll over is understood to be a heel to 180° (inverted). Unlike the design of a self-righting craft, such as many search and rescue vessels, a sailing yacht does not have to right herself.

5 CONCLUSIONS

At 0830 on 10 April 2013, the X-Yachts 442 German training craft, Sailing Yacht MERI TUULI, sailed out of Peniche in Portugal with five crew members. Her destination was Figueira da Foz. The distance and speed calculated for the voyage were 55 nm and 8 kts respectively with south-westerly winds of 5-6, later 7 Bft and a north-westerly swell of 3-4 m, meaning the time of arrival would have been at about 1630 in the afternoon in high tide. The MERI TUULI did not reach her berth in the port of destination. After the sails were struck, she abruptly heeled south-west of the northern jetty because of aft groundswell, probably to port, on the 10 m line at 1641. The mast broke, remained lying on deck on the port side, and four crew members fell overboard in the process. A police officer in a semi-rigid inflatable dinghy, which capsized, and a crew member of the MERI TUULI drowned during the rescue operation. The port was closed to vessels of less than 35 m.

The Portuguese investigation authority, GPIAM, had already investigated the marine casualty and published its report. Questions regarding the course of the accident remained open, however. Consequently, the BSU prepared its own investigation report. The gpiam report indicates that the yacht capsized and the mast touched the bottom. This statement is unlikely. The mast was broken and remained lying on the port side of the deck. According to the crew, the wave came from aft. After striking the sails, the crew intended to first pass the port entrance, assess the situation, and position the vessel with the sea approaching from aft in the event of entering.

The BSU believes that the accident was caused by the MERI TUULI broaching to the starboard side with aft breaking steep sea, which washed over the craft. At the same time, the groundswell caused by the swell and the chaotic crossing sea resulted in a steep 5-6 m-high wave, which rendered the rudder ineffective and led to strong roll moments, probably to the port side. The mast probably struck the surface of the water and broke (knockdown). The hull's range of stability of 115° allowed the MERI TUULI to right herself unaided and she drifted towards the beach because the screw was blocked. The exact scene of the accident could not be determined because AIS signals are not officially recorded by Figueira da Foz. According to witness statements, it is likely that the scene was about 100-200 m away from the northern jetty. The final nautical mile was not recorded on the electronic nautical chart plotter because of damage to the GPS antenna. Since the rigging was completely replaced about a year ago and at 1-2% elongation, the cables could not have been fully stretched yet, the mast possibly broke due to loose shrouds or a construction of the manufacturer that might be too weak[14] On the other hand, the shroud loads are calculated and specified by the mast manufacturer based on the rules for construction. The heeling moments of the hull are taken into account in the process. Possible forces when the mast strikes the water surface are not considered.

[14] According to statements made the MERI TUULI was said to have been overhauled and maintained extensively in a ship yard on Gran Canaria about 3 weeks before to the accident. The shrouds were reportedly under tension and were secured by split pins and adhesive tape. The rig was reportedly checked by the skipper prior to the voyage.

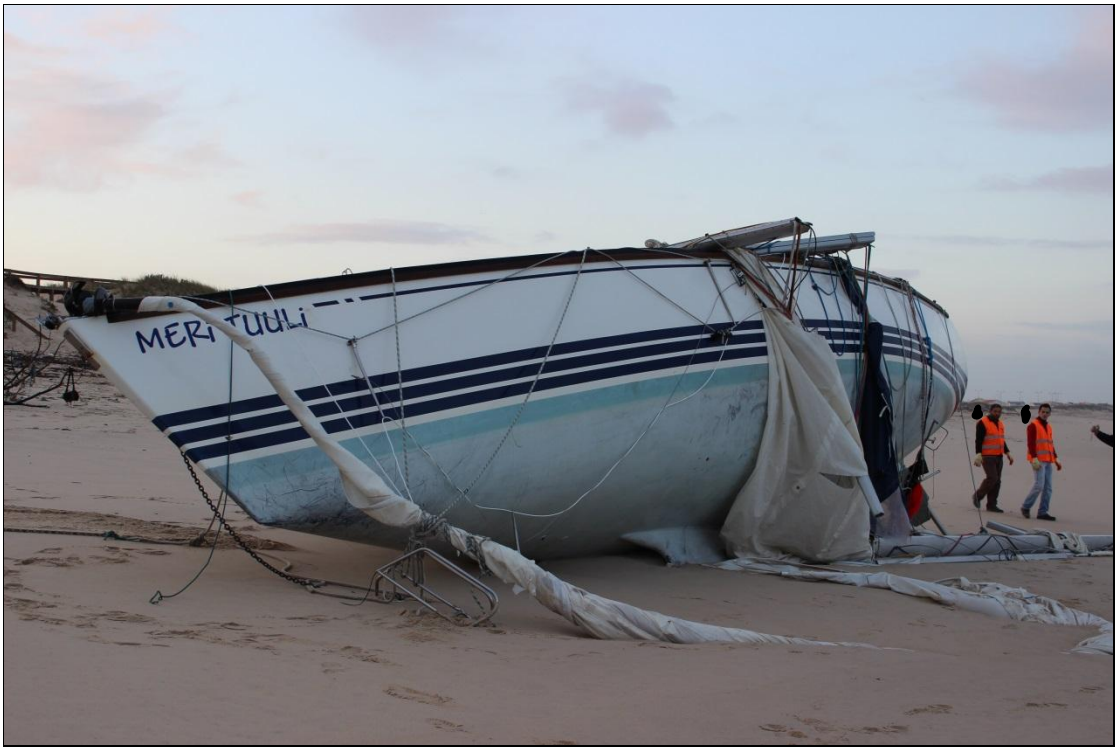


Fig. 25: Broken mast and railing

The rescue operation was initiated as a result of the red paraflare being fired and transmission of a mayday relay message by the craft sailing with the MERI TUULI, the TIME BANDIT. The MERI TUULI was already in the surf zone between the southern jetty and Praia do Cabedelo beach when the rescue cruiser PATRAO MOISES MACATRAO and the police boat PAPA NOS reached the scene of the accident. The PAPA NOS exposed herself to danger with three police officers and two survivors from the MERI TUULI on board in the process. Due to the shallow water and breaking waves, the PATRAO MOISES MACATRAO could no longer intervene without capsizing.

During the rescue, the inflated lifejackets impeded the survivors from the MERI TUULI. 257N jackets with spray hood were found, some of which had been removed and were tattered. It is possible that 150N jackets would have been easier to handle. It was not possible to climb the craft's stern ladder when they were inflated. Moreover, in the cockpit the skipper helped to release twisting and constriction at the neck of a sailor caused by the pressure of the lifejacket. The crotch strap also proved obstructive for one crew member. The designers of the lifejacket attempted to combine the function of a fall arrest belt with that of an inflatable lifejacket. The effect of this was the removal of the lifejacket by some crew members during the rescue and tragic death of a crew member. For unknown reasons, the inflatable lifejacket of the fatally injured police officer did not inflate. In the case of the lifteraft having not inflated, which drifted off, a mistake occurred in that attention was not paid to the fact that the release cord was no longer fixed to the craft because of the destroyed railing.

The decision to call at the port of Figueira da Foz was taken about 2 nm off the entrance. The crew was not aware of the information concerning the closure of the port, even though it was broadcast via NAVTEX and the receiver was on. It is likely that the message was lost among the many reports. The VHF calls made to obtain information on the port went unanswered. In some cases, the MERI TUULI called stations in Figueira da Foz incorrectly due to wrong information in the sailing directions on board. The TIME BANDIT, which was sailing with the MERI TUULI, called on VHF channel 14 shortly before the accident and was advised the port was closed to vessels of less than 35 m (probably by the pilot). Moreover, the Santa Catarina signal mast, which signalled the closure, was not visible from the sea with binoculars. It is located in the inner harbour entrance. Moreover, the BSU could not make it out even from the opposite southern jetty. Inasmuch, its value tends to be more tourism-related/historical.

Fig. 26: Outer southern jetty, focal distance = 25 mm

Fig. 27: Outer southern jetty, focal distance = 100 mm

Fig. 28: Santa Catarina signal station

The signal mast with the day signals of 50 cm in diameter is invisible outside the outer, recently completed jetties, from the sea.

The team management system for solving hazardous situations jointly by consulting practised in the sailing school (PSOOBAK) was not applied when it came to deciding to call at the port. It was a tacit decision made by the skipper. However, it must have been clear to everyone that Figueira da Foz would be called at after the sails were struck and safety briefing at the latest. It remains unclear why the direct route into the port entrance with mainsail was not taken. Striking the sails before the port entrance was probably a matter of habit. In this situation, the sea should have been observed more closely and the risk of striking the mainsail in erratic weather not taken, however[15]

[15] Note Co-sailor: Yes, we would have also sailed into the outer port of a port known to us, which is never closed. However, I consider sailing downwind into a port, which is allegedly dangerous and possibly closed, at least precarious. In case of imminent danger or closure of the port one would have to sail out of the port against the wind. The crew hadn't recognized the navigation marks for closing or non-closing the port even though a sharp lookout was kept before reaching the port entrance. We were not aware of the risk associated with a port closure. The light sea and wind conditions perceived by us suggested that the port could be opened. Therefore it was a matter of carefully approaching the port in order to recognize the possible dangers and the navigation marks having searched for in time. We sailed for 7 hours relaxed and dry. There was no wave exceeding 2.5 m in height in front of the port. The sails could be struck without any problems. That's why everyone looked ahead and nobody behind. The wave was unique and came out of the blue. Unfortunately we sailed very slow with a speed of 1 or 2 kts, when this "monster" struck. We possibly could have ridden the wave out with a speed of 5 or 6 kts. I don't hold against anybody if he or she cannot imagine this unique monster wave. I couldn't either at that time.

In addition to personal protective equipment and donned inflatable lifejackets, all crew members in the cockpit should attach themselves to the craft with a lifeline during the approach. It seems that this only happened properly once because four fell overboard during the knockdown. In the process, there was one casualty with a fractured shoulder. However, it is important to remember that during such roll moments a shock absorber woven into the lifeline would protect against supposed injuries if one's own body fell into the line. Such accidents would also lead to injuries.

It was not possible to determine reliably what sort of lifelines were used and how they were put on.

The Imray Nautical Chart C49 seized by the port authority in Figueira da Foz was from 2005 and revised by continuation sheets. However, the chart was replaced by a new issue in March 2012. The now extended northern jetty is not plotted in the old issue and the charted depths are different to those in the official nautical charts. The extended northern jetty is already plotted in the Reeds Nautical Almanac 2013; however, the beacon is in the wrong position and the charted depths correspond with the Imray chart from 2005. The Santa Catarina signal mast is plotted in both publications. In Reeds, the VHF calls for Figueira da Foz are specified incorrectly or insufficiently. There are the stations with the calls 'Marina da Figueira da Foz' VHF 8, 16, 'Figueira da Foz Pilots (Practicos)' VHF 14, 16, 'Capimarfoz' VHF 8, 16, and 'Polimarfoz' VHF 11, 16. The last two stations refer to the harbour master and the police station, which are in the same building. There is evidence to show that the MERI TUULI called Capimarfoz three times on channel 16 without getting a response. The marina did not have a permanent listening watch. A last ditch attempt by the MERI TUULI would have been calling the pilots on channel 14 or 16. These frequencies are not specified in the Reeds that was used. However, Reeds states in the foreword on page three that the information in the book is not verified by a hydrographic service and liability for errors cannot be accepted. The natural conditions and port signals are only referenced briefly in the voyage information for the Portuguese coast. Other sailing directions, such as the officially available Spanish sailing directions Derrotero de las Costas de Portugal y SW de Espana, or the local Portuguese port requirements like EDITAL N.º 01/2013 INSTRUÇÕES PARA A NAVEGAÇÃO E PERMANÊNCIA NO ESPAÇO DE JURISDIÇÃO MARÍTIMA DA CAPITANIA DO PORTO DA FIGUEIRA DA FOZ were additional sources, which are available in the maritime library of the BSH, for example. The Navionics electronic nautical chart used was up to date.

The crew of the MERI TUULI was experienced and well prepared for the voyage. Even though the NAVTEX report concerning the port closure was overlooked, it cannot be assumed that the approach would have been easier at an alternative port. It is possible that a knockdown would have occurred then, too. The decision to call at Iberian ports in difficult sea conditions can only be made at the scene, and preferably together. Ultimately, none of the crew was resolute in expressing concerns. If possible, rather than entering the breaking sea – only then is the risk of capsizing heightened – attempts should have been made to ride out the waves. A direct and resolute approach towards the port entrance under sail while observing the waves would have simplified the situation. The plan to enter at high tide (1602) was a wise choice because very strong currents can prevail in the immediate vicinity of the entrance (up to 3 kts in south-westerly winds). The currents are volatile, marked by the wind, and move in a southerly direction with just little wind (see Spanish sailing directions). The ebb current can reach 7 kts after heavy rainfall.

6 SAFETY RECOMMENDATIONS

6.1 Owner and operator of the MERI TUULI

The BSU recommends that the sailing school inspect and possibly improve the life-saving appliances on its recreational craft, in respect of their adequacy on international voyages on the Atlantic, in particular. Based on the area of operation (high seas, coastal waters or sheltered waters), it is important to ensure that the equipment is arranged so that the risk of falling overboard is reduced as far as possible and reboarding is facilitated. In this context, it is important to assess whether on sailing craft smaller lifejackets are more suitable than multi-purpose jackets with greater buoyancy. With regard to lifelines, based on the challenges of the area of operation an assessment must be made as to whether a fall arrest system with crotch strap and shock absorber, which is separate from the lifejacket, should be provided and anchoring points appropriate for reducing the risk of injury during high roll moments are available on the craft.

Current and revised nautical charts must be available on board for the voyage.

6.2 Skipper of the MERI TUULI

In addition to the individual responsibility of each crew member, the skipper is required to verify the proper application of personal safety equipment and draw attention to risks. It is helpful to discuss situations together and define a strategy. The risk of recreational yachts capsizing due to crossing waves that are steep, high or breaking is high. Inasmuch, breaking waves should be avoided and the wave pattern continuously monitored.

Sailing directions from several sources should be used for voyage planning in foreign and unknown waters. The Federal Maritime and Hydrographic Agency keeps a wide variety of maritime literature in its library for that purpose.

The NAVTEX receiver should be set so that clarity is not lost and relevant messages are sorted.

In radio traffic, it may be easier to obtain port-related information if calls are more general, e.g. to all stations, or possibly to contact the harbour pilots and emphasise the purpose of the call in the process.

It is important to ensure that paper nautical charts are up to date in addition to the electronic nautical charts.

The ship's equipment, especially the navigation and radio equipment, the running and standing rigging (shrouds), as well as the engine and sails, must be checked before starting a voyage.

Prior to port entrances affected by high swell waves and depending on the weather situation, an assessment should be made as to whether a direct approach under sail into the area protected by jetties would be more favourable than first striking the sails and being exposed to rough sea.

7 SOURCES

- Investigations by the waterway police (WSPK1 Hamburg), access to records and request for assistance, public prosecutor's office in Hamburg

- Investigations by the Ministerio da Defesa Nacional Marinha – Autoridade Maritima Nacional, Comando Local da Policia Maritima Figueira da Foz

- Investigations by the German Embassy in Lisbon

- Investigation report: Acidente com o veleiro MERI TUULI, 10 April 2013, Gabinete de Prevencao e de Investigacao de Acidentes Maritimos (GPIAM)

- Statements by the BSU in Figueira da Foz together with the GPIAM

- Written statements
  - Crew
  - Sailing school
  - X-Yachts Germany
  - Hamburg-Harburg University of Technology

- Witness accounts

- Reports and technical paper
  - Sailing school, Nordtoern & Well Sailing, Hamburg

- Sailing directions, library, Federal Maritime and Hydrographic Agency (BSH)

- Official weather report by Germany's National Meteorological Service (DWD)

- Radar recordings of VTS Lisbon

- Photos by the port police at Figueira da Foz, the sailing school Nordtoern & Well Sailing, the crew, and the BSU