ACCIDENT REPORT

Report on the investigation of

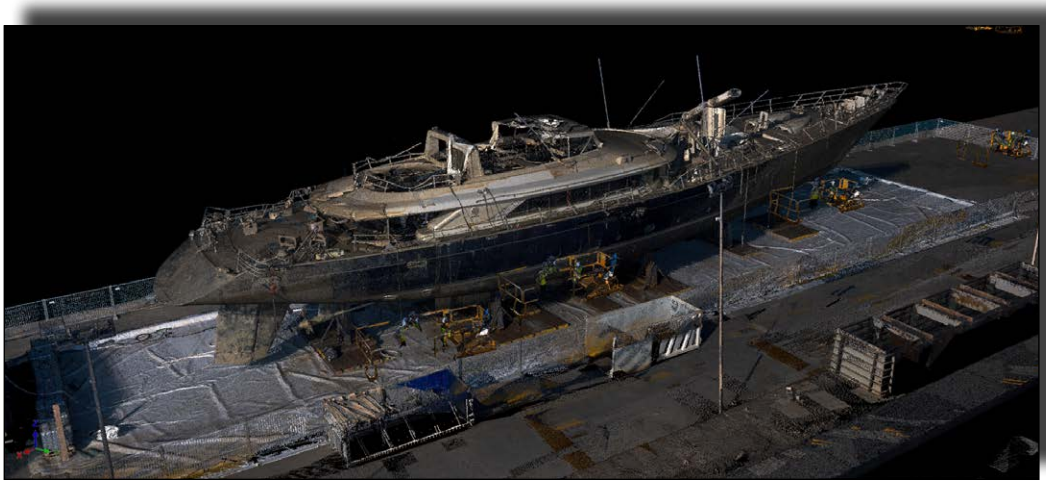
the foundering of the sailing yacht

Bayesian

with the loss of seven lives

0.5 nautical miles south-east of Porticello, Italy

on 19 August 2024



MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

VERY SERIOUS MARINE CASUALTY REPORT NO 22/2026 NOVEMBER 2026

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2026 – Regulation 5:

The sole objective of a safety investigation into an accident under these Regulations is the prevention of future accidents through the ascertainment of its causes and circumstances. It is not the purpose of such an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame.

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 19(1) of The Merchant Shipping (Accident Reporting and Investigation) Regulations 2026, shall be inadmissible in any judicial proceedings concerning liability unless the Chief Inspector of Marine Accidents or a court of law determine otherwise.

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Annex C MAIB interim report on the investigation into the foundering of *Bayesian*, issued May 2025

Annex D: MAIB safety flyer to the yachting industry

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AWA	-	apparent wind angle
BAC	-	blood alcohol concentration
C/E	-	chief engineer
C/O	-	chief officer
CAPE	-	convective available potential energy
CNI	-	Camper and Nicholsons International Limited
CNMCA	-	Centro Nazionale di Meteorologia e Climatologia Aerospaziale
CS	-	chief steward
EPIRB	-	emergency position-indicating radio beacon
GMAS	-	global multi-hazard alert system
gt	-	gross tonnage
GZ	-	righting lever
hPa	-	hectopascal
HRU	-	hydrostatic release unit
ICLL	-	International Convention on Load Lines, 1966
IMO	-	International Maritime Organization
ISM Code	-	International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention
J/kg	-	joules per kilogram
kts	-	knots
kW	-	kilowatt
LY1	-	Code of Practice for the Safety of Large Commercial Sailing and Motor Vessels
LY2	-	MSN 1792 (M) – The Large Commercial Yacht Code (LY2)
LY3	-	MSN 1851 (M) – The Large Commercial Yacht Code (LY3)
MCA	-	Maritime and Coastguard Agency
MetArea	-	meteorological area
mg/dL	-	milligrams per decilitre
MGN	-	Marine Guidance Note
MSN	-	Merchant Shipping Notice
MUCAPE	-	most unstable convective available potential energy

nm	-	nautical mile
NP45	-	Admiralty Sailing Directions – Mediterranean Pilot Volume 1
NP100	-	Admiralty – The Mariner's Handbook
NTSB	-	National Transportation Safety Board
REG	-	Red Ensign Group
SIB	-	stability information booklet
STCW	-	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended
SWIC	-	Severe Weather Information Centre
t	-	tonne
TSB	-	Transportation Safety Board of Canada
UKHO	-	UK Hydrographic Office
UNDRR	-	United Nations Office for Disaster Risk Reduction
UTC	-	universal time coordinated
WMO	-	World Meteorological Organization
WWMIWS	-	Worldwide Met-Ocean Information and Warning Service

TIMES: all times used in this report are UTC +2 unless otherwise stated.

SYNOPSIS



At 0406 on 19 August 2024, the private sailing yacht *Bayesian* was at anchor 0.5 nautical miles south-east of Porticello, Italy. A violent downburst of hurricane-force winds knocked the vessel onto its starboard side. Unable to right itself, *Bayesian* flooded and sank in 50m of water.

Six guests and nine crew members escaped the vessel as it foundered. Six guests and one crew member died in the accident. None of the liferafts on board automatically inflated or released from the vessel, requiring the crew to do so manually. The crew organised the survivors in the water and assisted them into a liferaft. They were later rescued by a nearby vessel and then taken ashore.

The investigation found that, with no sails set, *Bayesian*'s windage and stability characteristics left it vulnerable to knockdown in severe winds. This vulnerability was affected by its loading condition, apparent wind angle and the position of the centreboard, but had not been identified in the originally approved stability information available to the crew.

Information contained in guidance provided to mariners did not provide sufficient detail of the impact of possible weather conditions to support decision-making. The weather forecast for the area, while predominantly correct, did not indicate the risk of downbursts from the thunderstorms predicted.

Following the accident the MAIB published an interim report and has prepared a paper to submit to the International Maritime Organization to highlight the investigation findings.

Recommendations have been made to the Red Ensign Group to undertake a study of the vulnerabilities identified in this report and amend the Red Ensign Group Yacht Code and associated guidance to account for its findings.

The Maritime and Coastguard Agency has been recommended to amend its training syllabus for yacht masters to include the risks from downbursts and severe wind gusts.

A recommendation has also been made to the UK Met Office to raise with the World Meteorological Organization the need to consider how low likelihood, high impact weather hazards should be represented in its data services.

Lastly a recommendation has been made to the UK Hydrographic Office to develop and update guidance on the risks of such extreme weather in its publications.

SECTION 1 – FACTUAL INFORMATION

1.1 PARTICULARS OF *BAYESIAN* AND ACCIDENT

VESSEL PARTICULARS	
Vessel's name	*Bayesian*
Flag	UK
Classification society	American Bureau of Shipping
IMO number/fishing numbers	9503392
Type	Private sailing yacht
Registered owner	Revtom Limited
Manager(s)	Camper and Nicholsons International Limited
Construction	Aluminium Alloy
Year of build	2008
Length overall	55.9m
Registered length	49.7m
Gross tonnage	473
Minimum safe manning	Not applicable
Authorised cargo	Not applicable

VOYAGE PARTICULARS	
Port of departure	Milazzo, Italy
Port of arrival	Naples, Italy (intended)
Type of voyage	International
Cargo information	Not applicable
Manning	10

MARINE CASUALTY INFORMATION	
Date and time	19 August 2024 at 0406
Type of marine casualty or incident	Very Serious Marine Casualty
Location of incident	38°05.00'N 013°33.10'E 0.5nm south-east of Porticello, Italy
Place on board	Not applicable
Injuries/fatalities	7 fatalities, minor injuries to passengers and crew
Damage/environmental impact	Vessel loss, negligible pollution
Vessel operation	At anchor
Voyage segment	Anchored
External & internal environment	Sudden, severe winds associated with a downburst within a general background of thunderstorms and Beaufort force 3 to 5 north-westerly winds with gusts up to force 6; sea smooth to slight.
Persons on board	22

1.2 BACKGROUND

Bayesian **(Figure 1)** was a 55.9m monohull sloop[1] with a beam of 11.5m and a hollow aluminium mast that stood 72.25m above the waterline. The yacht **(Figure 2)** had three decks and a flying bridge with guest and crew cabins below the main deck. The yacht's machinery spaces, service and crew areas were located forward and aft of the guest cabins. Internal access routes led up through the saloon, wheelhouse and flying bridge. *Bayesian* had a hydraulic retractable centreboard.

Bayesian was operated as a private pleasure vessel. It regularly spent summers cruising in the Mediterranean Sea.

Image from Attilio Taranto (MarineTraffic)



Figure 1: *Bayesian*

[1] A sailing yacht with a single mast and sails rigged forward to aft.

Base image from Perini Navi S.p.A.

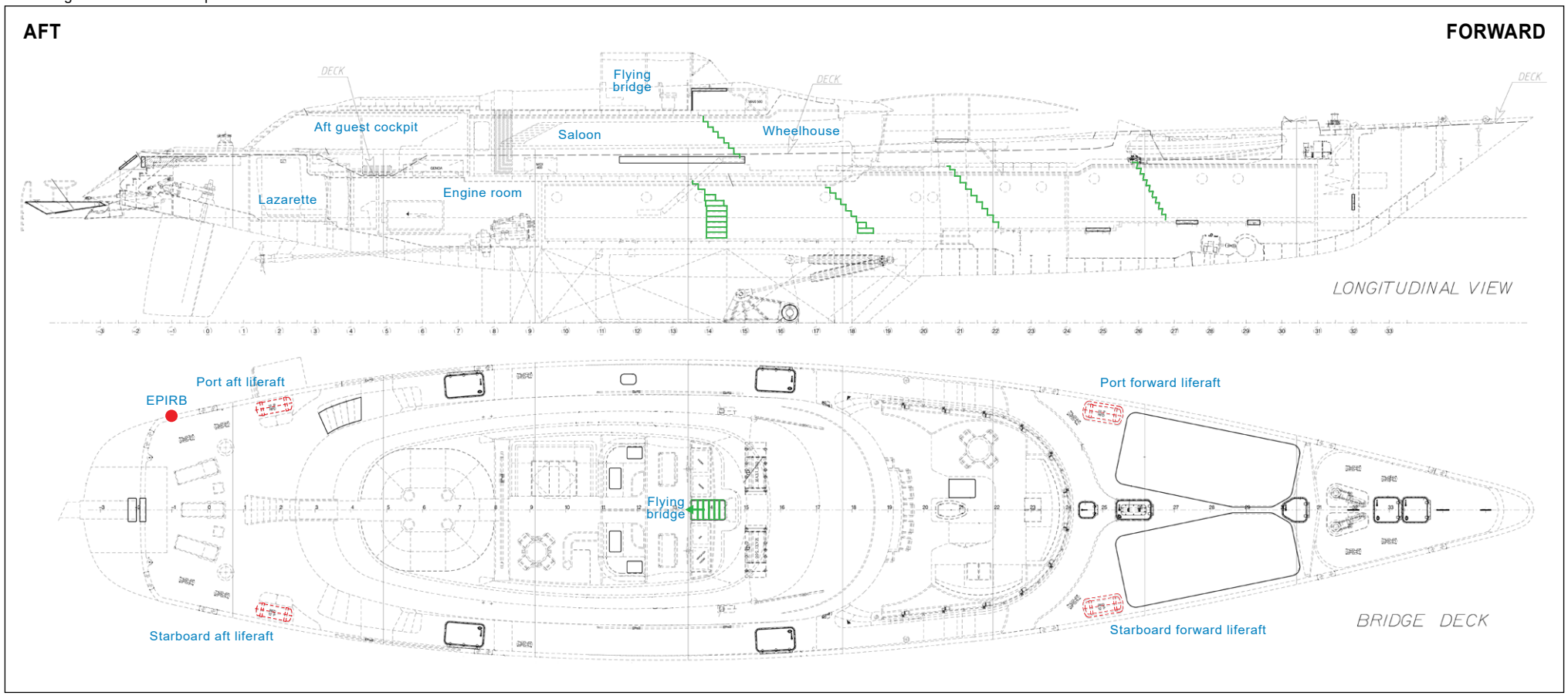


Figure 2: *Bayesian* general arrangement

Base image from Perini Navi S.p.A.



Figure 2: *Bayesian* general arrangement

1.3 INVESTIGATION SCOPE

Following the accident the Italian public prosecutor launched a criminal investigation in Termini Imerese, Sicily. Consequently, MAIB access to some witnesses and to evidence held by the public prosecutor was restricted. It is possible that the circumstances depicted in this report may alter following disclosure of evidence withheld by the Italian authorities.

This report does not examine the Italian authorities' search and rescue response or the circumstances surrounding the death of a diver during the operation to salvage *Bayesian*.

1.4 NARRATIVE

On 14 August 2024, *Bayesian* sailed from the port of Milazzo, Italy for an excursion around the Aeolian Islands and the north coast of Sicily. There were 12 guests and 10 crew on board. The intention was to disembark the guests on 19 August before proceeding to Naples for maintenance. On the morning of 18 August, *Bayesian* was anchored at Cefalù, northern Sicily.

With the weather forecast indicating an increasing westerly wind, the master decided to motor towards Porticello, 25 nautical miles (nm) to the west, and anchor overnight. The anchorage at Porticello afforded shelter from the forecast winds and allowed for easy disembarkation of guests the following day. At 2124, *Bayesian* anchored to the east of the main breakwater. Its centreboard was raised. The sailing vessel *Sir Robert Baden Powell*[2] was also at anchor close by.

Thunderstorms had been forecast, and occasional flashes of lightning to the west were seen from on board. The master checked the latest weather forecast and retired for the night, leaving instructions for the overnight watchkeepers (deckhands DH1 and DH2) to wake them if the wind increased above 20 knots (kts) or if there were signs that the anchor was dragging. DH1 and the evening steward (S1) were on duty.

By 0030 on 19 August 2024, the last guest had gone to bed. At 0100, DH2 took over the watch from DH1. The wind was noted as being no more than 8kts and there were no indications that *Bayesian* was dragging its anchor.

1.4.1 The accident

At 0300, DH2 noted that the wind was still 8kts from the west but thought that thunderclouds and lightning visible in the distance seemed to be getting closer. At about 0330, two of the guests (G1 and G2) woke but remained resting in their cabin.

At about 0330, the master of *Sir Robert Baden Powell* went on deck to oversee the transfer of guests ashore in the vessel's tender. Seeing the approaching thunderstorms, the master decided to delay disembarking their guests and ready the engine for manoeuvring.

On board *Bayesian*, DH2 also noted the advancing thunderstorm and checked the weather forecast on their personal device before videoing it. At 0344, they posted the video on social media. They then went on deck and closed three hatches on the

[2] A 42m length overall sailing vessel, with a mean draught of 2.25m and a mast height 30.6m above waterline.

forward deck and the cockpit windows to protect the yacht's interior from the rain that had started falling. On their return to the wheelhouse, they made an entry in the log book indicating the wind speed was 8kts.

At 0352, the master of *Sir Robert Baden Powell* photographed *Bayesian* at anchor **(Figure 3)**.

Image from Captain Karsten Börner, master of *Sir Robert Baden Powell*



Figure 3: *Bayesian* at anchor off Porticello at 0352 on 19 August 2024

At about 0355, DH2 noted that the wind had rapidly picked up to 30kts and was broad on the port bow. Two minutes later both *Bayesian* and *Sir Robert Baden Powell* began to drag their anchors. *Bayesian* started listing to starboard, reaching between 10° and 20°.

At about 0400, DH2 went below and woke the master. Together they returned to the flying bridge. Around the same time, the chief engineer (C/E) woke up. Having experienced bad weather at anchor before, and recognising there may be a need to manoeuvre *Bayesian*, the C/E went to the engine control room to prepare the yacht for manoeuvring. The C/E then went to the wheelhouse and started the steering pumps and controllable pitch propellers' hydraulic pumps. The shutters for engine room ventilation and valves in the engine exhaust systems were open.

The rest of *Bayesian*'s crew had been woken by the yacht's change of motion. The master noted that *Bayesian* was moving south-south-east, at an increasing speed, towards land around 5nm away. The owner, who had also woken, spoke briefly with their husband before brushing their teeth and leaving their cabin to see if taxis arranged for 0800 would have to be cancelled due to the weather.

The chief steward (CS) tidied away loose items in the crew mess then went to the upper deck to secure other items. The chief officer (C/O) went to the flying bridge, where the master told them to ensure the rest of the crew were awake as the anchor was dragging. Returning below, the C/O asked the bosun and DH1 to secure any loose items and stand by for further orders. The chef was in the galley stowing equipment and greeted the C/O and the stewards as they passed.

Two of the guests on *Bayesian* (G3 and G4) had been woken when the yacht took on the list and went to the saloon with their baby (G5).

Bayesian was lying with the wind about 60° off its port bow and moving south-south-east of its original position **(Figure 4)**. *Sir Robert Baden Powell* was also dragging its anchor at a similar rate and in the same general direction.

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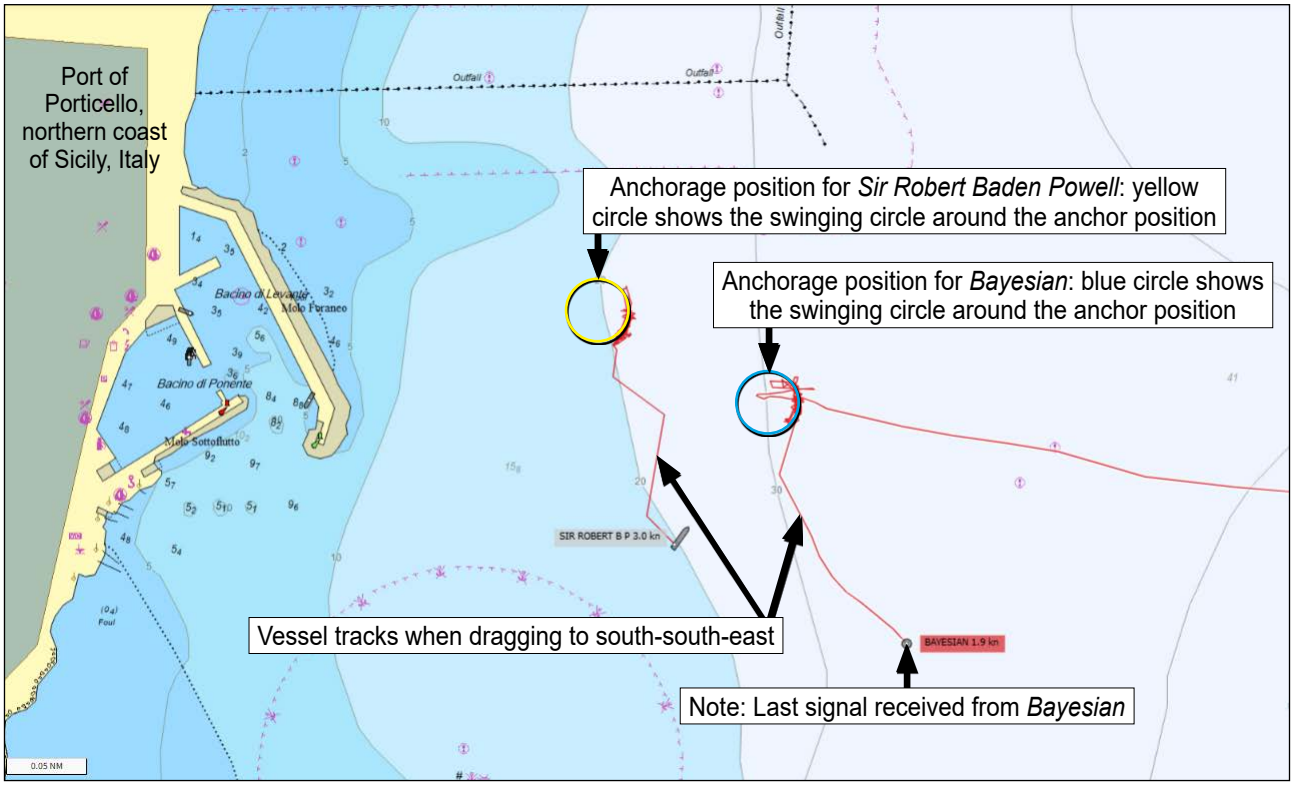


Figure 4: Automatic identification system track of *Bayesian* dragging anchor at 0405 on 19 August 2024

The C/O returned to the flying bridge and briefed the master on the crew activities. The master then told the C/O to check if the C/E had started the engines and pumps so that they could manoeuvre *Bayesian* into the wind. The C/O descended to the wheelhouse, where the C/E informed them that *Bayesian* was ready to manoeuvre. The C/O shouted up to the flying bridge to let the master know.

The owner, G3, and G4 (carrying G5) arrived in the saloon as the rain-soaked CS came in from the upper deck with items they wanted to protect from the rain and strengthening wind.

As the master prepared to manoeuvre *Bayesian*, the wind suddenly increased to about 70kts. The awning over the flying bridge ripped from port to starboard. At 0406, *Bayesian* violently heeled over 90° to starboard, taking less than 15 seconds to do so. People, furniture and loose items fell across the deck. The generators shut down immediately and battery-supplied emergency lighting automatically turned on.

The master, G4, owner, bosun and steward 2 (S2) were all injured, either by falling, or from items falling on them as *Bayesian* rolled onto its side. DH2 had been thrown into the sea from their position on the flying bridge and climbed back on board.

In their cabin, guests G1 and G2 used the furniture drawers as an improvised ladder to exit into the central alleyway. They climbed along the internal walls, making their way up the staircase into the saloon. S1 and DH1 climbed up the walls of the forward crew staircase, exiting from the crew mess area into the wheelhouse.

There was no indication of flooding inside *Bayesian* until water came in over the starboard rails as the yacht heeled over. With *Bayesian* lying on its side, water entered the internal spaces down the stairwells and into the accommodation.

The C/E exited the wheelhouse through the port forward wheelhouse door. Once clear, they helped DH1 out before moving to the yacht's port aft quarter where an emergency position-indicating radio beacon (EPIRB) was located. DH1 remained outside the wheelhouse door. Reaching down through the door, DH1 lifted both S1 and S2 out of the wheelhouse. With no one else immediately visible, the three crew members went aft and into the sea.

Separately, the C/O found the owner in the saloon and pushed them to the master on the flying bridge through the cascading water. The C/O and master evacuated G3, G4 and G5 by the same route.

Guests G1 and G2 went forward and into the wheelhouse. The bosun and DH2 assisted them onto the flying bridge.

As *Bayesian* rotated further to starboard and started to sink, the CS, bosun and DH2 were in a diminishing air pocket in the wheelhouse by the now closed port forward wheelhouse door. Assisted from outside by the injured G4, the three crew members opened the door and escaped.

The C/O had attempted to ascend to the flying bridge but was unable to due to the force of the water coming down. They were swept to an air pocket at the back of the saloon. They dived down and, after several attempts, opened the sliding doors at the rear of the space and swam clear.

The master instructed the guests on the flying bridge to swim away from the yacht and warned them to remain clear of the mast and boom as *Bayesian* was sinking.

At about 0412, the C/E deployed the EPIRB and then sat on the hull near the rudder. The C/E noted that the wind had eased and that *Bayesian* was only a short distance from shore. Hearing shouts from the master, the C/E jumped into the sea and swam towards the survivors gathering in the water.

The CS counted those present and checked for injuries. DH2 improvised a tourniquet for G4's gashed arm and G2 gathered a cushion to use as a flotation device for G5. Guest G1 used the torch on their mobile phone to search the water for other survivors.

The master and DH1 swam back to *Bayesian*. They unsuccessfully tried to release the port aft liferaft from its stowage. The C/O swam to the port forward liferaft. Releasing it from its stowage, the C/O towed the canister to the gathered survivors. By about 0424, the liferaft was inflated and DH1 entered it and helped the survivors to board.

From their position in the liferaft, the CS saw the bows of *Bayesian* rise up and then sink below the surface. The crew administered first aid to the injured and gathered the means to raise the alarm from the equipment contained in the liferaft. One of the survivors recalled seeing a vortex of water between the clouds and the sea surface a short distance away.

Bayesian sank in approximately 50m of water.

1.4.2 The rescue

The master of *Sir Robert Baden Powell* noted that the vessel had dragged its anchor over 350m in 11 minutes. *Bayesian* was not visible and the crew of *Sir Robert Baden Powell* initially believed that *Bayesian* had left the anchorage to avoid the sudden storm. The master of *Sir Robert Baden Powell* briefly saw a dark triangular shape in the water.

At 0434, *Bayesian*'s C/E fired a red parachute flare from the liferaft. As it rose, the flare was carried sideways in an area of strong wind. The C/E used the torch from the liferaft to signal towards the shore and to *Sir Robert Baden Powell*. At 0443, the C/E fired a second red parachute flare. The crew on board *Sir Robert Baden Powell* responded to the flares and the vessel's master dispatched its tender to assist, heading towards the visible flashing lights on the EPIRB and liferaft.

On arrival at the liferaft, *Sir Robert Baden Powell*'s tender crew transferred the survivors on board. One of the survivors noted a cone shape in the sky and estimated it to be about 100m in diameter, rising into the clouds above. At 0453, after a brief search for other survivors, the tender returned to *Sir Robert Baden Powell*.

The tender crew transferred the survivors to *Sir Robert Baden Powell* and, accompanied by *Bayesian*'s C/E, returned to the accident site to search for others. The tender returned to *Sir Robert Baden Powell* about 20 minutes later. At 0520,

Sir Robert Baden Powell's master called the local coastguard to report the accident and arrange transfers ashore. Accompanied by *Bayesian*'s master, the tender crew conducted a third and final search for survivors.

Over the next hour, all survivors were taken ashore for medical treatment and reception by the local authorities.

1.5 THE DECEASED

Bayesian's deceased crew member and six guests are listed in **Table 1**. Postmortem reports indicated that they all died of *cardiopulmonary arrest compatible with drowning*[3]. They were recovered by divers in, or near, *Bayesian*'s wreck position of 38°05.00'N 013°33.10'E at a water depth of 50m.

Name	Age	Nationality	Location recovered	Date recovered	Remarks[4]
Anne Elizabeth Judith (**Judy**) **Bloomer**	71	British	Guest accommodation	21 August 2024	BAC 57mg/dL Guest
Jonathan William **Bloomer**	70	British	Guest accommodation	21 August 2024	BAC 81mg/dL Guest
Hannah Deia **Lynch**	18	British	Guest accommodation	23 August 2024	BAC 28mg/dL Guest
Dr Michael Richard (**Mike**) **Lynch**	59	Irish and British	Guest accommodation	22 August 2024	BAC 46mg/dL Guest
Christopher (**Chris**) **Morvillo**	59	American	Guest accommodation	21 August 2024	BAC 67mg/dL Guest
Neda Nassiri **Morvillo**	57	American	Guest accommodation	21 August 2024	BAC 56mg/dL Guest
Recaldo (**Rick**) **Thomas**[5]	59	Citizen of Antigua and Barbuda and Canadian	Outside *Bayesian*'s wreck	19 August 2024	BAC 15mg/dL Crew

Table 1: Alphabetical list of the deceased

[3] Cardiopulmonary arrest occurs when the heart stops beating and breathing stops, leading to unconsciousness and death. When associated with drowning, the primary cause is being unable to breathe due to being underwater.

[4] The pathologist's reports for the deceased noted the complexity in the interpretation of blood alcohol concentration (BAC) due to postmortem production of alcohol in the body. All of the deceased tested negative for psychotropic substances. The drink driving limit for England and Wales was 80 milligrams per decilitre (mg/dL).

[5] Recaldo Thomas had recent injuries to his right forehead, left arm, left hand, left leg and right thigh, back and ribs.

1.6 ENVIRONMENTAL CONDITIONS

The sea surface temperature at the time of the accident was about 31°C. Winds immediately before and after the accident were north-westerly, Beaufort force 3 to 5. The weather is discussed in more detail in section 1.11 of this report.

1.7 *BAYESIAN*

1.7.1 General

Bayesian was built by Perini Navi S.p.A (Perini Navi) in 2008. Originally registered as *Salute* in the Netherlands, it was the was only sloop of this size constructed by Perini Navi; the other yachts were built as ketches[6]. In 2014, the owner at the time of the accident acquired the yacht through Revtom Ltd and its name was changed to *Bayesian*, registered in the UK.

Bayesian's single mast was hollow, though closed at its top, and had six pairs of spreaders up it. The regularly spaced spreaders were raked backwards and decreased in size up the mast. At the lowest spreader, the mast was 570mm wide. The 22m boom contained the mainsail when furled and was suspended aft of the mast. Forward of the mast there was a 12m spar that was used to move the yacht's boats.

There were three main stairways up from the crew accommodation, leading to a hatch on the foredeck, the forward guest cockpit, and the wheelhouse respectively **(**see **Figure 2)**. The wheelhouse stairway was mainly used by crew but could also be accessed as a secondary escape from the guest accommodation. The stairway leading up into the saloon from just forward of the owner's cabin was the main route to and from the guest accommodation and served as the primary escape route. Internally, access to the flying bridge was via a stairway from the wheelhouse.

Access to the lazarette, engine room and engineer's cabin was through a hatch on the port side of the main deck that led to a stairway into the lazarette. There were three doors on the main deck: one either side of the wheelhouse, opening outwards into the forward guest cockpit, and a set of sliding doors at the aft end of the saloon leading into the aft guest cockpit.

Guest cabins were arranged around a central corridor with doors opening inwards into each of the six cabin spaces.

Window shutters were available on board. At the time of the accident these were not fitted.

1.7.2 Tanks and machinery installation

Bayesian had tanks for fresh water, lubricating oil fuel oil, sewage, bilge water and oil sludge. Each evening the C/E filled the fuel oil day tanks. Generally, fuel oil was drawn from the aft fuel storage tanks in preference to the forward tanks to manage *Bayesian*'s trim and maintain the machinery exhausts clear of the waterline.

[6] A sailing yacht with two masts: a tall forward mainmast and a shorter aft mast positioned forward of the rudder post.

On 19 August 2024, the fuel level in two of the aft fuel oil storage tanks was low in preparation for the upcoming maintenance period. The yacht's fresh water tanks were generally maintained full, although the water makers were routinely switched off at about 1900 to minimise noise overnight.

For propulsion, *Bayesian* had two 720kW diesel engines driving two controllable pitch propellers. Three 90kW generators provided the main electrical power supply. For emergency power, a 20kW emergency generator was installed in a compartment below the forward deck and there was also a 24V battery bank.

Bayesian could be controlled and navigated from either the wheelhouse or the flying bridge. The propulsion machinery could be controlled from either the engine control room, wheelhouse or flying bridge. It was the practice on board to follow the operating manual and to start and stop main engines from the engine control room. Control was then transferred to either the wheelhouse or flying bridge as required.

Engine room ventilation supply and extraction ducts were fitted with watertight anti-flood shutters. Those for the ventilation supply were manually operated and those for the extraction were remotely controlled. The shutters on each side of the yacht could also be closed independently when necessary, depending on the operating conditions. The engines were each fitted with a water-cooled exhaust that injected seawater into the exhaust stream to both cool the exhaust and reduce noise. Valves in the exhaust systems were required to be opened for the engines to start and run.

Closing devices on hull openings had not been manually operated at the time of the accident (see section 1.8.2).

1.7.3 Keel and centreboard

Bayesian had a fixed box keel structure extending below its hull. The box keel was filled with 41.31 tonnes (t) of lead ballast. The box keel gave *Bayesian* a design draught of 4.05m.

A deployable centreboard filled with 52.3t of lead ballast was set into a housing in the box keel. Once lowered, the centreboard increased the yacht's draught to 9.83m.

The centreboard could be raised and lowered hydraulically. It took approximately 2 minutes and 30 seconds to deploy the centreboard using both the associated hydraulic pumps. Recovery of the centreboard took approximately 3 minutes and 40 seconds. The crew were aware of the increased draught when the centreboard was in the lowered position. When raised, the centreboard was secured in place by a hydraulic lock when the hydraulic pumps were switched off.

The centreboard was designed for use when the yacht was in the sailing condition. It was not required when *Bayesian* was motoring with its sails down.

1.7.4 Crew

Bayesian had 10 permanent crew. The master, C/O and CS had all been on board *Bayesian* for over 3 months at the time of the accident. The C/E, bosun, chef, stewards and DH1 had all been on board for about 2 months. DH2 had been on board for about a month. Each crew member undertook familiarisation training when

they joined the vessel. The working language on board was English, which all the crew spoke fluently. All crew members were appropriately certified for their positions on board, meeting the requirements for service on a pleasure vessel referenced in Marine Guidance Notice (MGN) 599 (M)[7] published by the Maritime and Coastguard Agency (MCA).

The master had captained *Bayesian* since early 2022 and had over 23 years' experience as a master or C/O of large yachts operating in the Mediterranean Sea and the Caribbean. Their experience included 11 years' service on a 56m ketch built by Perini Navi. The master had previously experienced a knockdown in high winds while under sail on the ketch, from which the vessel was able to recover. The master held an unlimited certificate of competency issued by the UK, certifying them as a master of yachts of greater than 3,000 gross tonnage (gt).

The C/O had 8 years' seafaring experience, of which they had served 2 years on board *Bayesian*. The C/O held a master unlimited certificate of competency for yachts of greater than 3,000gt.

The C/E had 13 years' experience on board *Bayesian*. The chef had over 25 years' experience working on large yachts.

The CS had a background in hospitality and had served on board *Bayesian* since 2022. The CS held a certificate of competency as a C/O on yachts of less than 500gt. S1 and S2 were new to *Bayesian* in 2024; both had completed the relevant basic safety training.

The bosun had started working on private yachts in 2011 and qualified as an offshore yachtmaster in 2020. They had served on board *Bayesian* since 2022.

Both DH1 and DH2 had joined *Bayesian* for the first time at the start of the 2024 summer season. Both DH1 and DH2 had completed the relevant basic training. Additionally, DH2 held a yachtmaster offshore certificate of competency.

1.7.5 Guests

There were 12 guests on board *Bayesian*, including the owner and their family who were familiar with the vessel.

On joining *Bayesian*, short safety briefings were given to those who had not sailed on the yacht before. Separate safety briefings were delivered by the C/O before *Bayesian* went under sail, or when guests embarked via the tender.

The owner and Dr Mike Lynch were staying in the master cabin in the aft section of the guest accommodation. Jonathan and Judy Bloomer were in the port side forward cabin, G1 and G2 in the starboard side forward cabin, and Chris and Neda Morvillo in the starboard side midships cabin. Guests G3, G4 and G5 were staying in the port side midships cabin, and Hannah Lynch was staying in the port side aft nanny's cabin **(**see **Figure 2)**.

[7] MGN 599 (M) Pleasure Vessels – Regulations and Exemptions – Guidance and Best Practice Advice MGN 599 (M) applied Merchant Shipping Notice (MSN) 1858 (M) Amendment 2 – UK Requirements for Deck Officers on Large Yachts (24m and over).

1.7.6 Anchoring

Bayesian anchored at Porticello with 2.5 shackles (69m) of chain out on the port anchor in 30m of water. *Bayesian* carried 150m of chain on each side connected to stockless anchors.

On 22 July 2024, *Bayesian* had been anchored in the Bay of Naples. During a period of high wind, the yacht had started to drag its port anchor, as had other superyachts anchored in the same area. During that event, the crew used the engines and the bow thruster to minimise the drag. *Bayesian* had reportedly heeled over to approximately 15°.

Bayesian had a propensity to yaw[8] at anchor when the centreboard was lowered. This increased snatching on the anchor cable and the consequential dragging risk. Excessive yaw also caused discomfort for those on board. The centreboard was rarely lowered when *Bayesian* was at anchor.

1.7.7 Lifesaving equipment

Bayesian carried four 12-person liferafts on the bridge deck **(**see **Figure 2)**: two on the forward deck, and two aft of the aft guest cockpit. Each liferaft sat in a hinged cradle designed to allow each liferaft to float free should the yacht sink in an upright condition. The cradles could be operated manually by the crew to deploy the liferafts as part of a controlled abandonment.

During *Bayesian*'s salvage the two aft liferafts were dislodged and floated free of the wreck and then inflated. The forward starboard liferaft remained in position and was recovered with the vessel **(Figure 5)**. Each hydrostatic release unit (HRU), intended to release the liferafts from their cradles in the event of the vessel sinking, had operated as designed.

Retaining strap released and yacht's outer guardrails missing after impact with seabed



Figure 5: Forward starboard liferaft in place after salvage

[8] Rotational movement of a vessel around its vertical axis.

Bayesian carried two EPIRBs: one in a container on the guardrail on the main deck's port aft quarter, the other in a container on the starboard side aft of the flying bridge deck.

Lifejackets were available in each guest and crew cabin and additional personal flotation devices were available on board for tender transfers or water sports.

1.7.8 Vessel certification

When built in 2008, *Bayesian* (then *Salute*), was surveyed against the requirements of the UK Large Commercial Yacht Code (LY2)[9]. The MCA issued a certificate of compliance against the LY2 requirements. When *Salute* became *Bayesian* in 2014, it was operated privately and was not available for chartering or other commercial activities and was therefore not required to comply with the requirements of LY2. No survey or certification activities related to compliance with LY2 was carried out on the vessel after this date. However, it was maintained substantially to the LY2 standard, including any subsequent amendments that would apply to a vessel in commercial operation; no surveys were conducted to verify compliance with the standard.

Bayesian was registered in the UK and was subject to the requirements for survey and certification as a pleasure vessel. The certification requirements were set out in MGN 599 (M)[10] published by the MCA in 2019. The yacht was subject to statutory and Class surveys carried out by surveyors from the American Bureau of Shipping (ABS). None of the statutory surveys required for *Bayesian* required an assessment of its stability.

1.7.9 Yacht management

In November 2014, the owner of *Bayesian* engaged Camper and Nicholsons International Limited (CNI) to manage the yacht's survey and maintenance activities. All guest arrangements were made by the owner directly.

As a privately operated vessel, *Bayesian* was not required to implement a safety management system. However, it operated a voluntary safety management system based on the requirements annexed to LY2 and informed by CNI's Mini-ISM system.

The responsibility for the management of *Bayesian* fell to a subsidiary of CNI based in Monaco. The fleet managers would regularly attend the vessel during maintenance periods and were in routine contact with the crew to offer guidance and support as required. The assigned fleet managers had worked with *Bayesian* for several years and were familiar with the yacht and its crew.

1.7.10 On board documentation

Operational documents and certificates were kept in *Bayesian*'s wheelhouse. These included the vessel's Operations and Safety Manual, Mini-ISM system, standing orders, and operational procedures and checklists. *Bayesian* also carried

[9] First published in 2005, MSN 1792 (M) – The Large Commercial Yacht Code (LY2), updated the earlier 1997 Code of Practice for the Safety of Large Commercial Sailing and Motor Vessels (LY1). LY2 was later updated to Edition 2, which became effective on 17 September 2007.

[10] The general exemptions annexed to this MGN had expired and were not extant at the time of the accident. The underlying legislation referenced was therefore applicable.

a range of Admiralty Nautical Publications, including Admiralty Sailing Directions – Mediterranean Pilot Volume 1 (NP45) and The Mariner's Handbook (NP100). These were also available online via a computer in the wheelhouse.

1.7.11 Wreck examination

Limited information was provided to the investigation on the recovery operations carried out on *Bayesian*. Although some dive videos were available, no dive records were provided that detailed the activities undertaken during the initial dives to recover the casualties.

The information available showed that *Bayesian* was lying on its starboard side on the seabed. The centreboard was in the raised position, and the transom shell door was closed.

The trace of the anchor scouring on the seabed mirrored the track of *Bayesian* shown in **Figure 4**.

The wreck of *Bayesian* was recovered to Termini Imerese, Sicily in June 2025. The MAIB was denied immediate access to the wreck by the Italian authorities. In July 2025, MAIB inspectors completed an external laser scan of the hull of the vessel to support the stability study. Examination of the yacht's internal spaces was not allowed at that time.

The Italian authorities permitted access to *Bayesian* in December 2025. When inspected, the yacht's internal spaces had been cleared of debris. Furniture, fittings, equipment and stores had been removed. No documented record of the items removed was available.

1.8 STABILITY INFORMATION

1.8.1 General

Bayesian was provided with a stability information booklet (SIB) which described the stability characteristics of the yacht in the intact condition. The SIB detailed the arrangements of *Bayesian*'s sails, hatches, doors and openings as well as tank information.

Bayesian's SIB had been assessed against the requirements of LY2 by Ensign large yacht services[11] and was approved on 3 July 2008.

Bayesian was subject to a voluntary lightship check[12] conducted on 12 November 2020. The derived values were compared with those from the original stability assessment carried out in 2008, which were included in the SIB. The increase in lightship weight was 0.19% and the position of the longitudinal centre of gravity had moved aft by 0.60%.

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[11] Ensign large yacht services was a specialist unit within the MCA. Ensign surveyors completed survey and certification of large commercial yachts under the MCA's large yacht codes.

[12] A lightship check assesses the displacement and the position of the longitudinal centre of gravity of a vessel without consumables, cargo, fuel, stores, ballast, crew, passengers or other variable loads. It is used to verify whether the vessel's SIB remains representative of its stability. The SIB is considered valid if the lightship weight is within 2% of the original displacement and the variation in the position of the longitudinal centre of gravity is within 1% of the length of the vessel between perpendiculars.

The SIB described a range of loading conditions:

- Lightship conditions – not seagoing conditions
    - centreboard raised
    - centreboard lowered
- Motoring conditions – centreboard raised
    - maximum load condition (departure condition)
    - contractual full load condition (departure condition)
    - light load condition (arrival condition)
- Sailing conditions – centreboard lowered
    - maximum load condition (departure condition)
    - contractual full load condition (departure condition)
    - light load condition (arrival condition)

1.8.2 Downflooding

Downflooding is the entry of seawater into the hull of a vessel through a fixed opening. It occurs once the relevant opening is immersed by water. The SIB stated that critical flooding would occur when openings with an aggregate area greater than 0.377m² were submerged[13].

The SIB set out the angle of heel where downflooding would occur in the three arrival and departure conditions with the centreboard in both the raised and lowered conditions. In the light load motoring condition, downflooding would start at 34.3° of heel and become critical at 47.5° when engine room ventilation and extraction openings were submerged. The identified openings and associated downflooding angles for *Bayesian* in various approved conditions are set out in **Table 2**[14].

[13] LY2 section 11.2.2.1 calculated the area of critical flooding as the value equal to the vessel's maximum displacement in tonnes divided by 1,500.

[14] These were detailed on a diagram contained in the SIB, with the associated angles of downflooding being listed in a separate table.

Item		Angle of downflooding (° from vertical)						Area	
Description	Side	Maximum load condition	Contractual full load condition	Light load condition	Maximum load condition	Contractual full load condition	Light load condition	Maximum area of opening on one side (m^2)	Progressively immersed area on one side (m^2)
		Centreboard raised			Centreboard lowered				
MCA line[15]	Port and starboard	24.4	25.1	27.0	24.5	25.2	27.1	--	--
Crew and galley extraction	Port and starboard	31.0	32.1	34.3	30.7	31.8	34.0	0.050	0.050
Engine room and lazarette extraction	Port and starboard	39.6	40.9	46.5	40.7	42.1	48.1	0.320	0.370
Engine room extraction/ ventilation	Port and starboard	42.7	43.8	47.5	43.0	44.1	47.9	0.340[16]	0.710
Tender locker ventilation and extraction	Port	45.8	47.2	50.1	45.4	46.8	49.7	0.080	0.790
Saloon extraction, guest ventilation, aerobic treatment unit suction	Port and starboard	51.2	52.3	55.2	51.3	52.4	55.2	0.170	0.960
Owner, saloon and wheelhouse extraction	Port and starboard	52.4	53.5	56.6	52.6	53.7	56.8	0.060	1.020
Lazarette ventilation	Starboard	58.6	60.3	66.0	59.7	61.4	67.4	0.030	1.050
Emergency diesel generator, forepeak and bow thruster vent and extraction	Port and starboard	78.7	80.5	84.0	77.9	79.5	82.9	0.070	1.120

Table 2: *Bayesian* SIB opening locations and associated downflooding angles and areas

[15] The MCA line was not defined in the SIB but was described in the damage SIB as being a line (also known as the 'margin' line) 75mm below the upper level of the weather/main deck. The sail system functioning logic was designed to keep the yacht under this value when under sail.

[16] Critical flooding point reached.

1.8.3 Guidance on the prevention of capsize

The SIB template published by the MCA noted the need for a section outlining guidance to the master on shipboard procedures. It stated that the SIB should include:

> *any procedures relating to the safe operation of the yacht affecting stability or survivability following damage, hit by squalls etc that the master is to be made aware of in order that the appropriate action can be taken either in the course of normal seagoing preparation or in the case of an emergency*

The template provided generic suggested text, noting that it was *not to be considered exhaustive of what is expected and that they should be modified as required to suite the specific yacht in question* [sic]. The guidance in the SIB on *Bayesian* mirrored the generic text from the template.

The SIB on *Bayesian* detailed precautions to be taken to prevent capsize while it was underway, including that the master should:

> *exercise prudence and good seamanship having regard.* [sic] *to the season of the year, experience of the crew, weather forecast and the navigational zone, and should take appropriate action as to the speed, course and sail setting warranted by the prevailing conditions.*

The SIB noted that:

> *The amount of sail carried is at the discretion of the Master and his decision will have to take into account many factors.*

Further, that:

> *The Master should note that the presence of the vent and skylights significantly reduces the ability of the vessel to withstand down flooding and with these openings securely closed the safety of the vessel is enhanced considerably.*

The SIB identified the risk of capsize in gusts or squalls, advising the master to use the readings from the inclinometer and anemometer to determine the risk. It stated that the master may then:

> *decide to shorten sail together with other actions he considers necessary.*

The SIB discussed precautions to be taken against the risk of capsize, including that all external hull doors and flush hatches were to be closed and secured, and stated that:

> *In adverse weather conditions and where there is the possibility of encountering a severe gust, squall or large breaking wave, all exposed doors, hatches, skylights, vents, etc. should be closed and securely fastened to prevent the ingress of water. If available, storm boards, blanking plates etc. should be erected and fitted.*

The SIB's 'Master shipboard procedures' section considered four scenarios:

1. In sheltered anchorages and in port – reminding masters of their responsibilities to evaluate risks and hazards and take appropriate precautions. The SIB recommended that the door from the lazarette to the engine room be kept closed whenever the shell door was open.

2. Preparing for sea – all external hull doors and flush hatches, internal hinged watertight doors and sidelights that could be opened were to be closed securely. Internal sliding watertight doors had to be tested.

3. Preparing for rough weather passage – reminding masters of their responsibility to take precautions, including, but not be limited to, securely lashing all loose gear, large or heavy items of furniture, putting shutters over the windows, and to *secure closing device as appropriate*.

4. At sea – the internal sliding watertight doors could be left open when appropriate but should be checked as required to make sure they closed properly. Internal hinged watertight doors *should remain closed but may be opened when passing trough* [sic].

Bayesian's Operation and Safety Manual included checklists for preparing for sea and entering heavy weather. The checklists mirrored the advice provided in the SIB for the closing of watertight hatches, doors and hull openings.

The SIB's 'Master responsibility on stability under sail' section highlighted that the angle of vanishing stability (or GZ righting lever positive range)[17] was 84.3° when *Bayesian* was in the light load sailing condition with the centreboard lowered.

The SIB contained graphs of statical stability (GZ curves) for maximum load, contractual full load and light load conditions when in the sailing condition (centreboard lowered and with sails set). A GZ curve describes a vessel's ability to return to an upright position. The gust limit is defined by the point at which the wind heeling forces are balanced by a vessel's capacity to right itself or the point at which a vessel reaches an angle of heel sufficient to commence critical downflooding (or 60°, whichever is the lesser value). Beyond that limit, should the wind heeling forces be sustained, the vessel would be knocked down or subject to critical downflooding. Beyond the angle of vanishing stability, a vessel is no longer able to right itself irrespective of any wind heeling forces.

The steady state wind heeling curve is derived from the gust wind heeling curve. At any angle, the value of the steady state wind heeling lever is half of the gust wind heeling lever. The steady state wind heeling limit is then defined as the point at which the steady state wind heeling curve first intersects the GZ curve. Beyond the steady state wind heeling limit a vessel is considered to be at risk of knockdown or downflooding as the result of a wind gust. In the light load condition, when under sail and with the centreboard down, the SIB detailed *Bayesian*'s steady state wind heeling limit as 17.0°.

[17] The angle of vanishing stability is the angle of heel where the righting moment has reached zero and is no longer able to right itself. The GZ righting lever positive range describes the range from upright (0°) to the angle of vanishing stability.

1.8.4 Management of wind heeling moment

The SIB detailed the respective curves of maximum steady heel angle to prevent downflooding in gusts and squalls. These sections were provided for *Bayesian* in specific sailing conditions, all with the centreboard lowered. This information was not provided for any motoring conditions with the centreboard raised and no sails set.

Bayesian had an automatic sail monitoring and control system that was used to control the sails when the yacht was under sail. This system monitored the sail operating loads and would automatically ease the sheets to reduce the wind heeling moment when preset load limits were surpassed.

1.9 WOLFSON UNIT STABILITY STUDIES

1.9.1 Initial stability and windage study

Following the accident, the MAIB contracted the University of Southampton's Wolfson Unit for Marine Technology and Industrial Aerodynamics (Wolfson Unit) to conduct a stability and windage study of *Bayesian*.

The Wolfson Unit's initial study considered the stability information available for the yacht, including the original approved SIB, the MCA digital stability model used for the original assessment and approval of its stability information, and drawings from *Bayesian*'s builders.

The study assessed an assumed loss condition equating to the light load motoring condition with the centreboard raised. The results of this study **(Annex A)** were used to inform the MAIB's interim report **(Annex D)** published in May 2025.

The initial study identified inconsistencies between the stability model used when the SIB was originally approved and the other documents contributing to the study. These were addressed in the development of the digital stability model by the Wolfson Unit, which was subsequently used to calculate the vessel's stability. The report of the study stated that:

> *Even though differences have been observed between the SIB and the Wolfson models, these had no significant impact on the overall stability characteristics of the vessel at the loading conditions evaluated.*

The Wolfson Unit study also assessed *Bayesian*'s aerodynamic loading with no sails set to estimate the maximum wind speed that the yacht could withstand given its stability characteristics. The study concluded that, *With the wind on the beam and the vessel in the motoring light load condition…an envelope of limiting wind speed of 53 – 63 knots could capsize the vessel*.

1.9.2 Post-wreck examination study

The Wolfson Unit was subsequently contracted to refine its initial assessment of *Bayesian*'s stability characteristics and aerodynamic loading based on the information recovered once the wreck was brought ashore. Estimates of tank contents and stores were based on information gathered during the investigation and details of the yacht's intended operation. This work was completed in March 2026 **(Annex B)**.

The Wolfson Unit study used the data from the laser scan of the hull conducted during the investigation and updated the initial stability and aerodynamic models to account for tank contents, deadweight assessments, and the aerodynamic effects of the yacht's fittings. The study also assessed the possible impact of accumulation of rainwater in the lazarette.

The probable loss condition assessed was based on the best information available but remains an estimate of *Bayesian*'s stability condition when the yacht foundered.

The Wolfson Unit derived wind heeling data for *Bayesian* in the probable loss condition **(Figure 6)**. The aerodynamic study predicted the wind speeds that would produce the limiting heel angle for apparent wind angle (AWA) ranges relative to the bows. These predictions are shown in **Table 3**. The predicted high limits included the impact of interactions and blanketing effects between different elements of the mast and rigging. The predicted low limits excluded these effects.

In the probable loss condition, the Wolfson Unit study concluded that *Bayesian* would maintain a positive righting lever when heeled over until the angle of heel reached 73° – the angle of vanishing stability. The derived wind heeling moment in this condition indicated that the vessel was at risk from gusts when at a steady wind heeling angle of 13.9° **(Figure 6)**.

The Wolfson Unit assessed that *Bayesian*'s mast contributed more than 56% of the total wind heeling moment and the furled sails contributed more than another 20%.

The study concluded that accumulated rainwater in the lazarette was unlikely to have been a significant factor.

Image from Wolfson Unit

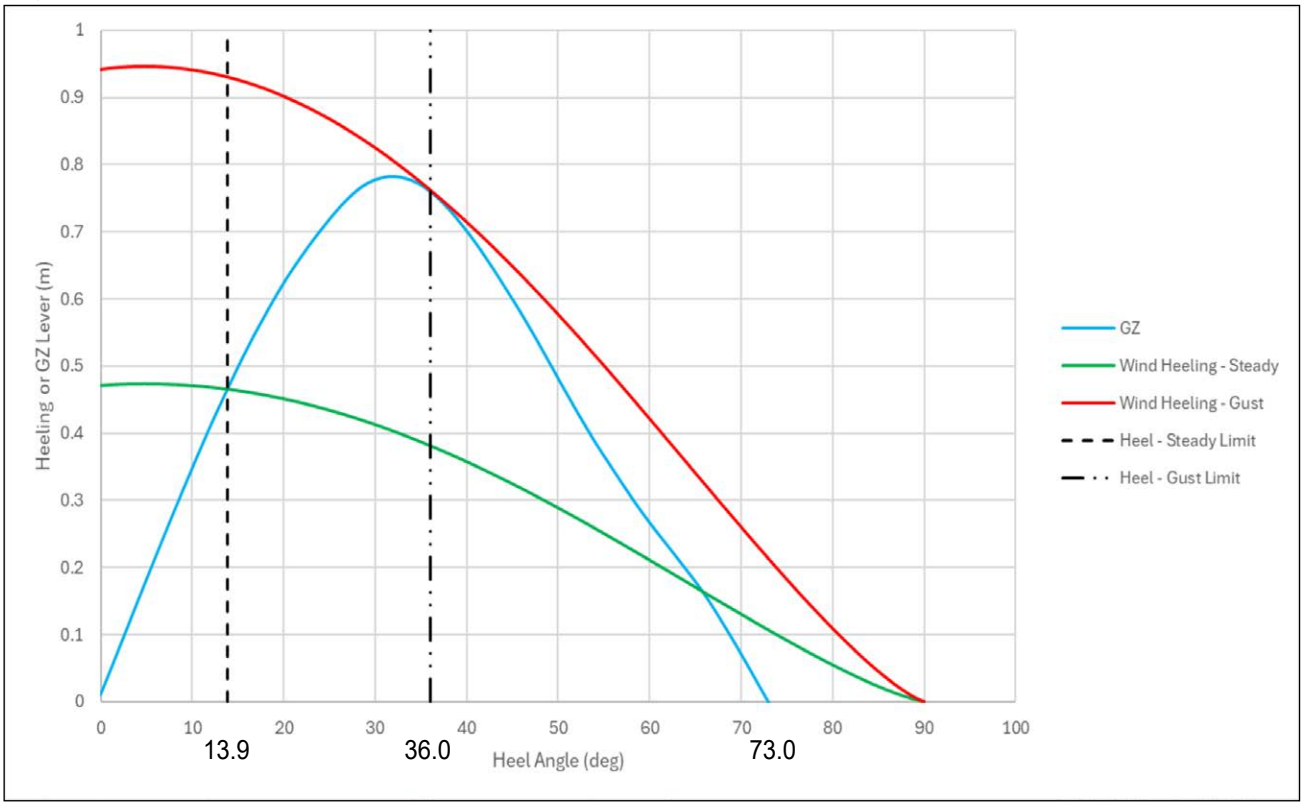


Figure 6: Wolfson Unit derived wind heel data for *Bayesian* (probable loss condition) at 90° apparent wind angle

AWA (°)	Steady low (kts)	Steady high (kts)	Gust low (kts)	Gust high (kts)
0	-	-	-	-
10	61.2	73.7	86.6	104.2
20	51.2	61.6	72.3	87.1
30	58.0	69.5	82.0	98.3
40	48.9	57.9	69.2	81.9
50	44.6	52.2	63.1	73.8
60	43.6	50.4	61.7	71.3
70	43.0	49.3	60.9	69.7
80	42.7	48.6	60.4	68.7
90	42.6	48.4	60.2	68.4
100	43.0	48.9	60.8	69.1
110	44.2	50.5	62.5	71.4
120	46.5	53.5	65.8	75.7
130	50.3	58.6	71.2	82.8
140	56.5	66.7	79.9	94.4
150	67.0	80.3	94.7	113.6
160	86.5	105.5	122.3	149.2
170	133.9	166.1	189.4	234.9
180	-	-	-	-

Table 3: Wolfson Unit prediction of limiting wind speeds (at 10m height) envelopes at a range of AWAs for *Bayesian* in the probable loss condition

1.10 ABANDON SHIP PROCESS AND DRILLS

Bayesian's Operation and Safety Manual included information on the alarm signals and actions to be taken in the event of the need to abandon ship. A muster list assigned tasks to the crew for the mustering of people and the process for a controlled abandonment of *Bayesian*.

The guests were to muster in the aft guest cockpit and await instructions during any emergency on board.

Bayesian's crew completed monthly training on emergency procedures, although not normally when guests were on board.

1.11 ACCESS TO WEATHER INFORMATION

Bayesian was equipped with a digital navigational telex (NAVTEX)[18] unit in the wheelhouse that displayed marine safety information provided by an authorised provider, including navigational warnings and search and rescue information. Additionally, it provided meteorological forecasts and warnings.

[18] An international automated direct printing telex system that was an integral part of the Global Maritime Distress and Safety System and the Worldwide Met-Ocean Information and Warning Service (WWMIWS).

Meteorological weather forecasts sent via NAVTEX were transmitted in a specific timeslot. These were locally transmitted to ensure relevance to the vessel receiving the signal, although local stations needed to have been selected on the receiving unit. Weather forecasts were broadcast at least twice daily and were coordinated across the meteorological area (MetArea).

The authorised provider could use NAVTEX to set off an alarm at the receiving unit, alerting vessels to important warnings. Meteorological warnings were allocated a priority of 'important' and were repeated at each subsequent scheduled transmission for as long as the warning was in force. Such warnings only contained the warning information and were separate to the weather forecast.

The NAVTEX unit on *Bayesian* was operational in the period leading up to the accident. The crew routinely referred to official forecasts and warnings received by this method.

The guidance in MGN 599 (M) strongly advised crews on board pleasure vessels to *check the weather and tidal conditions*. The crew supplemented NAVTEX information with both official and unofficial data from application-based programs available on their smartphones. The master referred to such application-based programs regularly.

1.12 WEATHER AND CLIMATE

1.12.1 General conditions

On the evening of 18 August 2024, the predominant winds off Sicily's north coast were forecast to be from the north-west at between force 3 or 4, gusting up to force 5 or 6. An area of low pressure that was moving in a south-easterly direction from the Gulf of Genoa towards the north Tyrrhenian Sea. This area of low pressure deepened as it developed. Another area of low pressure had developed during the day in the Tyrrhenian Sea and was moving slowly towards Sicily's north coast.

As the evening progressed, thunderstorms developed over the north Sicilian coastline and there were regular bursts of lightning and heavy showers. The photograph of *Bayesian* taken from *Sir Robert Baden Powell* 14 minutes before its foundering showed how the weather appeared locally off the coast **(**see **Figure 3)**.

Surface winds returned to a north-westerly force 3 or 4 following the accident.

1.12.2 Marine weather forecasts for the western Mediterranean Sea

The World Meteorological Organization (WMO) divided the world's oceans up into 21 different areas. The provision of marine meteorological information to shipping was delivered by the WWMIWS, which was part of the WMO.

The Mediterranean Sea was designated as MetArea III and was coordinated by Greece. Météo-France was responsible for the provision of forecasts and services in the western Mediterranean Sea, covering the area from the west coast of Italy to the Strait of Gibraltar. **Figure 7** shows the geographic extent of the MetArea III meteorological areas near the accident site.

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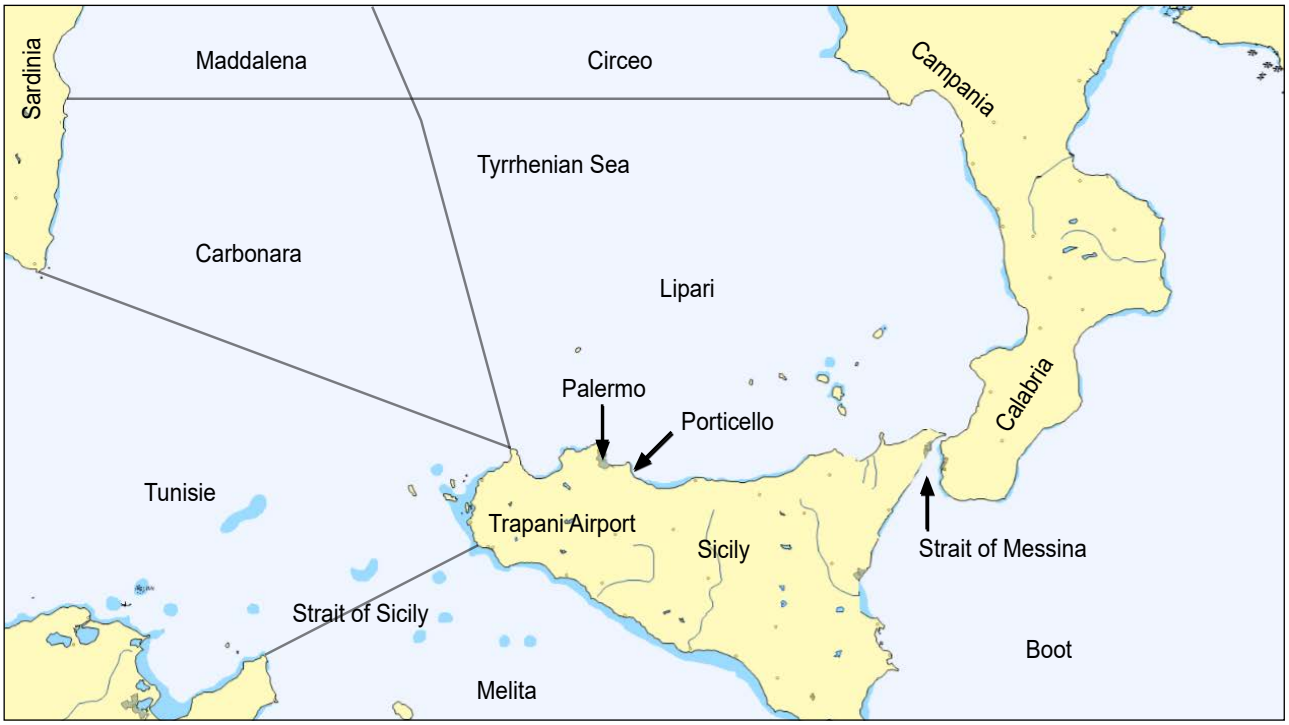


Figure 7: Meteorological areas in MetArea III relevant to the accident

Weather bulletins

A weather bulletin is a message used to communicate weather information, including any weather warnings in place for the specific area. Each weather bulletin listed the forecast wind speeds before describing the sea state and then the visibility, with any significant weather feature for each sea area. Wind speed and sea state were given in the Beaufort[19] and Douglas[20] scales respectively.

Météo-France issued weather bulletins for the western Mediterranean Sea at 1100 and 2300 daily. Each bulletin was valid for 27 hours and carried a cautionary note that stated:

> *Please be aware, wind gusts can be a further 40 percent stronger than the averages given here, and maximum waves may be up to twice the significant height.*

The 1100 bulletin for the Lipari sea area on 18 August 2024 stated:

> *Westerly 3 or 4, temporarily Northwest overnight, then increasing 4 or 5 in south at end.*
>
> *Smooth or slight, becoming slight or moderate in second part of the night.*
>
> *Poor visibility in showers or thunderstorms.*

[19] The Beaufort Wind Scale is an empirical system relating wind speed to observed conditions at sea or on land that categorises wind speed from force 0 (calm) to force 12 (hurricane).

[20] The Douglas scale is an empirical system describing the roughness of the wind-driven waves that ranges from 0 (calm) to 9 (phenomenal). It can also be used to describe the swell height and length from 0 (no swell) to 9 (confused – swell wavelength and height not definable).

The 2300 bulletin for the Lipari sea area on 18 August 2024 changed very little from the earlier bulletin, only updating the forecast wind to:

> *Westerly 3 or 4, temporarily Northwest overnight, then increasing 4 or 5 in south in afternoon.*

At 1400 on 18 August 2024 the Centro Nazionale di Meteorologia e Climatologia Aerospaziale (CNMCA) issued a weather bulletin and *forecast of intense phenomena* that stated:

> *Heavy rain, mainly in the form of showers or thunderstorms, will continue for the next 18 hours over Liguria, central-western Emilia-Romagna, Tuscany, Umbria, Lazio, Marche and Abruzzo. In the evening, the phenomena will be extended to Campania, Basilicata, Calabria and Sicily, especially to the Tyrrhenian coast.*
>
> *From tomorrow morning, Monday 19 August 2024, and for the next 24 hours, intense and persistent rain, mainly in the form of showers or thunderstorms, is expected in Friuli-Venezia Giulia, Emilia-Romagna, Veneto and Marche, especially on the coasts and plains. Higher rainfall accumulations are expected in Lower Veneto and Eastern Emilia-Romagna. Storms will be accompanied by strong wind gusts, frequent electrical activity and local hail.*[21]

At 2300 on 18 August 2024, the CNMCA updated its bulletin. As well as highlighting gale force 8 winds in the vicinity of Corsica and Sardinia, it included:

> *Isolated thunderstorms with local gusts over…Tyrrhenian Sea and concerning coastal regions. Isolated thunderstorms with local gusts expected over…Sicily Strait,…and concerning coastal regions.*

At 0200 on 19 August 2024, the CNMCA repeated the bulletin without any changes.

Weather warnings

A weather warning is a specific alert advising of hazardous weather requiring attention or action. At 2055 on Sunday 18 August 2024, Météo-France issued a weather warning[22] via NAVTEX. This warning reiterated an earlier warning of gale force 8 north-westerly winds in the north-west Mediterranean Sea, to the north and west of Sardinia. There were no weather warnings in place for the Lipari sea area. The weather warning provided detail on the pattern of low-pressure systems in the area:

> *General synopsis, Sunday 18 of August*
>
> *Low 1005*[23] *over French Riviera, moving over Gulf of Genoa in evening, then moving between Corsica and Italy tomorrow morning.*
>
> *Secondary thundery low deepening 1004 in north of Corsica in second part of night, moving southwest and expected just west of Corsica at midday, and losing its identity in evening.*

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[21] Liguria, Emilia-Romagna, Tuscany, Umbria, Lazio, Marche, Abruzzo, Basilicata Friuli-Venezia Giulia, Veneto and Lower Veneto were outside the accident area of interest.

[22] NR181.

[23] The weather warning used the hectopascal (hPa) unit of pressure.

Low area 1005 over Tyrrhenian Sea, expected 1006 just north of Sicily tomorrow evening.

By 0900 on the morning of 19 August 2024, this weather warning had been updated[24]. It noted the south-easterly movement of the Tyrrhenian Sea low towards the Strait of Messina and now only referenced one gale warning situated off the south-east coast of mainland France.

1.12.3 Weather observations

There were four official local meteorological weather stations near Porticello. Their data for 19 August 2024 is summarised in **Table 4**.

Weather readings were obtained from a vessel approximately 5nm to the north-west of the Porticello anchorage. At 0352 on 19 August 2024, wind speeds were recorded as having increased from about 5kts to 41kts from the north-west. Radar information from the same vessel showed the passage of dense rain clouds towards Porticello at the same time **(Figure 8)**.

Closed-circuit television cameras in Porticello showed intense squalls of wind and heavy rain around the time of the accident. This CCTV footage showed debris and street furniture being thrown around by the wind. Visibility in these squalls reduced significantly and was associated with lightning strikes and thunder.

No weather data from electronic equipment recovered by the Italian authorities from *Bayesian*'s wreck was made available to the investigation.

Site	Approximate distance from accident site (nm)	Data frequency	Wind speed (kts)	Surface air pressure (hPa)
Bagheria[25]	2.1 west	Hourly	2.7 Peak average at 0400 on 19 August 2024[26]	1,000.8 at 0400 on 19 August 2024
Termini Imerese 1	9.3 south-east	Hourly	12 Peak average at 0400 on 19 August 2024	991.9 at 0400 on 19 August 2024
Termini Imerese 2[27]	9.3 south-east	5 minutes	Northerly 18.3 Peak at 0420 on 19 August 2024	Not recorded
Lascari	19.3 east-south-east	5 minutes	North-easterly 10.2 Peak at 0440 on 19 August 2024	Not recorded

Table 4: Local official meteorological weather station data

[24] NR182.

[25] It is unknown how Bagheria and Termini Imerese 1 averaged wind speeds, although they only recorded on an hourly basis. Neither the exact site nor calibration data for these weather stations was made available to the investigation.

[26] The recording period accessed for Bagheria and Termini Imerese 1 was from 2300 on 18 August 2024 until 0700 on 19 August 2024.

[27] Termini Imerese 2 and Lascari recorded data at 5-minute intervals, although it is unknown how average peak wind speeds were calculated or how these stations were calibrated.

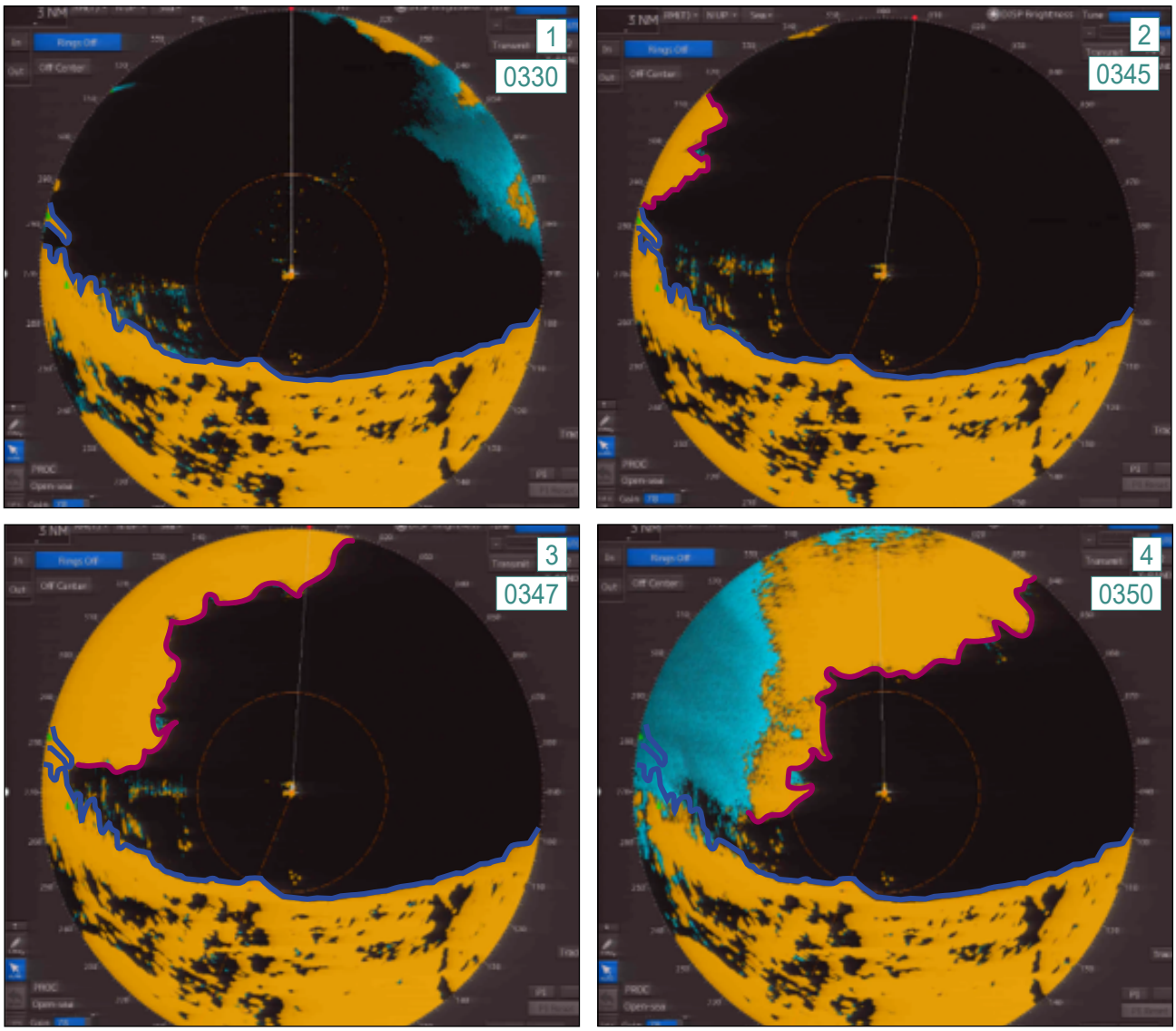


Image from Google Maps



Figure 8: Radar images showing passage of storm front across the Bay of Palermo on 19 August 2024

1.12.4 Convective available potential energy

Convective available potential energy (CAPE), measured in joules per kg (J/kg), describes the instability of the atmosphere and provides an approximation of updraft strength within a thunderstorm. Higher CAPE values generally indicate there is more energy in a system and greater potential for strong thunderstorms to form.

Theoretical virtual temperatures are used to account for the impact of moisture on the air density through which an air parcel moves. Use of virtual temperatures enables the production of more accurate estimates of CAPE, known as most unstable CAPE (MUCAPE).

At 0200 and 1400 each day, weather balloon ascent data was recorded at Trapani-Birgi Airport, Sicily, 59 miles west-south-west of the accident site. At 0200 on 19 August 2024, the airport recorded a surface air pressure of 1,009 hPa and winds of 3kts from the west.

The ascent data from Trapani was used to derive an assessment of the CAPE in the atmosphere. Using a virtual temperature, the MUCAPE was assessed to have a value of 2,553.73 J/kg. Values of MUCAPE above 2,000 J/kg are indicative of strong atmospheric instability with a high potential for severe convective weather.

1.12.5 Weather study

The MAIB commissioned the UK Met Office to conduct a study of the weather conditions over the seas north of Sicily on the night of 18/19 August 2024.

The Met Office concluded that a trough approached northern Sicily through a region characterised by a broad area of low pressure. Referencing the weather balloon ascent at Trapani-Birgi Airport, the study stated that:

> *…the Trapani ascent suggests large amounts of CAPE available and shear*[28] *borderline for supercell development*[29] *(0-6km shear) and also borderline for bow echoes*[30] *or downdrafts (0-3km shear).*

The Met Office noted that the Trapani observations were not directly within the area of the most significant storm activity and that atmospheric instability and wind shear may have been even greater nearer to the developing storm. High inshore sea surface temperatures may also have contributed energy to the development of weather systems.

The Met Office study of available satellite imagery concluded that:

> *a mesocyclonic storm front was probably demonstrating the properties of a significant supercell. In this type of weather system, it is possible for associated downdrafts to reach near-surface wind speeds up to, and exceptionally in excess of, 100 miles per hour (87kts).*

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[28] Changes to wind speed or direction with increasing altitude, or around local geographic features.

[29] An isolated storm containing updrafts of vertically rotating wind (known as a mesocyclonic storm). Supercells can produce damaging winds and develop into a tornado. Downdraft associated winds can be intense and cause damage when they reach the ground.

[30] A fast-moving system capable of producing extreme straight-line winds. Bow echoes develop when a strong, organised squall line (or cluster of storms) begins to surge forward faster in the middle than at the ends.

The study further concluded that a mesocyclonic storm was highly likely, with an associated supercell being probable. Further, the study suggested that tornadic waterspouts and downdrafts were possible where local winds could reach extreme hurricane force. The horizontal extent of such tornadic waterspout features could be as small as 50m to 100m.

The Met Office noted that:

> *…with increasing sea surface temperatures and availability of moisture, tornadoes in the Mediterranean might be increasing in the future climate, but there is high uncertainty and low confidence in this notion…*

1.12.6 Other meteorological studies

On 22 August 2024, the CNMCA produced a report into the meteorological conditions at the time of the accident. This report studied satellite data and local observations. The report stated that the nature of the weather and the lack of available observation data did not allow a precise explanation.

On its examination of the data from Trapani-Birgi airport, the CNMCA report stated that:

> *The thermodynamic survey carried out by the Trapani station at 00UTC shows a very high CAPE1 index value of 3200 Joule/kg and also the presence of strong DLS (Deep Layer Shear) windshear between 0-6 km (18 m/s). These values are favourable for the formation of thunderstorms organised into supercells…*

The report concluded that:

> *The meteorological event over Porticello is associated with the passage of a thunderstorm line within the rapid transit of a cold frontal system. This type of weather system is generally capable of producing strong, organised thunderstorms over very large areas.*

And that:

> *It is not possible to determine whether the event was a strong downburst (falling winds associated with thunderstorm activity) or a waterspout… However, from the information recorded by various meteorological stations along the coast, the hypothesis of a strong downburst current seems more reasonable…*

In November 2025, the Royal Meteorological Society journal *Weather* carried a paper on the *Bayesian* accident[31]. The paper studied local observations from three local CCTV cameras, the Trapani-Birgi Airport ascent data, available satellite information, and data gathered from local amateur weather stations.

[31] De Martin et al. (2025). The *Bayesian* sinking in Porticello: a predictable convective windstorm? RMetS Weather, volume 80, No.11.

The paper concluded that the wind generated at the time of the accident was likely to have been a downburst associated with a convective windstorm. The paper further stated that:

> *While these observations suggest that the storm responsible may not have been a supercell, in the absence of radar observations, we cannot be entirely confident in this conclusion. While we are not aware of any tornado damage along the coast, and all the observations analysed in this study do not suggest the presence of a tornado, its occurrence cannot be completely ruled out.*

On the predictability of such events, the paper noted the challenges behind forecasting precise time and location information for localised events more than a few hours in advance. The paper did note that satellite analysis identified that the storm developed 3 hours before the accident *and kept a coherent trajectory during its lifetime*.

1.12.7 Thunderstorms and downbursts

The Met Office factsheet on thunderstorms[32] indicated that they were *associated with convective clouds and are most often, but not necessarily, accompanied by precipitation at the ground*. The factsheet noted the damaging impact of heavy rainfall, hail, and the electrical discharges associated with thunderstorms. The factsheet contained limited maritime information and little description of associated winds.

The United Nations Office for Disaster Risk Reduction (UNDRR) website mentioned the risks from strong winds associated with thunderstorms, noting that they can damage structures and pose risks to aviation[33]. The UNDRR website described downbursts as:

> *powerful, localized columns of sinking air that rapidly descend from thunderstorms and impact the ground with intense winds, often exceeding 100 km/h*[34] (54kts).

A combination of evaporative cooling and precipitation drag within the storm primarily drives these hazardous wind events. Rain or hail evaporates or melts as it falls through a dry or cooler layer of air below the thunderstorm, cooling the air and making it denser. This cold dense air plunges rapidly and accelerates. At the surface the downdraft spreads out radially, generating damaging straight-line winds. Strong temperature gradients and high atmospheric instability can further intensify downbursts. While often confused with tornadoes due to their destructive nature, downbursts produce different wind patterns and are classified as non-rotational.

1.12.8 Guidance for actions in extreme weather

NP45: Admiralty Sailing Directions – Mediterranean Pilot Volume 1

The UK Hydrographic Office (UKHO) published a series of Admiralty Sailing Directions to provide essential information to support port entry and coastal navigation. NP45 provided guidance to ships sailing in the western Mediterranean Sea. Additionally, NP45 contained specific navigational information on Sicily's northern coast and off-lying islands.

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[32] Met Office Factsheet 2: Thunderstorms

[33] UNDRR: Thunderstorm

[34] UNDRR: Downburst

A section on natural conditions showed typical tracks followed by depressions in the region. This illustrated that the north Sicilian coast could expect about 19 depressions annually, tracking from the north-west to the south-east.

The guidance indicated that sea surface temperatures usually reached a maximum in August each year, with associated diagrams showing that the mean sea surface temperature to the north of Sicily was above 26°C. Similar diagrams showed that the expected August air pressures north of Sicily would be between 1,014 hPa and 1,016 hPa.

Cold fronts were described as being *very active in the region, and they could give rise to violent conditions with severe squalls and thunderstorms*. Thunderstorms were noted as being at their most frequent in late summer and autumn, although NP45 did note that the highest frequency occurred in northern and eastern parts of the area.

Coastal winds were described as being largely controlled by the area's general pressure distribution, although *straits, headlands and steep-sided valleys may cause local increases in wind strength due to funnelling*. NP45 indicated that the percentage frequency of force 7 winds in August was less than 2% for the area.

Waterspouts were described as developing *when the airflow is very unstable* and *relatively frequent* in the west and south of the western Mediterranean Sea.

The NP45 data was averaged and referred to specific coastal stations, *and therefore may not be totally representative of the conditions over the open sea or in approaches to ports in their vicinity*.

Climate data for the period from 1974 to 2019 for Punta Raisi, Palermo, Sicily, located 24.3 miles west-north-west of the accident site, indicated that thunderstorms occurred on average less than once every August and that gale conditions occurred on fewer than 0.06% of August days. The mean sea level barometric pressure was about 1,014 hPa in August.

NP100: Admiralty – The Mariner's Handbook

The UKHO's NP100 publication provided general guidance on navigation, sea and ice conditions, meteorology and regulations. Chapter 5 defined squalls as:

> *A gust is any sudden, rapid increase of wind of very short duration, typically just a few seconds… A squall is a sudden increase of mean wind speed which lasts for several minutes before the wind returns relatively quickly to its previous mean value. A squall can include many gusts.*

On the arrival of a cold front in the northern hemisphere, NP100 stated that any wind *veers markedly* to the west or north-west and that this *may be accompanied by sudden squalls*. On cyclonic depression in the northern hemisphere, NP100 stated that winds may fall light and variable near the centre of a depression before a *rapid onset of strong or gale-force winds*. NP100 did not contain any information on waterspouts or downbursts.

1.12.9 Low likelihood, high impact weather forecasting

Weather forecasts are predictive in nature and combine scientific understanding of atmospheric systems with meteorological observations. Marine areas often have a limited number of observations available to support detailed analysis and description of specific weather features.

The Met Office described ensemble forecasting as *a technique that involves running a weather prediction model multiple times, each with slightly different starting conditions*[35]. The set of forecasts generated were known as an *ensemble* of member forecasts.

A high degree of confidence could be ascribed to a forecast where there was high agreement between each member forecast in an ensemble, and less certainty when agreement between the member forecasts was lower. This technique was employed in the production of MetArea III forecasts.

The WMO established its Global Multi-Hazard Alert System (GMAS) framework to support a United Nations initiative to deliver early warning to people of impending hazard. The GMAS framework included a web-based Severe Weather Information Centre (SWIC), which collated all *authoritative warnings and information related to extreme and/or potentially high impact weather, water, and climate events from WMO members*[36]. By early 2024, users could search the SWIC for weather warnings issued by more than 130 WMO members worldwide.

1.13 REGULATION AND GUIDANCE

1.13.1 Training standards

The MCA set out the UK requirements for the training and certification of deck officers on large yachts in MSN 1858 (M) Amendment 1[37]. The MSN set out the implementation of training elements contained in the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, as amended, and its associated code.

The training programme for the master of a large yacht of less than 500gt was included in the training programme for yachts up to 3,000gt and contained a seamanship and meteorology (master yachts) training module. The syllabus included cloud formation, the local and regional effects of heating and cooling, the relationship between pressure and wind, and air masses. It also included sections on tropical storms, and monsoons in the Indian Ocean.

The forecasting element of the syllabus covered the interpretation of marine weather forecasts, different types of weather messages, organisations providing forecasts, and the use of forecasts to deduce probable weather conditions and changes. It also addressed the reliability of forecasts in relation to forecast intervals and duration.

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[35] Met Office: Understanding ensemble forecasting

[36] SWIC 3.0

[37] MSN 1858 (M) Amendment 1 – Training & Certification Guidance: UK Requirements for Deck Officers on Large Yachts (24m and over), published 10 January 2023. This publication was withdrawn on 21 May 2026 and replaced with MSN 1858 (M) Amendment 2.

The meteorology training module did not include thunderstorms, waterspouts, downbursts, downdrafts or mesocyclonic supercells. Neither did it cover how local observations may be used to increase forecast accuracy, or the risks that such weather systems might pose to a sailing vessel.

1.13.2 Large yacht certification scheme

The UK's large yacht certification scheme began in 1997, with the publication of LY1. The code provided an alternative regulatory framework based on equivalent levels of safety to international conventions including the International Convention on Load Lines, 1966 (ICLL). LY1 was revised and reissued as LY2 in 2004, introducing updated technical requirements and provisions for short-range yachts. LY2 was updated to edition 2 on 17 September 2007. A further revision, LY3, came into force in 2013, incorporating further technical developments and the requirements of the International Labour Organization's Maritime Labour Convention, 2006.

The Red Ensign Group (REG) is a partnership of British shipping registries comprising the UK, Crown Dependencies, and UK Overseas Territories that operate ship registries[38]. In 2019, the requirements for the certification of large yachts across the REG were consolidated into the Red Ensign Group Yacht Code (REG Yacht Code), creating a unified code for both large commercial yachts and passenger yachts registered in the REG administrations.

Bayesian was initially surveyed against the requirements of LY2 edition 2. As the codes were revised and reissued, some elements of the revised codes were applied retrospectively to existing large yachts. Weathertight integrity and stability requirements for vessels of *Bayesian*'s size and type remained unamended when both LY3 and the REG Yacht Code were introduced.

When *Bayesian* transitioned to become a pleasure vessel, the requirements set out in LY2 and any retrospectively applied by LY3 or the REG Yacht Code, as well as the requirements of the ICLL, ceased to apply.

1.13.3 Pleasure vessel standards

The MCA provided guidance to the operators of pleasure vessels in its MGN 599 (M). This guidance note directed vessel owners and crew members to the requirements for the operation of UK registered pleasure vessels. Pleasure vessels of greater than 13.7m in length were defined in the legislation as Class XII vessels. The guidance included topics subject to regulation including, among others, manning and lifesaving appliances.

1.13.4 Weathertight integrity

The requirements for the weathertight integrity of large yachts set out in LY2 were aligned with those of the ICLL. LY2 did allow for arrangements that were considered to provide an equivalent level of safety and generally required hatches to be kept closed at sea.

[38] The REG comprised the shipping registries of the UK, Isle of Man, Guernsey, Jersey, Anguilla, Bermuda, British Virgin Islands, Cayman Islands, Falkland Islands, Gibraltar, Montserrat, St Helena and the Turks & Caicos Islands.

Special consideration was required for windows positioned below the freeboard deck, noting the need for operational instructions to be provided to the master as to when strong protective covers should be fitted.

The ventilation of compartments such as the machinery space, which needed to remain open, also required special consideration, taking into account the effect of downflooding. Engine exhausts were to be provided with means to prevent back flooding into the hull through a damaged exhaust system.

1.13.5 Stability requirements

Bayesian was initially assessed against the intact stability standard related to monohull sailing vessels set out in section 11.2.2.1 of LY2. For compliance with LY2, statical stability curves were required to be produced for at least the loaded departure (100% consumables on board) and loaded arrival (10% consumables on board) conditions.

When outlining these statical stability curves, LY2 required monohull sailing vessels to have a positive range of stability of not less than 90°, although for vessels of *more than 45m, a range of less than 90° may be considered but may be subject to agreed operational criteria*.

Additionally, a derived heel angle, obtained from the intersection of a derived wind heeling lever curve and the statical stability curve had to be greater than 15° **(Figure 9)**. LY2 stated that if the derived heel angle was less than 15° *the vessel will be considered as having insufficient stability for the purpose of the Code*.

Base image from LY2 The Large Commercial Yacht Code, Edition 2

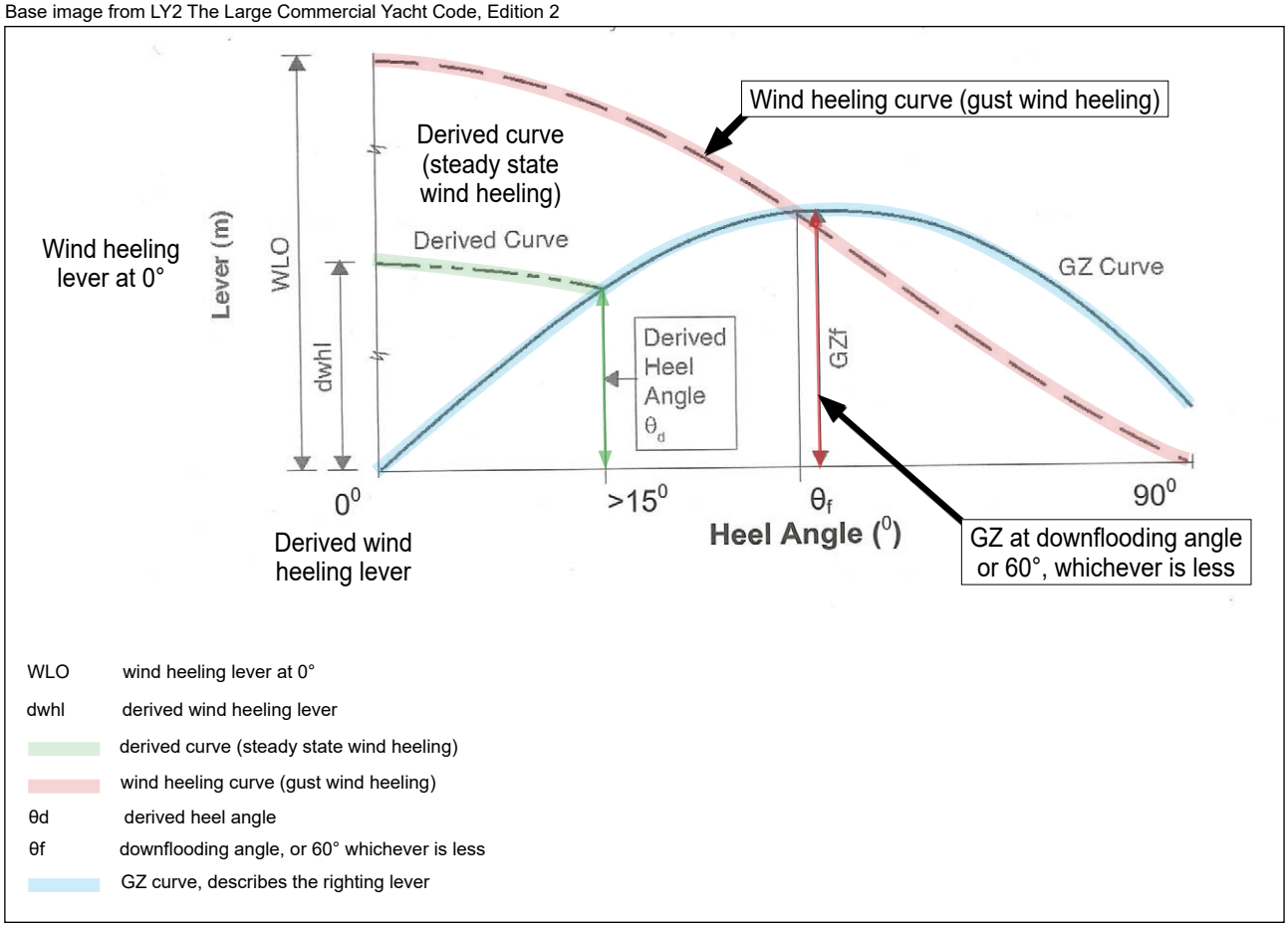


Figure 9: An example GZ curve of statical stability as described in LY2

Downflooding angles were to be determined considering all *regularly used openings for access and for ventilation*, with the limitation that no hull opening, regardless of size, that could lead to progressive flooding *should be immersed at an angle of heel of less than 40*°, although air pipes to tanks could be disregarded.

LY2 noted, that providing a vessel complied with the requirements for statical stability, angle of steady heel and downflooding angles, and was sailed with an angle of heel no greater that the derived angle of heel, then *it should be capable of withstanding a wind gust equal to 1.4 times the actual wind velocity* without immersing the downflooding openings *or heeling to an angle greater than 60°*.

There was a requirement in LY2 for vessels to be provided with an approved SIB. The content, form and presentation of the information in the SIB was to conform to a published model booklet for the vessel type. For sailing vessels, a copy of the SIB's '*Curves of Maximum Steady Heel Angle to Prevent Downflooding in Squalls*' was required to be available for ready reference by a watchkeeper.

Bayesian did not have any requirement for stability as a pleasure vessel operating under the requirements referenced in MGN 599 (M).

1.13.6 Liferaft requirements

The arrangement of the stowage, launching and float-free arrangements for the liferafts on board *Bayesian* was approved against the requirements of LY2 when it was built. Liferafts were to be stowed on the weather deck, or in an open space, and be fitted with HRUs. The HRUs were designed to operate when submerged to a depth of between 1.5m and 4m so that the liferafts would float free from the vessel and automatically inflate. The later REG Yacht Code required that:

> *Liferafts which form part of the float free complement for all vessels regardless of length or GT shall be capable of floating free, clear of any obstructions with the vessel in the upright condition.*[39]

Neither LY2 nor the REG Yacht Code considered the float-free capability of liferafts carried on monohull sailing vessels following a knockdown.

The liferaft stowage arrangements on *Bayesian* remained unchanged when the vessel became a pleasure vessel. The arrangements were aligned with the requirements referenced in MGN 599 (M)[40], which required that liferafts be stowed so that:

> *the liferaft floats free and, if inflatable, inflates automatically when the ship sinks.*

[39] REG Yacht Code, section 13.3 (7).

[40] MGN 599 (M) referred to SI 1999 No. 2721: the Merchant Shipping (Life-Saving Appliances for Ships other than Ships of Classes III to VI (A)) Regulations 1999.

1.14 PREVIOUS SIMILAR ACCIDENTS

1.14.1 *Island Bay* – downflooding, capsize and grounding

On 10 September 2022, the 9.91m passenger vessel *Island Bay* flooded, capsized and drifted aground in Carpenter Bay, British Columbia, Canada. The Transportation Safety Board of Canada (TSB) investigation (TSB report M22P0259[41]) found that the cumulative effect of modifications to *Island Bay* had reduced the vessel's stability and made it susceptible to heeling, downflooding and capsize. Sustained exposure to the sea, tidal stream and wind onto the vessel's side made *Island Bay* heel significantly. The combination of environmental effects allowed water to be shipped on deck, causing the vessel to list. This led to downflooding until the point at which all reserves of buoyancy were lost and *Island Bay* capsized.

1.14.2 *Concordia* – knockdown, capsize and foundering

On 17 February 2010, the 46.5m sail training yacht *Concordia* was knocked down, capsized and sank 300nm miles south-south-east of Rio De Janeiro, Brazil. The 64 crew and trainees on board all managed to abandon ship to the vessel's liferafts and were all rescued on 19 February 2010. The TSB investigation (TSB report M10F0003[42]) found that the vessel had been knocked down in a squall associated with a likely meteorological downburst, *Concordia* was also vulnerable to moderate wind speed increases, and that guidance on the use of squall curves was not required on many sail training vessels. Additionally, training in the use of squall curves was not required for crew certification in sail training vessels. The investigation also found that the risk of knockdown, despite being well known, had not resulted in their consequences being prepared for: three of eight liferafts became inaccessible, a further liferaft was damaged following deployment and the remaining four liferafts were difficult to release. The report further identified that, despite indications of the impending weather, the officer of the watch did not perceive any threat to the vessel.

The TSB issued Marine Safety Advisory Letter 06/10: Considerations and Precautions Regarding Knockdown of Sailing Vessels highlighting the risks of knockdowns in sail training vessels, and advised operators to review their procedures when in squalls. The TSB also recommended that initiatives be undertaken to adopt international standards on the provision of stability guidance to assist officers assessing the risk of knockdown and capsize.

1.14.3 *Pride of Baltimore* – knockdown, capsize and foundering

On 14 May 1986, the 27.4m sailing vessel *Pride of Baltimore* was knocked down, capsized and foundered with the loss of four lives about 250nm north of Puerto Rico in the Caribbean Sea. The USA National Transportation Safety Board (NTSB) investigation (NTSB report PB87-916401[43]) found that the *Pride of Baltimore* had been knocked down to port after a sudden thunderstorm downburst of high velocity winds that exceeded the limits of the vessel's stability. Following the knockdown there was extensive downflooding due to the lack of watertight bulkheads in the hull.

[41] TSB Canada report M22P0259: Island Bay

[42] TSB Canada report M10F0003: Concordia

[43] NTSB report PB87-916401: Pride of Baltimore

Liferafts were challenging to access as they were stowed under the tiller and had to be released by hand. One liferaft was eventually orally inflated and eight of the 12 crew survived after drifting in it for over four days.

The vessel's crew were unaware of the impending hazard because they had no forecast for the high winds, or any warnings of the potential for these to develop near thunderstorms. The NTSB made a recommendation to the US National Weather Service to include in its Marine High Seas forecasts a warning of the potential for rapidly developing high winds near thunderstorms. This recommendation was particular to situations where no specific knowledge of thunderstorm intensity was available.

SECTION 2 – ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 OVERVIEW

Bayesian was knocked down by extreme winds that were not explicitly forecast. *Bayesian* did not recover, downflooded and sank. No liferafts were released automatically. The crew released one liferaft manually and it was boarded by 15 survivors before their rescue. One crew member and six passengers drowned.

This section of the report examines the factors that contributed to the foundering of *Bayesian*, including the yacht's stability and the effects of high wind on its ability to remain upright with no sails set; the weather information available; crew preparations; and the provision of lifesaving equipment.

2.3 THE ACCIDENT

Bayesian was anchored close to the breakwater at Porticello before it foundered. The weather forecasts received during the day before the accident had identified the possibility of thunderstorms in the general area around Porticello, but did not explicitly warn of the risk of accompanying winds. *Bayesian*'s master recognised the possibility of strong winds and had left instructions to be woken by the overnight watchkeepers if the wind speed rose or the yacht started dragging the anchor.

The winds were light and the seas calm when *Bayesian*'s crew and guests retired for the night, and they were unaware of the possibility of significant weather of the magnitude experienced passing through the anchorage. The local weather remained benign until about 11 minutes before the knockdown.

The master and off-duty crew were woken up when the wind increased beyond the limit set by the master in their night orders and *Bayesian* began to drag its anchor. Having had recent experience of dragging anchor in strong winds, the master and crew did not perceive any immediate danger from the yacht's movement. Some of the crew started to prepare the main engines to enable the master to manoeuvre *Bayesian* while others started to secure loose items of equipment and mitigate the effects of the wind and the heavy rain.

The shore was approximately 5nm away to the south-south-east in the direction *Bayesian* was travelling. The need for urgent action to manoeuvre the yacht away from a possible grounding was not immediate.

None of the crew on board *Bayesian* were aware of a risk of knockdown in high winds when the sails were not raised. They did not therefore perceive an immediate need to close and secure all external hull doors and flush hatches to improve its weathertight integrity to account for such a risk.

As the wind increased and *Bayesian* heeled over to starboard at an estimated angle of between 10° and 20°, the yacht reached an angle similar to that experienced while under sail. The downflooding points on board were not immersed at this angle of heel. The crew's continued perception was that dragging the anchor and weather damage to items of upper deck furniture were the only risks to be managed.

The crew were unaware of the critical knockdown hazard and were focused on minimising anchor drag and securing the yacht. By attempting to use the engines to point *Bayesian* into the wind, the master was inadvertently also acting to reduce the risk of knockdown; however, there was insufficient time to complete the manoeuvre.

The postmortem reports indicated the presence of alcohol in all of the deceased. Recognising the possibility that at least a proportion of the alcohol found was generated after death, the levels detected are not considered to have influenced the outcome of the accident.

Six passengers and one crew member died when *Bayesian* was knocked down by an extreme wind that heeled it over to an angle from which it could not recover. Flooding into the internal spaces of the vessel caused it to founder approximately 18 minutes later.

2.4 VESSEL STABILITY

2.4.1 Vulnerability in the motoring condition

The initial study conducted by the Wolfson Unit compared the stability model used by the MCA for the original approval of the SIB with the yacht as examined after the accident. While the stability model used by the MCA had simplified some aspects, the effect was not significant and the Wolfson Unit study concluded that the SIB reflected the stability of the yacht to an acceptable degree.

The SIB included curves of maximum steady heel angle to prevent downflooding in gusts for various sailing conditions. The Wolfson Unit studies showed that the mast and furled sails contributed significantly to the heeling moment applied to the vessel by wind but the SIB did not include any information on its effect in the motoring condition with the centreboard raised and no sails set. The crew on board were therefore unaware of the risk that high winds posed to *Bayesian* in this configuration.

Similar to the accident involving *Concordia* in 2010, without knowledge of the vulnerability of *Bayesian* to extreme weather, no actions to mitigate the risk of knockdown in the motoring condition had been identified and included in the SIB for the guidance of the crew.

The vulnerability of *Bayesian* to wind heeling moments while in the motoring condition had never been assessed, resulting in the crew being unaware of a critical risk to the vessel and unable to take account of it in their operations.

2.4.2 Knockdown risk

Knockdown was a recognised hazard for a vessel under sail. *Bayesian*'s master was aware that this risk extended to large yachts, having previously experienced one. That vessel had recovered successfully.

When under sail, *Bayesian* had an identified angle of vanishing stability of less than the 90° stipulated in LY2 that the SIB had been originally approved against. The reduced angle of vanishing stability was identified when the vessel was in the light load sailing condition with the centreboard lowered. To use the relaxation of this requirement provided for larger yachts in LY2, *Bayesian* was fitted with a sail control system that would automatically shed load from the sails to minimise the knockdown risk.

Independent of the sail monitoring and control system, the crew were able to reef, furl or drop the sails when sailing to further mitigate any risk of knockdown. Such mitigations did not apply to the motoring condition with no sails up and, in any case, the vessel's vulnerability to knockdown in this condition was unknown because it had not been assessed.

The Wolfson Unit study commissioned by the MAIB indicated that, in the conditions assessed, *Bayesian* was vulnerable to extreme winds on the beam. Further, that any knockdown in this condition would be irrecoverable once the yacht passed the angle of vanishing stability, assessed in the probable loss condition as being 73°. Regardless of the wind velocity, once *Bayesian* had passed this angle of heel it could not right itself.

The derived wind heeling data in the Wolfson Unit study for the probable loss condition identified that when the yacht was initially heeled to between 10° and 20° it was at an angle where a risk of knockdown from a significant gust of wind likely existed.

It was not possible to determine the effect of the movement of items on board *Bayesian* as the heel increased. The movement of liquids, stores and other items would have increased the heeling moment, reducing the ability of the vessel to resist capsize.

The winds experienced were almost certainly of sufficient magnitude and duration to cause a heeling moment that resulted in *Bayesian* heeling beyond its angle of vanishing stability, an angle from which it could not recover.

2.4.3 Stability information booklet guidance

Bayesian's SIB provided generic guidance to the master on the prevention of capsize. This guidance did not define what might be considered *adverse weather* or a *severe squall* or when specific interventions would be required. Only the instruction to keep the door from the engine room to the lazarette closed when the port side shell door was open related to the yacht being at anchor. On the night of the accident that shell door was shut.

The SIB listed actions to be taken by the crew to prepare for a rough weather passage. However, *Bayesian* was not intending to depart on passage through heavy weather at the time of the accident so such activities were neither planned nor initiated before the yacht was knocked down.

Other than providing a generic instruction to close the openings on board *Bayesian* before departing in heavy weather, the SIB did not set out any need to do so at anchor. Similarly, it did not provide guidance on how to manoeuvre the yacht to account for such weather.

When in the lowered position, the centreboard lowered *Bayesian*'s centre of gravity and therefore increased the yacht's righting moment. However, the SIB only indicated that the centreboard needed to be in this position in the sailing conditions it contained.

Lowering of *Bayesian*'s centreboard while at anchor increased the yacht's propensity to yaw, increasing the likelihood of it dragging its anchor. With no guidance in the SIB, or elsewhere, about use of the centreboard at anchor, it was not the practice to have it lowered. This reduced the risk of dragging the anchor, a risk that the crew were aware of, but inadvertently increased the vulnerability of *Bayesian* to knockdown in high winds; a risk that the crew were unaware of.

Bayesian's SIB contained generic instructions on when or why precautions for watertight integrity and downflooding should be applied. This limited its usefulness in supporting the crew's preparations for an approaching storm when the yacht was at anchor.

2.4.4 Downflooding

Bayesian's crew were unaware of the risk of knockdown when in the motoring condition and the SIB did not define under what circumstances the listed generic precautions against downflooding should be applied. The crew's actions in the lead-up to the accident were therefore in response to the heavy rain and dragging of the anchor and not specifically to mitigate any risk of downflooding in the event of excessive heel. With no perceived need, some external doors, flush hatches and hull openings remained unsecured.

Bayesian initially heeled over to an angle estimated to be between 10° and 20° to starboard. At this angle none of the openings that would allow water to enter the hull were immersed, and no downflooding occurred.

At the point of knockdown, *Bayesian* took less than 15 seconds to go from the previous 10° to 20° of heel to lying flat in the water. During this period, downflooding would start, allowing water to enter through the yacht's openings.

In the light load motoring condition set out in the SIB, critical flooding would begin when the angle of heel passed through 47.5° with progressive flooding into other spaces as the angle of heel increased further. Water would also enter over the sides of the yacht.

Bayesian was knocked down in a very short period of time. It is therefore unlikely that the volume of water entering the vessel during the period between the downflooding points being first immersed and the yacht lying on its side had any material effect on the knockdown. Once past the angle of vanishing stability, *Bayesian* was unable to right itself.

When *Bayesian* was lying on its side, the open accesses near the centreline leading to the guest and crew accommodation spaces would also have been at least partially submerged. Similar to the accidents involving *Concordia* and *Pride of Baltimore*, once knocked down, water was able to freely flow into the below-deck compartments.

It was not possible to determine whether the sinking would have been prevented or slowed significantly had all openings been shut and secured. The state of openings had negligible impact of the knockdown and only become relevant once *Bayesian* was on its side and capsizing.

The effect of the very heavy rainfall *Bayesian* experienced was considered in the second Wolfson Unit study. It was determined that the influence of rain accumulating between decks was not a significant factor in the time *Bayesian* was exposed to it.

It is unlikely that downflooding into *Bayesian*'s internal spaces had a material effect on its foundering until the yacht was lying on its side, by which time it was unable to right itself.

2.4.5 Red Ensign Group Yacht Code requirements

Bayesian was a monohull sailing vessel built to the requirements of LY2. Although not required, it was maintained substantially to the standards of that code and the applicable requirements of the REG Yacht Code.

LY2 allowed *Bayesian* to have an angle of vanishing stability of less than 90° and the *agreed operational criteria* required by LY2 was contained in the approved SIB. The agreed operational criteria related to the automatic sail monitoring and control system and its ability to shed the wind heeling load with the yacht under sail.

Wind heeling levers were a factor in the accidents involving both *Concordia* and *Pride of Baltimore*. Both LY2 and the later REG Yacht Code required curves of statical stability and wind heeling limits to be provided, but only for vessels when in the sailing condition. However, like the accident involving *Island Bay*, high winds had the ability to generate significant heeling moments for *Bayesian* while in the motoring condition with sails down.

The Wolfson Unit study concluded that *Bayesian*, in its probable loss condition, similar to the motoring condition with sails down and the centreboard in the raised position, was vulnerable to winds on the beam. It further concluded that the steady state wind heeling limit and the angle of vanishing stability in this condition were lower than when in the sailing condition.

Neither LY2 nor the later REG Yacht Code required the assessment of the vulnerability of monohull sailing yachts with an angle of vanishing stability below 90° to high winds when operating without sails set, placing the people on such vessels at an undetermined risk.

2.4.6 Approval of minimum downflooding angle

The list of openings and their associated downflooding angles contained in the SIB indicated that there were openings on *Bayesian* that became immersed at an angle of heel of less than 40°.

The LY2 requirement for minimum downflooding angle stated that *No opening regardless of size which may lead to progressive flooding should be immersed at an angle of heel of less than 40*°. It did not reference the greater critical flooding

angle that was a calculated value based on the area of the openings progressively immersed with increasing angle of heel. The approved SIB did not comment on how these openings were treated against the LY2 requirement.

At the time that the SIB was approved, *Bayesian* did not meet the LY2 requirements for minimum downflooding angle and was therefore vulnerable to progressive flooding at angles below that required by the code.

2.5 WEATHER AND CLIMATE INFORMATION

2.5.1 Weather forecasts

Prior warning of low probability, high impact events is a significant challenge to all weather forecasters. The official forecasts of Météo-France and CNMCA for the night of the accident predicted sustained winds of up to force 5, with gusts of up to 40% stronger, across the Lipari sea area and Tyrrhenian Sea coastal regions. Having specifically mentioned thunderstorms, these official forecasts further described associated strong wind gusts but did not detail their strength or severity.

High observed values for CAPE and elevated sea surface temperatures both meant that there was significant energy feeding the weather system. The resulting instability meant that damaging winds were possible along the north coast of Sicily. The forecasts did not account for features and no associated warnings for violent winds or downbursts were issued. Other than this specific risk, the official forecasts did reflect the predominant weather experienced across the wider sea areas and coastal regions in question.

From the time *Bayesian*'s master went to bed on 18 August 2024 until the time of the accident, there were no weather forecasts that explicitly warned of the risk of downbursts with damaging hurricane force winds.

The master had recognised the possibility of high winds, leaving instructions to be woken by the overnight watchkeepers should this rise above a set limit. However, similar to the findings of the investigation into the knockdown and foundering of *Pride of Baltimore*, the official weather forecasts did not forewarn the crew of *Bayesian* to the risk of extreme weather and of the possibility of hurricane force winds.

The official weather forecasts for the area of the accident, although broadly accurate, did not communicate the potential severity and impact of the predicted thunderstorms, limiting the crew's ability to recognise the developing hazard and take timely action.

2.5.2 The weather experienced

It is not possible to determine the exact weather phenomenon that generated the extreme winds experienced in the anchorage off Porticello on 19 August 2024. Reported sightings of a feature resembling a waterspout could not be discounted. However, all of the possible weather events analysed contained the potential to generate extreme wind speeds.

The very localised winds experienced made both *Sir Robert Baden Powell* and *Bayesian* drag their anchors in a near-straight line, making it most likely that the winds persisted in the same direction during the period while the vessels were dragging. As waterspouts do not feature straight-line winds, they were unlikely to have been the driving weather phenomenon during the accident.

The extreme winds experienced by *Bayesian* were most likely the result of a downburst associated with a convective windstorm.

2.5.3 Guidance on weather features

Mobile depressions, thunderstorms and waterspouts were described in NP45's general information on weather features that may be encountered in the Mediterranean Sea.

The general meteorological guidance provided in NP100 included specific information related to tropical storms and using local observations to determine how forecast weather might be experienced locally. However, it did not contain reference to thunderstorms, waterspouts, downbursts, downdrafts or mesocyclonic supercells, or how these features might change with local effects and features.

On board *Bayesian*, and in all the previous similar accidents identified, the impact of the local environment was significantly underappreciated by those facing the effects of the weather at the time.

The guidance provided in the UKHO's Admiralty publications provided insufficient information for thunderstorms, waterspouts, downbursts, downdrafts or mesocyclonic supercells to help mariners prepare for the risks they present.

2.5.4 Training requirements for meteorology

The required knowledge of seamanship and meteorology for the issue of a UK certificate of competency for masters serving on large yachts was contained in MSN 1858 (M) Amendment 1. The holder of a UK certificate of competence was not required to understand the factors that could contribute to the generation of squalls and violent wind gusts. The report into the loss of *Concordia* identified a lack of knowledge of squall curves on sailing vessels as being contributory to that accident.

Local effects can modify the predominant weather experienced more broadly across a larger geographic area. With mountains nearby, elevated sea surface temperatures and forecast thunderstorms, there was much to indicate that such local effects could impact the weather in the anchorage off Porticello. The significance of all these weather features was not detailed in official guidance or training, limiting the ability of *Bayesian*'s crew to interpret their observations and the information available to assess the level of risk present.

The UK training syllabus for masters of large sailing vessels did not provide sufficient information to support the assessment of risk when proximate to severe thunderstorms.

2.6 ESCAPE AND LIFESAVING

2.6.1 Accommodation escape routes

Guests G1 and G2 were already awake when *Bayesian* was knocked down and escaped from their cabin on the lower deck, exiting via the main guest stairwell into the saloon. They were the only people to escape from the guest cabin area once *Bayesian* was lying on its side.

The investigation did not have access to dive records identifying the precise locations of the casualties and debris within the wreck. These records might have assisted in determining their movements following the knockdown. It is therefore unknown why the other guests in the accommodation areas were unable to escape.

The remaining people in the guest cabin area, and any loose items, would have fallen to the starboard side when *Bayesian* was knocked down. For those in cabins on the yacht's starboard side, it is likely that they were either thrown into a position from where they were unable to ascend to reach the exit from their cabins or lacked the physical ability to do so. For those on the port side, it is possible that falling debris may have blocked the inward opening doors. Any delay increased the likelihood that the incoming water would prevent their escape.

The chef was last seen in the galley, and it is most likely that he was in this compartment when the knockdown happened. The chef would have been subject to the same issues as those in the cabin area; falling to the starboard side of the space along with any loose items and having to ascend to escape the compartment.

Though the chef probably sustained his injuries during knockdown, given he was located outside the wreck, it is almost certain that he did manage to escape the hull following the knockdown. The investigation was unable to establish what route he took to escape or whether he left doors or hatches open behind him.

The rapid knockdown of *Bayesian* limited the time available to escape from the lower deck. Occupants were hindered by altered orientation, potential obstructions and rapidly worsening flooding conditions, which significantly reduced their ability to escape the yacht before it sank.

2.6.2 Abandon ship

The accident to *Bayesian* developed within a short period of time; from apparently benign conditions at 0352, to dragging anchor at around 0357, then to being knocked down in hurricane force winds at 0406.

In the early stages of the accident there was no perceived need to alert the guests. The speed and distance that both *Bayesian* and *Sir Robert Baden Powell* were dragging their anchors gave no immediate concern that the vessels would run aground or require the mustering of the guests on board either vessel. When *Bayesian* was knocked down, all those on board reacted to the situation they found themselves in, and any attempt to initiate the emergency procedures became superfluous.

During the abandonment of *Bayesian*, the crew needed to respond to a rapidly developing situation that had not been anticipated in the on board drills. The master was able to direct the abandonment, overseeing the evacuation of the guests and crew in the upper areas of the vessel, and instructing survivors to enter the water and swim clear.

Crew members took independent action where necessary, including the release of the EPIRB to transmit a distress alert and the delivery of first aid to the injured.

The manual release of the liferaft from *Bayesian* provided the means for those crew and guests able to escape from the vessel to survive while awaiting rescue. *Bayesian*'s crew were familiar with the equipment inside the liferaft, and this enabled them to signal for assistance and care for the people on board.

The emergency procedures and drills undertaken on board *Bayesian* did not anticipate a casualty of a type or pace that effectively bypassed the formal muster and evacuation arrangements.

The safety of those crew and guests able to leave *Bayesian* following the accident relied heavily on the training, experience and initiative of individual crew members.

2.6.3 Liferaft release

None of the liferafts on *Bayesian* were released automatically from the yacht when it foundered, requiring the crew to manually release the port side forward liferaft.

When *Bayesian* was initially knocked down, the liferafts on the starboard side were inaccessible and it was not possible to determine whether the HRUs had activated at that time. At the point of knockdown, the HRUs for the port side liferafts were unlikely to have submerged sufficiently for the hydrostatic pressure to activate them.

After the accident, all of the HRUs were found to have operated and the buoyant liferafts were held in place by the stowage arrangement. Two of the three liferafts that remained on board when *Bayesian* sank were released from the wreck during the salvage operation. Both liferafts operated as designed on release, inflating and separating from the vessel.

The liferaft stowage arrangements on *Bayesian* met the regulatory requirements to which they were initially surveyed. LY2 required liferafts to release, float free and inflate but did not specifically require consideration of their ability to do so after a knockdown. Later regulation in the REG Yacht Code required only that liferafts be capable of floating free, clear of any obstructions with the vessel in the upright condition.

Regulatory requirements for the float-free arrangements for liferafts did not adequately account for the knockdown and sinking scenario applicable to large sailing yachts.

SECTION 3 – CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. Six passengers and one crew member died when *Bayesian* was knocked down by an extreme wind that heeled it over to an angle from which it could not recover. Flooding into the internal spaces of the vessel caused it to founder approximately 18 minutes later. [2.3]

2. The vulnerability of *Bayesian* to wind heeling moments while in the motoring condition had never been assessed, resulting in the crew being unaware of a critical risk to the vessel and unable to take account of it in their operations. [2.4.1]

3. The extreme winds experienced were almost certainly of sufficient magnitude and duration to cause a heeling moment that resulted in *Bayesian* heeling beyond its angle of vanishing stability, an angle from which it could not recover. [2.4.2]

4. *Bayesian*'s SIB contained generic instructions on when or why precautions for watertight integrity and downflooding should be applied. This limited its usefulness in supporting the crew's preparations for an approaching storm when the yacht was at anchor. [2.4.3]

5. It is unlikely that downflooding into *Bayesian*'s internal spaces had a material effect on its foundering until the yacht was lying on its side, by which time it was unable to right itself. [2.4.4]

6. Neither LY2 nor the later REG Yacht Code required the assessment of the vulnerability of monohull sailing yachts with an angle of vanishing stability below 90° to high winds when operating without sails set, placing the people on such vessels at an undetermined risk. [2.4.5]

7. The official weather forecasts for the area of the accident, although broadly accurate, did not communicate the potential severity and impact of the predicted thunderstorms, limiting the crew's ability to recognise the developing hazard and take timely action. [2.5.1]

8. The extreme winds experienced by *Bayesian* were most likely the result of a downburst associated with a convective windstorm. [2.5.2]

9. The guidance provided in the UKHO's Admiralty publications provided insufficient information for thunderstorms, waterspouts, downbursts, downdrafts or mesocyclonic supercells to help mariners to prepare for the risks they present. [2.5.3]

10. The UK training syllabus for masters of large sailing vessels did not provide sufficient information to support the assessment of risk when proximate to severe thunderstorms. [2.5.4]

3.2 SAFETY ISSUES NOT DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. Regulatory requirements for the float-free arrangements of liferafts did not adequately account for the knockdown and sinking scenario applicable to large sailing yachts. [2.6.3]

3.3 OTHER SAFETY ISSUES NOT DIRECTLY CONTRIBUTING TO THE ACCIDENT

1. At the time that the SIB was approved, *Bayesian* did not meet the LY2 requirements for minimum downflooding angle and was therefore vulnerable to progressive flooding at angles below that required by the code. [2.4.6]

2. The rapid knockdown of *Bayesian* limited the time available to escape from the lower deck. Occupants were hindered by altered orientation, potential obstructions and rapidly worsening flooding conditions, which significantly reduced their ability to escape the yacht before it sank. [2.6.1]

3.4 SAFETY LEARNING

1. The safety of those crew and guests able to leave *Bayesian* following the accident relied heavily on the training, experience and initiative of individual crew members. [2.6.2]

SECTION 4 – ACTIONS TAKEN

4.1 MAIB ACTIONS

The **MAIB** has:

- Issued an interim report into the accident **(Annex C)**.
- Issued a safety flyer to the yachting industry **(Annex D)**.
- Prepared a paper detailing the hazards identified in this report, for consideration by the casualty analysis group, to be submitted to the 13th session of the IMO Sub-Committee on Implementation of IMO Instruments (III).

4.2 ACTIONS TAKEN BY OTHER ORGANISATIONS

No safety actions have been taken by other organisations.

SECTION 5 – RECOMMENDATIONS

The **Red Ensign Group** is recommended to:

2026/162 Complete a study of the vulnerability of monohull sailing vessels that are certified under the Red Ensign Group Yacht Code to the risk of knockdown with no sails set.

2026/163 Amend the Red Ensign Group Yacht Code as appropriate to the study's findings and publish guidance on identified vulnerabilities.

2026/164 Amend guidance on the content of the stability information booklet carried on board vessels certified to the Red Ensign Group Yacht Code with respect to preparations to be taken in advance of forecast extreme weather, whether underway or at anchor.

2026/165 Amend the Red Ensign Group Yacht Code to ensure that liferafts installed on all sailing vessels vulnerable to knockdown are stowed to permit them to float free from their stowage, inflate, and break free from the vessel in the event of its sinking.

The **Maritime and Coastguard Agency** is recommended to:

2026/166 Review and, where appropriate, amend yacht officer seamanship and meteorology syllabi to ensure candidates can recognise severe convective weather hazards including thunderstorms, downbursts and extreme wind gusts to assist in the application of appropriate precautions when sailing, motoring or at anchor.

The **Met Office** is recommended to:

2026/167 Invite the World Meteorological Organization Worldwide Met-Ocean Information and Warning Service Sub-Committee to consider how low likelihood, high-impact weather hazards should be represented within future data services.

The **UK Hydrographic Office** is recommended to:

2026/168 Liaise with the Met Office and Maritime and Coastguard Agency to develop and update guidance on the risks of extreme weather events for inclusion in NP45: Admiralty Sailing Directions – Mediterranean Pilot Volume 1 and NP100: Admiralty – The Mariner's Handbook as appropriate.

Safety recommendations shall in no case create a presumption of blame or liability

Wolfson Unit Report No. 2950mp-ms_Rev3, dated 24 April 2025: *Bayesian*: Assumed loss condition

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Marine Accident Investigation Branch

Stability and Windage Analysis of S/Y Bayesian

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EXECUTIVE SUMMARY

This report presents the stability and windage analysis of S/Y Bayesian based on input data provided by MAIB. These data include the vessel's approved Stability Information Book (SIB), various technical drawings of the hull, rigging and superstructure, and a hull form definition by the Maritime and Coastguard Agency (MCA). This data was used to derive a digital stability model of the vessel and a windage model of the hull, superstructure and rigging.

The digital stability model enabled the stability assessment of the vessel over a range of motoring load conditions. The windage tool was used to estimate the aerodynamic loading on various components of the rigging, and to derive the wind heeling moment at a range of apparent wind angles, strengths and gradients. The windage tool includes the results of a 3D Computational Fluid Dynamics (CFD) assessment of the 2D mast section.

The digital stability model of the vessel and the aerodynamic loading tool were combined to estimate the maximum gust velocity magnitude the vessel could withstand given its stability characteristics.

A number of inconsistencies have been identified between the supplied information and the SIB digital stability model. These were addressed in a digital stability model created independently by the Wolfson Unit, which was subsequently used to calculate the vessel's stability. Even though differences have been observed between the SIB and the Wolfson models, these had no significant impact on the overall stability characteristics of the vessel at the loading conditions evaluated.

With the wind on the beam and the vessel in the motoring light load condition, the wind heeling tool predicts that an envelope of limiting wind speed of 53 – 63 knots could capsize the vessel.

ABBREVIATIONS AND ACRONYMS

AP	Aft Perpendicular
AVS	Angle of Vanishing Stability
AWA	Apparent Wind Angle
AWS	Apparent Wind Speed
BL	Base Line
CFD	Computational Fluid Dynamics
Cx	Aerodynamic Drive Force Coefficient
Cy	Aerodynamic Side Force Coefficient
FP	Forward Perpendicular
Fr.	Frame
GHS	General Hydrostatics software suite by Creative Systems, Inc.
GZ	Righting Lever
HST	Hydrostatics and Stability software suite by the Wolfson Unit
INAB	Ingenieros Navales Asociados de Baleares S.L.
LBP	Length Between Perpendiculars
LCB	Longitudinal Centre of Buoyancy
LCF	Longitudinal Centre of Flotation
LCG	Longitudinal Centre of Gravity
MAIB	Marine Accident Investigation Branch
MCA	Maritime and Coastguard Agency
MP	Midships Position
SIB	Stability Information Book
USK	'Underside of Keel' or 'Keel Line'
VCG	Vertical Centre of Gravity

GLOSSARY

Capacity Plan	a 2D technical drawing showing size and position of a vessel's tanks
Displacement	weight of water that is displaced by the underwater portion of a floating body taking into account the specific gravity of the water
General Arrangement	a 2D technical drawing showing a vessel's layout and internal subdivision
Lines Plan	a 2D technical drawing of a vessel's hull and its appendages
Sail Plan	a 2D technical drawing showing the mast, rigging and sails in the hoisted position

1 HULL MODELLING AND VALIDATION

This section discusses the digital stability models:

- "Copy 2 of CM 65000 -Salute' - Perini Navi C2095.hst" of Figure 1
- "HULL H.8 - Copy 2 of CM 65000 -Salute' - Perini Navi C2095_Base Model.hst" of Figure 2.

1.1 MCA hull modelling

The MCA hydrostatics had 15-17 tonnes excess displacement (or 3 - 4%) compared to the Stability Information Book (SIB) hydrostatics, over 3.7 to 4.0m draught. Re-calculation of the unmodified MCA model confirmed these results. Further inspection of the MCA model highlighted the inconsistencies presented in Tables 1 and 2.

Table 1 - Key inconsistencies between MCA model and Perini Navi drawings

No.	Description	Impact on MCA validation process
1	~32m^3 excess buoyancy in way of skeg due to incorrect centre board case model NOTE: 1m^3 excess buoyancy = 1.025t excess displacement at any given draught	- MCA model ~33t heavier than SIB at any given draught. - the more buoyant MCA hull floats higher than SIB hull at any given loading.
2	MCA skeg is 100mm shallower than the as-designed skeg, resulting in 1.6m^3 less buoyancy. This is evidenced by skeg depth measurements made on the digitized C.2095 Capacity Plan, at Frames 9, 9+460, 11.5, 16 and 18.	MCA model ~2t lighter than SIB at any given draught.
3	MCA rudder has 1.3 m^3 less buoyancy than the as-designed rudder.	MCA model ~1t lighter than SIB at all draughts, if the as-designed rudder was modelled in the SIB
4	Fore/aft cockpits not modelled	MCA model has excess buoyancy and excess waterplane area in way of the fore/aft cockpits at large heel angles, hence excess stability.
5	Part of buoyant superstructure not modelled	MCA model has reduced buoyancy and reduced waterplane area in way of the superstructure at large heel angles, hence reduced stability.

Table 2 - Key inconsistencies between MCA hull model and SIB

No.	Description	Impact on MCA validation process
1	MCA vertical datum 100mm below USK. SIB vertical datum is 100mm above USK.	This affects draughts, VCBs, lightship VCG, tanks' VCG, weights' VCG.
2	MCA longitudinal datum is Fr 16.5 whereas SIB longitudinal datum is Fr 16.5 + 55mm	MCA and SIB longitudinal datums are 55mm apart. This affects LCBs, LCFs, lightship LCG, tanks' LCG, weights' LCG.
3	In the MCA validation process, the HST moulded displacement was compared to the SIB full displacement	Add ~3t to displacement delta between MCA and SIB, at all draughts.

1.2 Wolfson hull modelling

The MCA hull definition was modified as appropriate to resolve the inconsistencies of Tables 1 and 2. Such modifications were based on digital and paper-based drawings by Perini Navi, a copy of the approved Intact SIB and MAIB notes supplied to the Wolfson Unit.

The transverse sections through the hull and skeg provided in the MCA model were used as a starting point for the Wolfson hull modelling.

The 1:50 lines plan of 56m ketch 'Santa Maria' (yard number C.2053), sister vessel to Bayesian, was used to validate the MCA hull definition of Section 1.1. In particular, the 'Santa Maria' aft run (Fr. -3 to Fr. 11) was digitized and modelled in HST for comparison with the MCA data. These two definitions of the vessel's aft run were within 0.24% in volume of each other (average over 2.4 to 6m draught at zero trim), which is within the 0.5% tolerance deemed acceptable by the Wolfson Unit for digital stability modelling purposes.

The MCA skeg depth was increased by 100mm and its length extended by 476mm aft. This is consistent with Perini Navi drawings:

- digitized Sail Plan 2095.01.30.010 Rev K, and
- digitized Capacity Plan 2095.01.40.011 Rev G

The MCA model datums were adjusted as follows, to align the Wolfson HST model with the datums stated in the SIB:

- longitudinal (fore/aft) datum moved to Fr16.5 + 55mm;
- vertical datum moved to 100mm above the underside of the keel.

The geometries of the rudder, centreboard and centreboard case were obtained from the Bayesian Capacity Plan 2095.01.40.011 Rev G and Bayesian Sail Plan 2095.01.30.10 Rev K. and modelled in HST.

1.3 Wolfson base model

The SIB does not state if the calculated hydrostatics and stability results refer to the appended or unappended hull, and does not specify the floodable volume (if any) within the centre board case.

The Wolfson Unit calculated the hydrostatics at several hull and appendage configurations, including three centre board case options:

i. 'Solid skeg: centre board case fully buoyant. Buoyant volume 19.4m^3
ii. 'No board': centre board case fully floodable. Floodable volume 19.4m^3
iii. 'Board up': centre board case floodable and board fitted in the fully raised position. Floodable volume 13.3 m^3 = 19.4m^3 – 6.1m^3 board volume.

The various configurations were compared to the SIB hydrostatics, and the best match was obtained with the 'No board' option and no rudder fitted.

The HST digital stability model with **no board**, **no rudder, no deck camber** and **no buoyant superstructure** is referred to as **Wolfson base model** and is shown in Figure 2.

All key assumptions made in the Wolfson modelling are described and evidenced in Table 3. The validation of the Wolfson base model against the SIB hydrostatics is described in Section 0 and a sensitivity study is presented in Section 0.

Table 3 – List of assumptions made in the Wolfson base model

No.	Assumption	Rationale
1.1	SIB hydrostatics assume no board fitted ie full flooding of centreboard case	Supported by validation process
1.2	SIB hydrostatics assume no rudder fitted	Supported by validation process
1.3	The 'motoring lightship' condition presented in the SIB includes 52.3 tonnes board weight	Consistent with deadweights' list in the 'Motoring' and 'Sailing' load conditions presented in the SIB
1.4	The 'motoring lightship' condition presented in the SIB assumes the board is raised	Consistent with 'Sailing' load conditions presented in the SIB, where 'board up' weight item deducted from lightship @ high VCG and 'board down' added to lightship @ low VCG
1.5	SIB displacement is Full, not Moulded	Consistent with ABS Italy letter dated 29/09/08 & SIB pg. 26 'Freeboard and Load Line Marks'

1.4 Validation of Wolfson base model

1.4.1 Validation of datums against SIB tank data

The SIB advises the following datums:

i. Longitudinal datum: Frame 16.5 + 55mm ie Midships 'MP'
ii. Vertical datum: Baseline ie 100mm above keel line

It is standard practice to refer the vertical position of all centres of gravity ie lightship, onboard masses and tank contents to a common vertical datum. Similarly, the horizontal positions of all centres of gravity are typically referred to a common horizontal datum.

The assumption that all centres of gravity refer to SIB datums (i) and (ii) was verified by modelling two arbitrary tanks in HST from the original Capacity Plan, and verifying that the calculated centres of gravity of the fluid mass at full capacity coincided with those advised in the SIB.

The calculated centres of gravity are presented in Table 4 and support the initial assumption.

Table 4 – Centre of gravity position at 100% capacity for tanks '3P' and '910C'

			SIB		HST	
Name	Sp. Gravity	Weight (t)	LCG, m fwd H Datum	VCG, m from V Datum	LCG, m fwd Fr.16.5 + 55mm	VCG, m from Baseline
Tank 3.P	1.000	9.60	4.020	2.318	4.022	2.318
Tank 910.C	0.850	1.71	-10.512	2.334	-10.512	2.326

Note: Tank 3.P is a large fresh water tank on the vessel's port side. Tank 910.C is a small, hydraulic oil tank on the vessel's centre line.

1.4.2 Validation of hull lines against SIB hydrostatics

The hydrostatics of the Wolfson base model (no board, no rudder, no deck camber and no superstructure) were validated against the hydrostatic data presented in the SIB and against the vessel's flotation at equilibrium in the four 'motoring' conditions.

- At zero trim, the HST displacement was within 0.4% of the SIB displacement over the entire range of draughts ie 3.5 to 4.1m, see Figures 5 and 6.

- The equilibrium draught, trim and heel presented in the SIB at the four motoring conditions were then input to HST and the corresponding four displacements calculated. These were compared to the SIB displacements and centres of buoyancy (CoB). The HST displacement was within 0.5% of the SIB displacement at all four conditions. The HST CoB was within 0.3% of the SIB in all directions and at all four conditions. These results are shown in Tables 5a and 5b.

- Further checks at the motoring load conditions (trimmed and heeled) were conducted by setting the displacement and CG in HST and comparing the calculated equilibrium draught to the SIB results. Figure 8 shows that the two sets of draughts agree.

- Displacement deviations of 0.5% or less from approved data are deemed acceptable by the Wolfson Unit when validating stability models produced by third parties, therefore the 'Wolfson base model' of SY Bayesian agrees with the GHS stability model used for producing the SIB hydrostatics.

Table 5a – SIB and Wolfson base model data at motoring load conditions: displacement checks

	SIB				HST	Relative Displ. change
Load Condition	Base plane draught, m	Trim, m +ve by stern	Heel, deg	Full Displ., t	Full Displ., t @ SIB Draught, Trim and Heel	HST Displ /SIB Displ -1
Lightship	3.733	0.302	0.73	468.20	470.211	+0.4%
Light Load	3.801	0.224	1.35	489.73	492.212	+0.5%
Full Load	3.957	0.171	0.41	543.41	545.511	+0.4%
Max Load	4.025	0.088	0.41	565.51	567.784	+0.4%

Table 5b - SIB and Wolfson base model data at motoring load conditions: centre of buoyancy checks

		SIB			HST			Non-dimensional change		
Load Condition	Vessel's flotation	LCB, m	VCB, m	HCB, m	LCB, m	VCB, m	HCB, m	LCB change[1]	VCB change[2]	HCB change[3]
Lightship	as per Table 5a	-2.667	2.868	0.061	-2.634	2.885	0.062	0.07%	0.26%	0.01%
Light Load		-2.561	2.908	0.111	-2.537	2.925	0.112	0.05%	0.26%	0.01%
Full Load		-2.553	3.004	0.032	-2.542	3.019	0.032	0.02%	0.23%	0.00%
Max Load		-2.449	3.043	0.031	-2.442	3.057	0.031	0.02%	0.22%	0.00%

([1]) presented as percentage of Length Between Perpendiculars (LBP) = 46.06m

([2]) presented as percentage of moulded depth amidships = 6.44m

([2]) presented as percentage of overall beam /2 = 6.34m

1.5 Sensitivity study on the Wolfson base model

The sensitivity of the Wolfson base model was investigated at the request of MAIB. The study compared the vessel's righting lever (GZ) curve in the 468.2 tonnes 'Motoring Lightship' condition presented in the SIB, with families of GZ curves obtained from the Wolfson base model. 'Motoring Lightship' is a non-seagoing condition with empty tanks, so the results are not affected by free surface effects.

Two parameters were investigated:

a. **Centreboard case flooding**: systematic variation of the floodable volume of the centreboard case over the range 0% (ie "Solid skeg", see 1.3.i) to 100% (ie "No board", see 1.3.ii)

b. **Keel Line (USK) to Baseline (BL) distance**: systematic variation over the range 0mm (USK at BL) to 160mm (USK below BL)

The outcomes of a. and b. are plotted in Figures 9 and 10 respectively. All GZ curves are plotted up to the angle of vanishing stability for consistency with the SIB. However, the GZ comparison should only be conducted up to the angle of deck edge immersion ~28°. The reason is that the HST and SIB curves are expected to diverge beyond that angle, because the Wolfson Base model has a flat, featureless deck whereas the SIB model may have additional buoyancy in way of the cambered deck and superstructure.

It was concluded that:

a. The SIB hydrostatics are best approximated by the "No board" model, but the SIB stability in the 'Motoring Lightship' condition and up to deck edge immersion is best approximated by the more buoyant "Board up" model. In particular, adding ~6m^3 centreboard buoyancy in way of the skeg would yield a closer correlation between the HST GZ curve and the SIB GZ curve, but would invalidate the hydrostatics. No additional hull buoyancy increases both the hydrostatics correlation and the GZ correlation, and there is no evidence of the SIB using two different models, one for the hydrostatics and one for the stability analysis. Therefore the Wolfson base model, which best matches the SIB hydrostatics, was confirmed as the starting point for the loss analysis of Section 2.

b. Offsetting USK from 100mm below BL (the figure advised in the SIB) to 160mm below BL would yield a closer correlation between the HST GZ curve and the SIB GZ curve, but would also invalidate the hydrostatics. No vertical offsetting of the hull lines improves both the hydrostatics correlation and the GZ correlation and there is no evidence of the SIB using two different datums, one for the hydrostatics and one for the stability analysis. Therefore, the USK position advised in the SIB was confirmed.

2 HULL MODELLING FOR LOSS ANALYSIS

This section discusses the digital stability model:

- "HULL H.8 - Copy 2 of CM 65000 -Salute' - Perini Navi C2095_Loss Model.hst" of Figure 3.

The Wolfson base model (no board, no rudder, no deck camber and no superstructure) of Section 1.3 was modified to represent the likely configuration of SY Bayesian at the time of its loss. In particular:

- The board was added in the 'Board Up' configuration, see Section 1.3.iii
- The as-designed rudder was added.
- The variable deck camber (~215mm amidships) and the stepped foredeck shown in the lines plan 2053.1.20.001 Rev A of sister vessel Santa Maria were added, as they affect the vessel's large angle stability characteristics.
- The superstructure geometry (deck camber, foredeck steps, saloon, flybridge, fore and aft cockpits) was lifted from the Bayesian Capacity Plan 2095.01.40.011 Rev G, Bayesian Sail Plan 2095.01.30.10 Rev K and Santa Maria lines plan 2053.1.20.001. The buoyant part of the superstructure was modelled.

The HST digital stability model with **board up**, **rudder**, **deck camber, cockpits** and **buoyant superstructure** is referred to as **Wolfson loss model**.

2.1 Wolfson loss model: motoring lightship condition (non-seagoing)

The lightship condition used in the Wolfson loss analysis was derived from (Perini Navi 2008) and (INAB 2020). The former report details the approved inclining experiment conducted in 2008, and the latter report presents the latest available lightship survey of S/Y Bayesian, performed in 2020. The 2020 lightship survey identified minor changes in the vessel's lightship displacement and LCG position, but these were within the (MCA 2007) permitted deviations from the approved data (namely 2% on displacement and 1% on LCG). Therefore, the vessel was not re-inclined and the stability information was not updated.

The 2020 lightship was produced from the 2008 SIB hydrostatics which, in turn, are affected by the assumed buoyancy deficiencies of the SIB model (no centreboard and no rudder) discussed in Section 1 of this report. It would be incorrect to apply the 2008/2020 lightship data to the more buoyant Wolfson loss model, so a re-analysis was conducted.

The inclining experiment (Perini Navi 2008) was re-analyzed using the Wolfson loss model, to derive the 2008 motoring lightship displacement, LCG and VCG position. The 2020 lightship survey data (INAB 2020) was also re-analysed using the Wolfson loss model, to derive the 2020 motoring lightship

displacement and LCG position. Table 6 presents the results of the Wolfson re-analysis alongside the original lightship data from (Perini Navi 2008) and (INAB 2020).

The Wolfson motoring lightship of S/Y Bayesian uses the latest re-analysed data, namely the 2008 VCG, the 2020 LCG and the 2020 displacement:

Motoring Lightship: 480.906t, LCG -2.992m, VCG 5.753m

Table 6 – Derivation of Motoring Lightship Condition

	Perini Navi	INAB		Wolfson Loss Model, 2025		
	SIB inclining 28/02/2008	Lightship check 12/11/2020	Re-incline*?	Analysis of 2008 inclining	Analysis of 2020 lightship check	Re-incline*?
Full Displ (t)	468.20	469.11	0.19% < 2% re-incline not required	478.62	480.906	0.48% < 2% re-incline not required
LCG (m forward MP)	-2.648	-2.924	-0.60% < 1% re-incline not required	-2.756	-2.992	-0.51% < 1% re-incline not required
VCG (m above BL)	5.788	n/a		5.753	n/a	
Draught @ MP (m)	3.735			3.730	3.726	
Trim (m)	0.306			0.307	0.452	

(*) The maximum permitted deviations on lightship displacement (2%) and lightship LCG position (1%) are advised in (MCA 2007) paragraph 11.5.3.

2.2 Wolfson loss model: seagoing motoring conditions

The 'Motoring Lightship' condition of Section 2.1 was combined with the deadweight presented in the SIB for the motoring conditions 'Light Load', 'Contractual Full Load' and 'Maximum Load' to derive the respective righting lever (GZ) curves, downflooding angles and assessment against the stability criteria. The stability results are shown in Appendices 1 to 4.

Appendix 2 presents the assessment of the motoring conditions against the applicable stability criteria, and the associated Maximum KG results. The downflooding points are ignored in this analysis, as is done in the SIB.

Appendix 3 is essentially Appendix 2 with all downflooding points active. It shows that:

- in the Maximum Load condition, point 'F' (Galley & Laundry Extraction) would become immersed at 31.6° causing the vessel to fail the stability criteria;
- in the Light Load and Full Load conditions, the vessel would pass the stability criteria.

Appendix 4 compares the vessel's righting lever (GZ) curves presented in the SIB with those obtained from the Wolfson loss model at two motoring conditions: Lightship and Light Load.

Table 7 - List of assumptions made in the Wolfson loss model

No.	Assumption	Rationale
2.1	All loading conditions assume zero heel at equilibrium that is, TCG=0.	In the Wolfson loss model the initial heel angle is 0.7° or less at all motoring conditions, including lightship. Transverse movement of internal deadweight would compensate small initial heel angles this and enable zero heel at equilibrium.
2.2	For the purpose of digital stability modelling, the superstructure is assumed buoyant up to the flybridge sole.	The drawings supplied by MAIB do not identify buoyant volumes above the flybridge sole.

Figure 1 – profile of MCA stability model

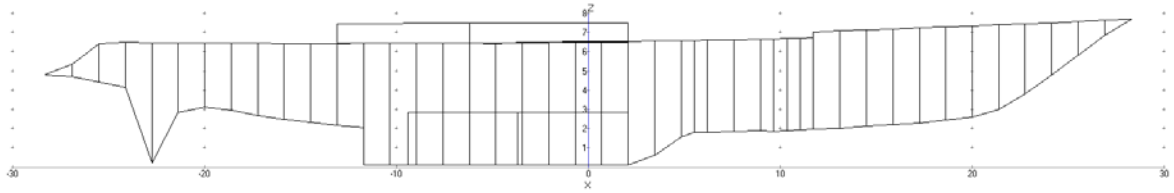


Figure 2 - Wolfson base model: no board, no rudder, no deck camber and no superstructure

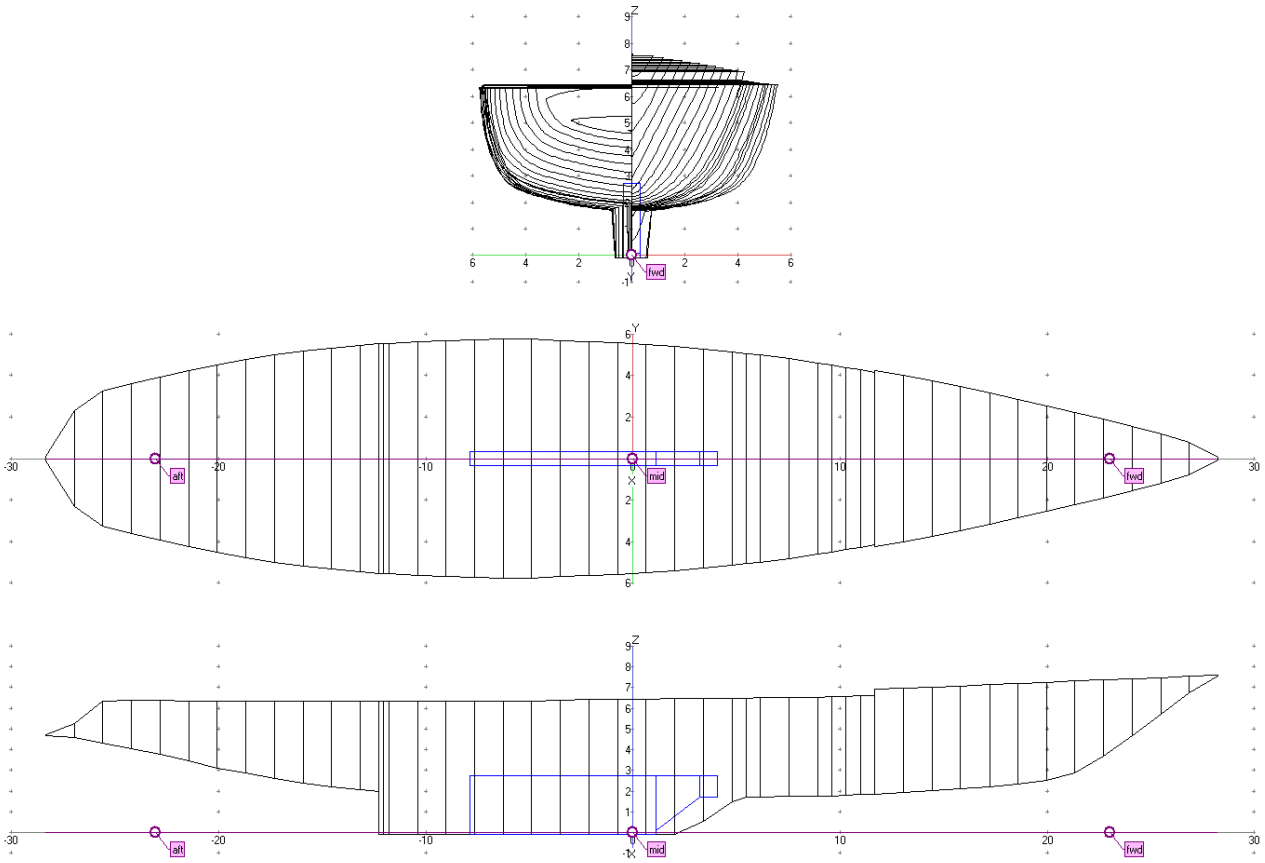


Figure 3 - Wolfson loss model: board up and rudder fitted, cambered deck, cockpits and buoyant superstructure

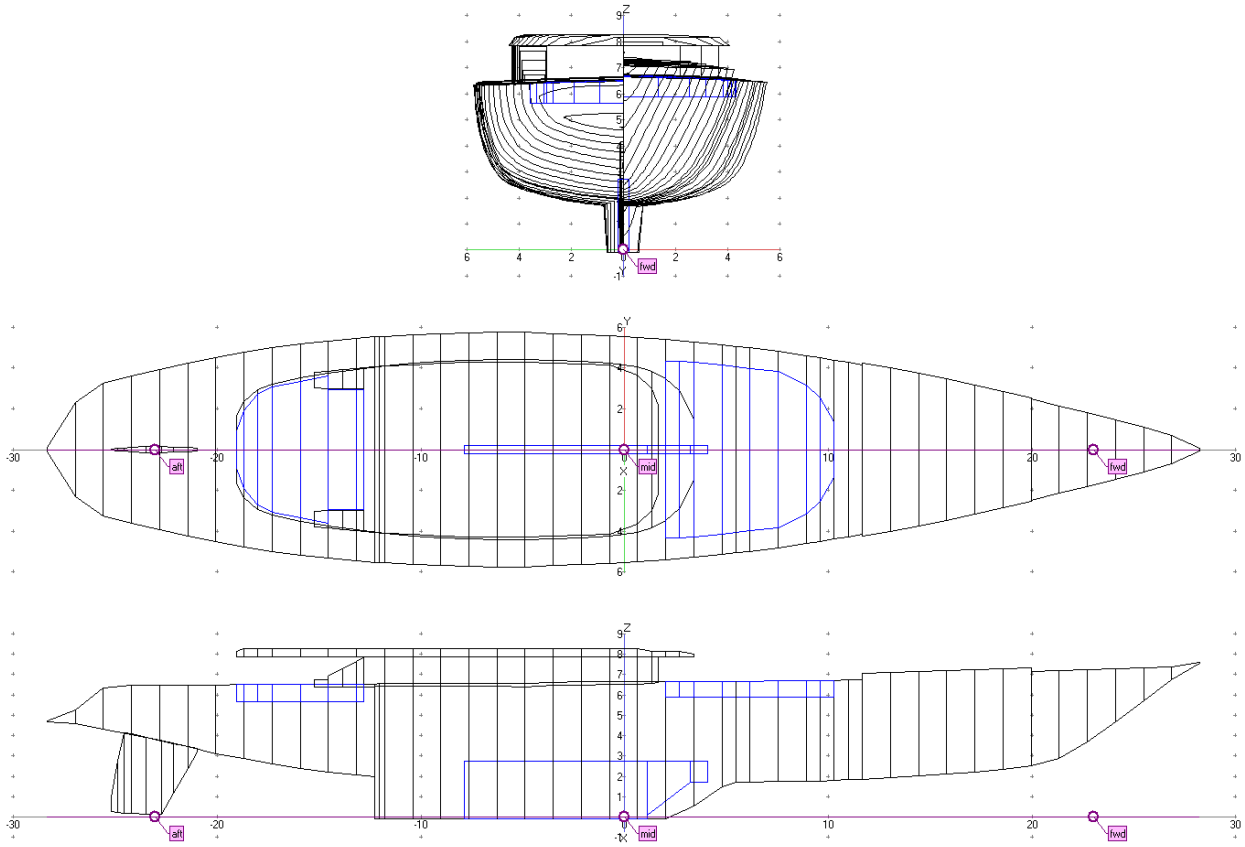
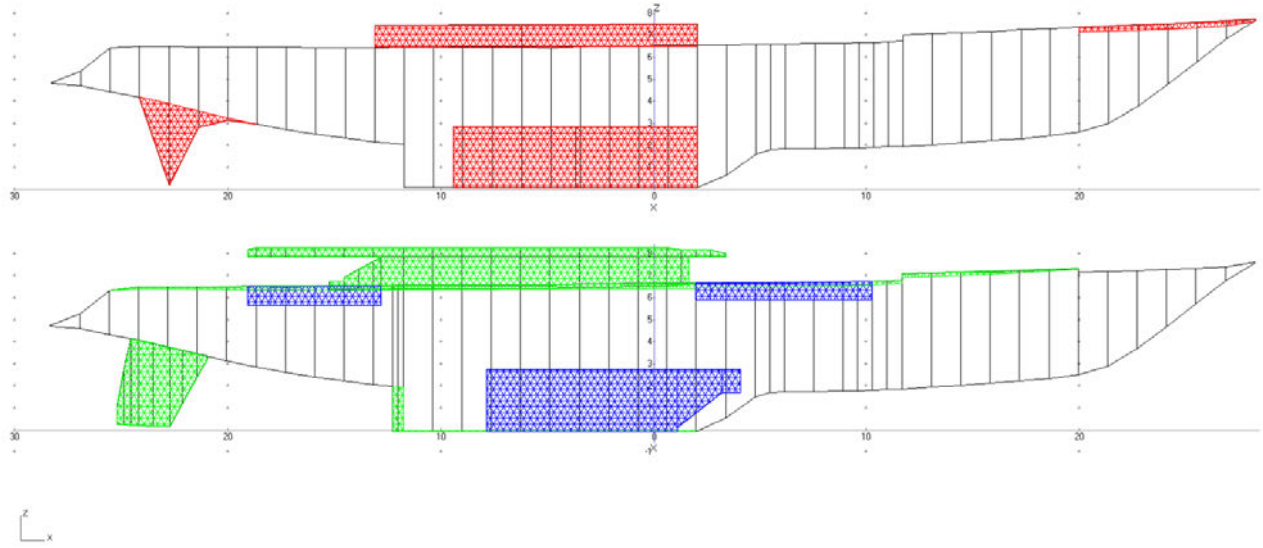


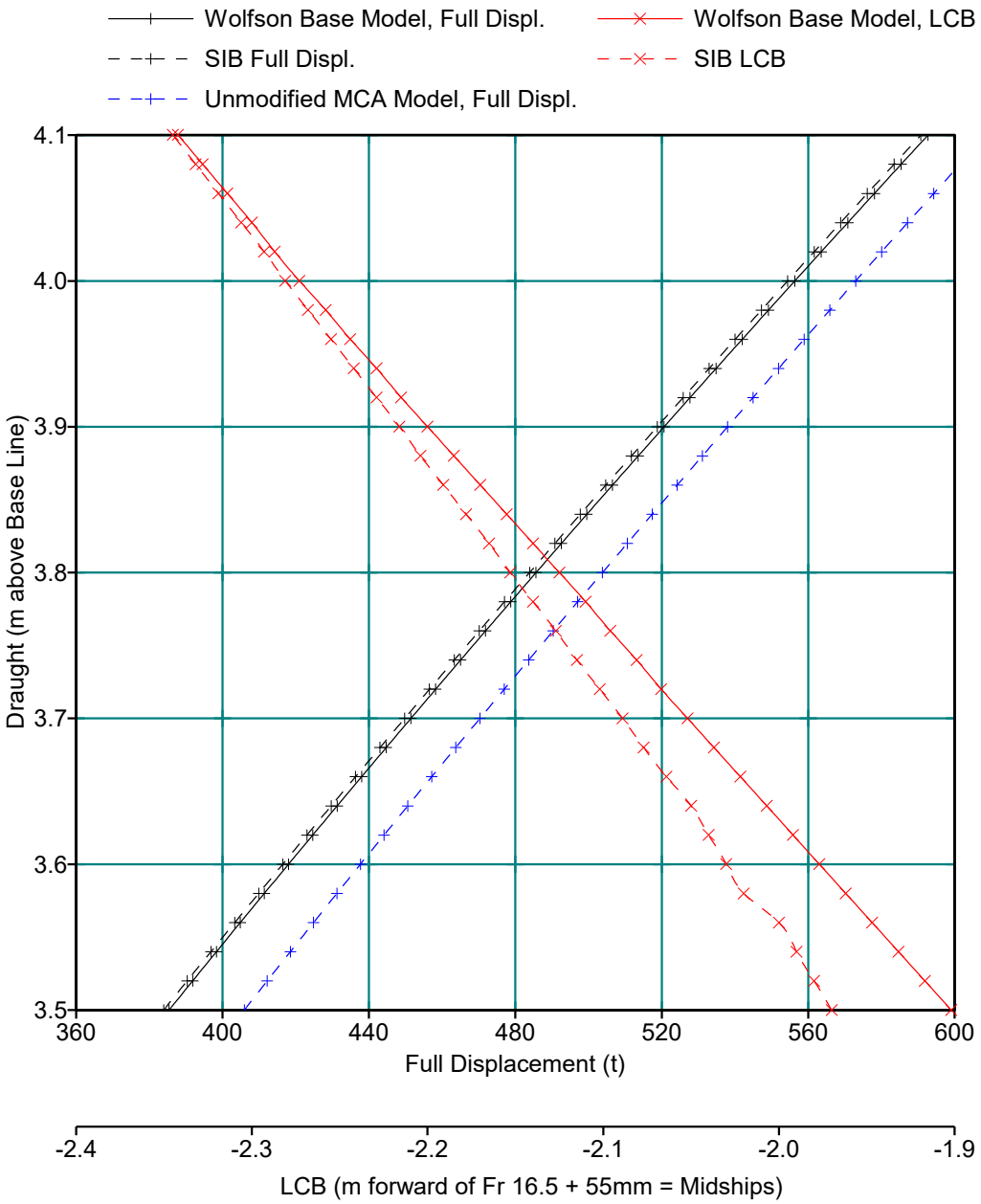
Figure 4 – Key differences between MCA model (top) and Wolfson loss model (bottom)



Red areas = features removed
Green areas = buoyant features added
Blue areas = floodable features added

NOTE: floodable region in way of centreboard case is empty case (floodable) less board volume (buoyant)

Figure 5 – Variation of Displacement and LCB with Draught (all data at level trim)



NOTE:
Wolfson Base Model: Base Line @ 100mm above Keel Line
SIB: Base Line @ 100mm above Keel Line
Unmodified MCA Model: Base Line @100mm below Keel line

Figure 6 – Variation of Displacement ratio with Draught (all data at level trim)

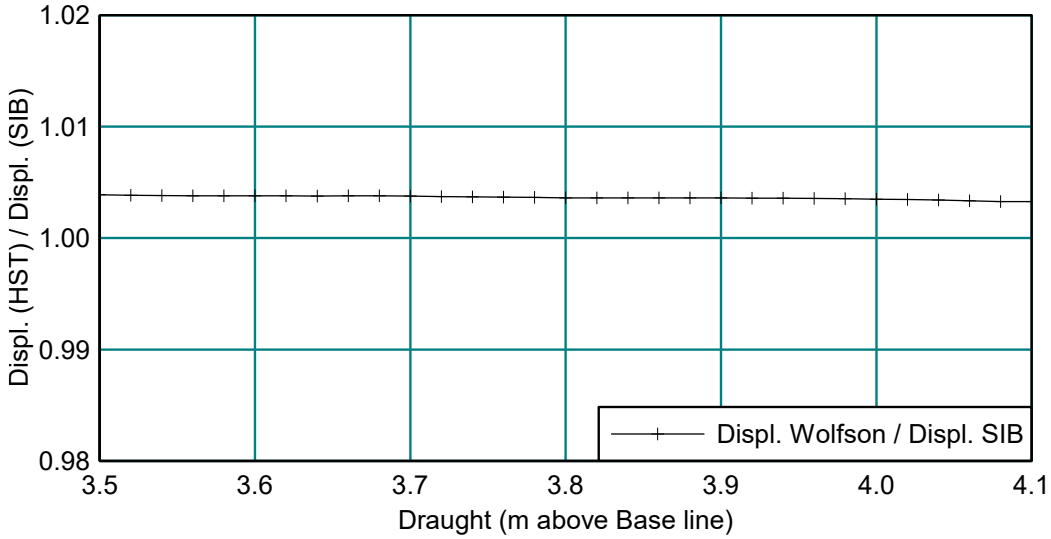


Figure 7 - Variation of LCB ratio with Draught (all data at level trim)

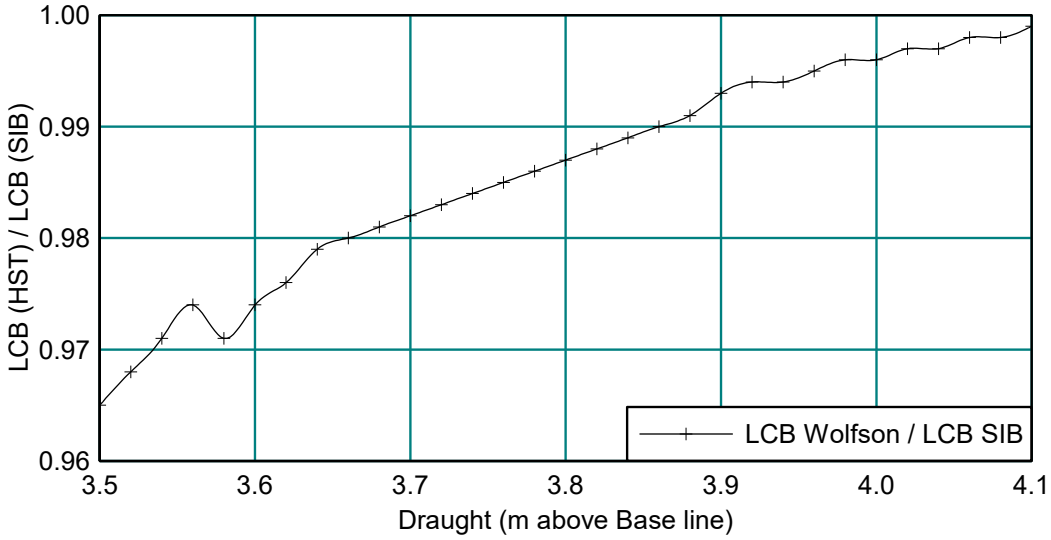


Figure 8 – Variation of Draught with Displacement at Motoring Loading Conditions

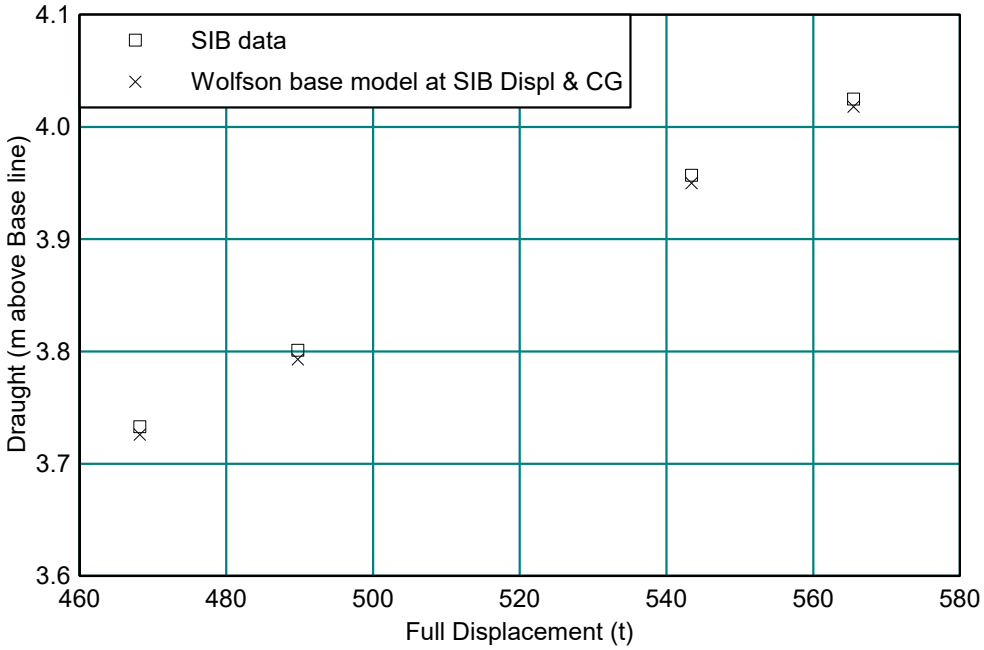
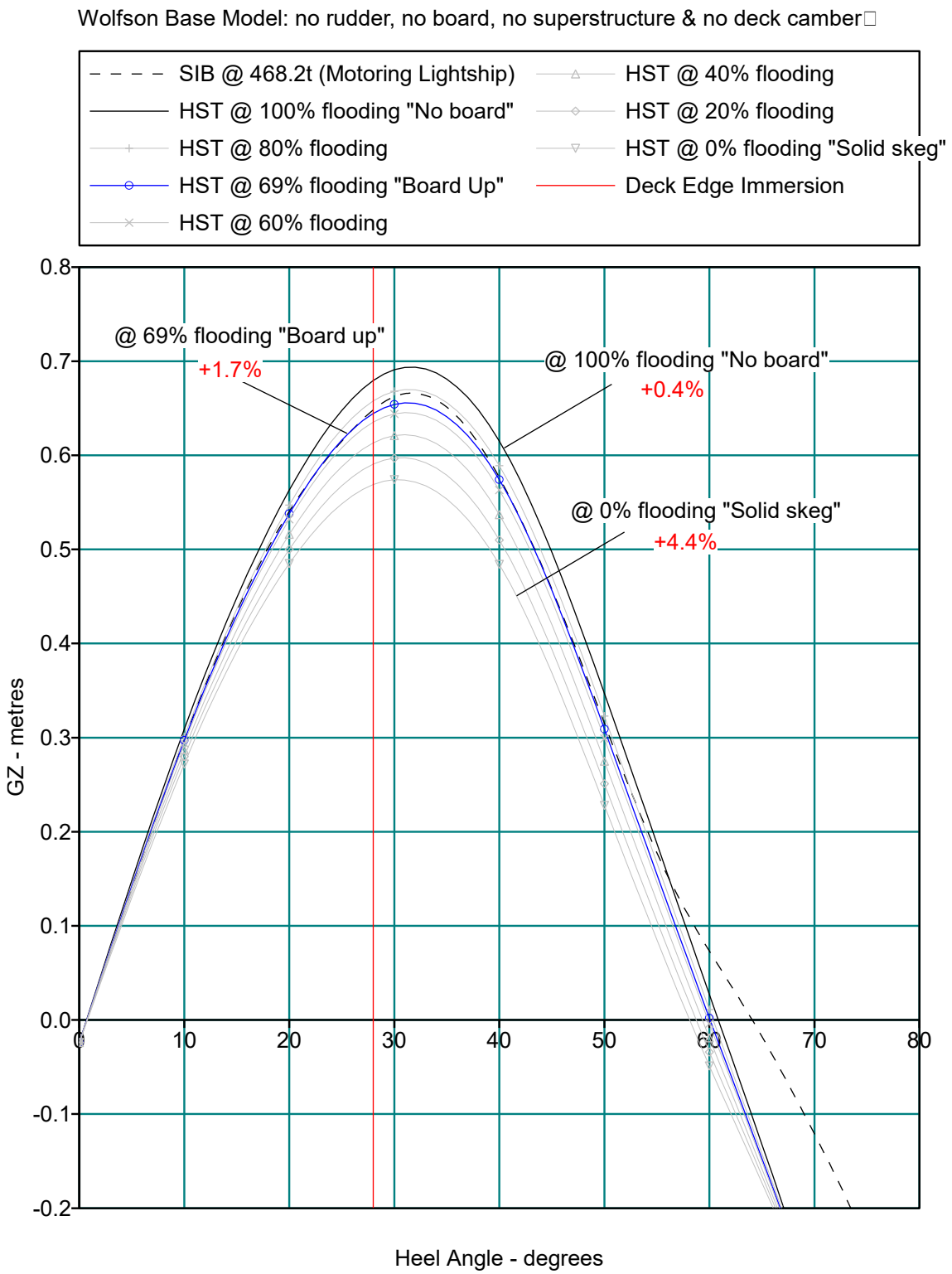
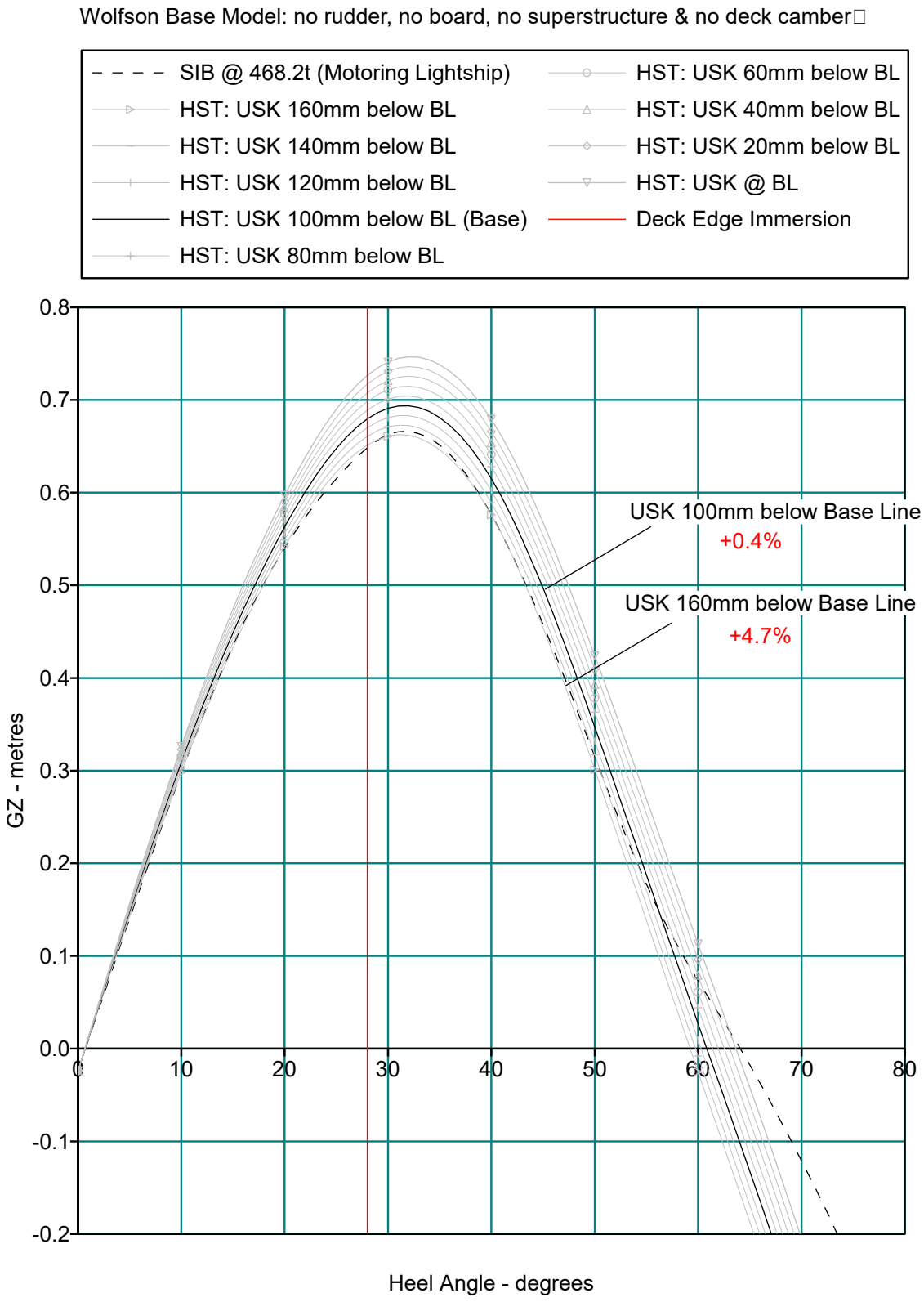


Figure 9 – Variation of Righting Lever (GZ) with Heel angle at 468.20 t 'Motoring Lightship'



NOTE: the figures in red are relative displacement changes (i.e. HST Displacement / SIB Displacement - 1) averaged over the range of draughts 3.5 to 4.1 metres.

Figure 10 - Variation of Righting Lever (GZ) with Heel angle at 468.20 t 'Motoring Lightship'



NOTE: the figures in red are relative displacement changes (i.e. HST Displacement / SIB Displacement - 1) averaged over the range of draughts 3.5 to 4.1 metres.

3 PREDICTION OF WIND HEELING MOMENT

The following section summarises packages of work on the prediction of wind heeling moment for the vessel.

It includes:

- the creation a tool to predict the aerodynamic loadings on various components to assess the wind heeling moment at a range of apparent wind angles, strengths and gradients, supplied separately from this report to MAIB
- computational fluid dynamics (CFD) assessment of the 2D mast section with inclusion of results in the aerodynamic loading tool

3.1 Wind Heeling Moment Approach

A macro based Excel spreadsheet tool has been created to estimate the maximum gust velocity magnitude and heel angle that the vessel is predicted to withstand using an approach based on static balance of moments with no account for dynamic effects.

The tool comprises of the vessel GZ curve(s) and wind heeling lever(s) and allows for the limiting steady state wind velocity (i.e. gust velocity / $\sqrt{2}$) to be calculated. The steady state wind velocity and associated heel angle represents the limits at which a gust is likely to cause capsize.

This approach has been influenced by the method laid out in (Red Ensign Group 2019) Sailing Vessel Monohulls but includes all hydrostatic and stability info relating to the displacement condition in question and ignores the impact of downflooding.

The following windage elements have been included in the tool.

- Hull
- Superstructure
- Other deck geometries such as main hoop, awning
- Mast tube
- Boom
- Rigging elements
- Furlers and furled sails
- Satellite domes

These represent the main contributing windage items of the vessels, elements that have been omitted include spreaders, stanchions and all other detailed items.

Frontal and side areas and vertical levers of all windage elements have been estimated based on data extracted from the Sail Plan ref (Perini Navi 2005) in conjunction with data sources such as references (Nicolson 2004) and (ORC 2024 SY VPP).

Force coefficients for each of these windage elements have been estimated, some based on references including (Hoerner1965) and (ORC 2024 VPP).

A wind gradient of a power law (1/9) has been adopted for the analysis in this report, this represents ‘unstable air above a flat open coast‘ as per reference (Kaltschmitt 2007).

The wind heeling arm uses the $\cos^{1.3}\theta$ term with heel, in keeping with references such as (Deakin 2001). No other modifications to the force coefficients with heel have been applied.

The tool allows for a range of apparent wind angles (AWAs) to be analysed, 0° - 180°.

Factors have been applied to some of the element force coefficients to represent ranges of blanketing and interactive effects between adjacent modelled components. This has resulted in likely envelopes of predicted limiting wind speeds at each AWA.

3.1.1 Computational Fluid Dynamic (CFD) modelling of the mast section

The mast was identified as an area for investigation, to gain an understanding of the potential for generation of lift at low AWAs.

A short study was conducted to predict the driving force and sideforce capabilities of the 2D sections.

3.1.1.1 Geometry

The mast section geometry provided in (Perini Navi 2006) was converted into a CAD format suitable for the CFD simulations.

3.1.1.2 CFD software

All simulations were conducted using an optimised version of the OpenFOAM software package. The flow around the geometry was simulated using a compressible Reynolds-averaged Navier-Stokes (RANS) based CFD solver, with the free-stream air assumed to be a compressible perfect gas.
Further assumptions of the CFD model are as follows:

- The mast section was modelled in isolation, without sails or rigging.
- The simulations were modelled as three dimensional in order to correctly account for dissipation rates, but the mast section was constant along its length
- The mast crossed the entire domain in the vertical direction, with symmetry boundary conditions at either end.
- The inlet condition was specified as a uniform wind speed across the domain, with effects of change in apparent wind speed and direction with height modelled out with the CFD simulations.
- Outlet conditions were defined as constant pressure outlets.
- The domain size was 30m by 30m in the horizontal plane and 15m in the vertical direction
- The air was modelled as compressible and turbulent (a RANS k-omega SST turbulence model)
- The CFD mesh is optimised to capture the flow over the mast and its wake
- A typical mesh size was 50 M cells, which proved to be mesh independent.

3.1.1.3 Limitations of approach

The approach used is a steady state RANS method, hence time dependent flow phenomenon such as vortex shedding are not modelled and detailed results of fully separated flow will not be accurate. The accuracy of predicting the stall angle may be out by up to 5˚. It is however capable of predicting forces accurately up until stall and can be expected to predict forces to within 25% error post stall.

3.1.1.4 Computational resources

The high performance computing facilities at the University of Southampton were used for all computations.

3.1.1.5 Results

As stated above, the mast section modelled was a constant section, bridging the domain. Force data from a 3m section in the middle of the domain is presented only summarised in Figure 12 in terms of drive force (force parallel to the vessel and mast centrelines) and side force (force perpendicular to the vessel and mast centrelines) coefficients (Cx & Cy), in order to achieve as close to 2D data as possible.

It should be noted that the results at 90° reflect similar levels of side force as that published by (Hoerner 1965) and other authors relating to elliptical section shapes of a comparable aspect ratio.

3.2 Results

The tool predictions of limiting wind speeds envelopes for a range of AWAs are presented below in Table 8 for the vessel in the Wolfson loss model, motoring light load (502.4t) condition. These highlight the decreasing limiting wind speeds with increasing AWA towards 90°, along with the lift production (which results in increased side force) from the mast at AWAs of 20° and less.

Table 8 - Prediction of limiting wind speeds (measured at 10m height) envelopes at a range of apparent wind angles

	Predicted Limiting Wind Speed Envelopes			
	Steady		***Gust***	
AWA	***Low***	***High***	***Low***	***High***
deg	***knots***	***knots***	***knots***	***knots***
0	-	-	-	-
10	55.9	66.7	79.1	94.4
20	46.1	55.0	65.3	77.8
30	50.6	60.2	71.6	85.2
40	43.0	51.2	60.8	72.4
50	39.3	46.9	55.6	66.3
60	38.4	45.8	54.4	64.8
70	37.9	45.2	53.7	64.0
80	37.7	44.9	53.3	63.5
90	37.6	44.8	53.2	63.4
100	40.4	48.1	57.2	68.1
110	41.3	49.2	58.4	69.6
120	43.0	51.3	60.9	72.5
130	46.0	54.7	65.0	77.4
140	50.9	60.5	71.9	85.6
150	59.3	70.5	83.9	99.7
160	75.3	89.4	106.4	126.4
170	114.2	135.7	161.5	191.8
180	-	-	-	-

With the associated limiting heel angles are presented below in Table 9 and in Figure 11.

Table 9 highlights a relatively low AVS (less than 71°) which results in low limiting heel angles.

Table 9 - Limiting heel angles

Parameter	*Units*	*Steady*	*Gust*	*AVS*
Heel Angle	deg	14.2	36.3	70.6

Figure 13 provides a breakdown of the wind heeling moment contribution from each of the windage elements at 90° AWA. This highlights the very high influence of the mast which equates to 50% of the total heeling moment.

Figure 11 - Derived wind heel data in Wolfson loss model, motoring light load condition

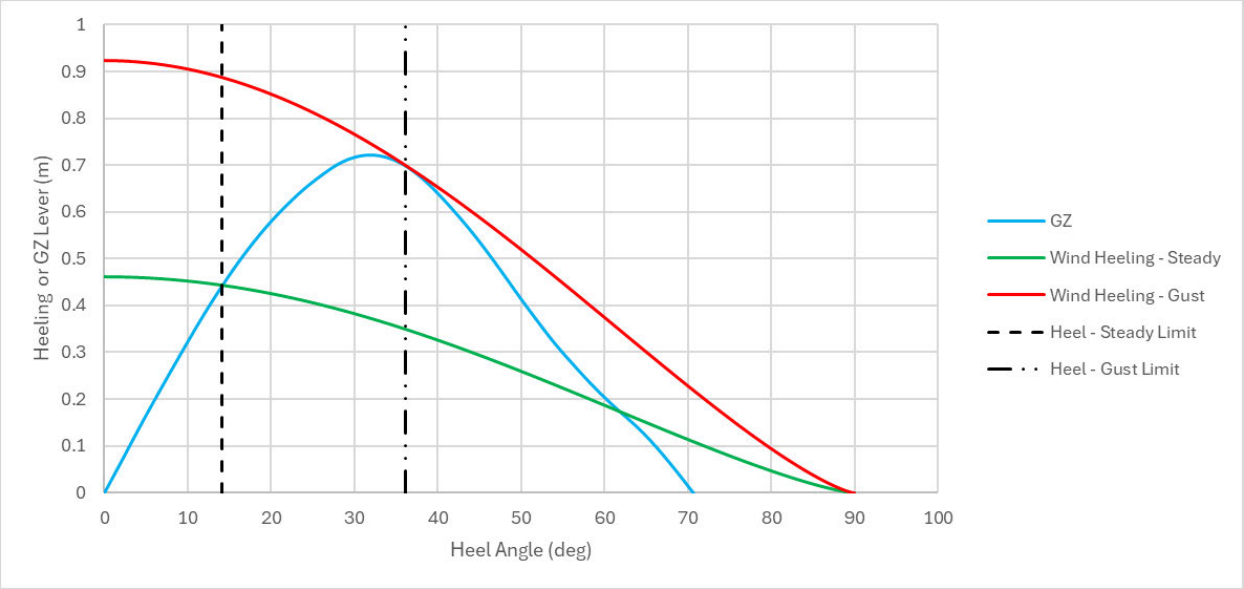


Figure 12 - Summary of 2D mast section CFD results used in tool

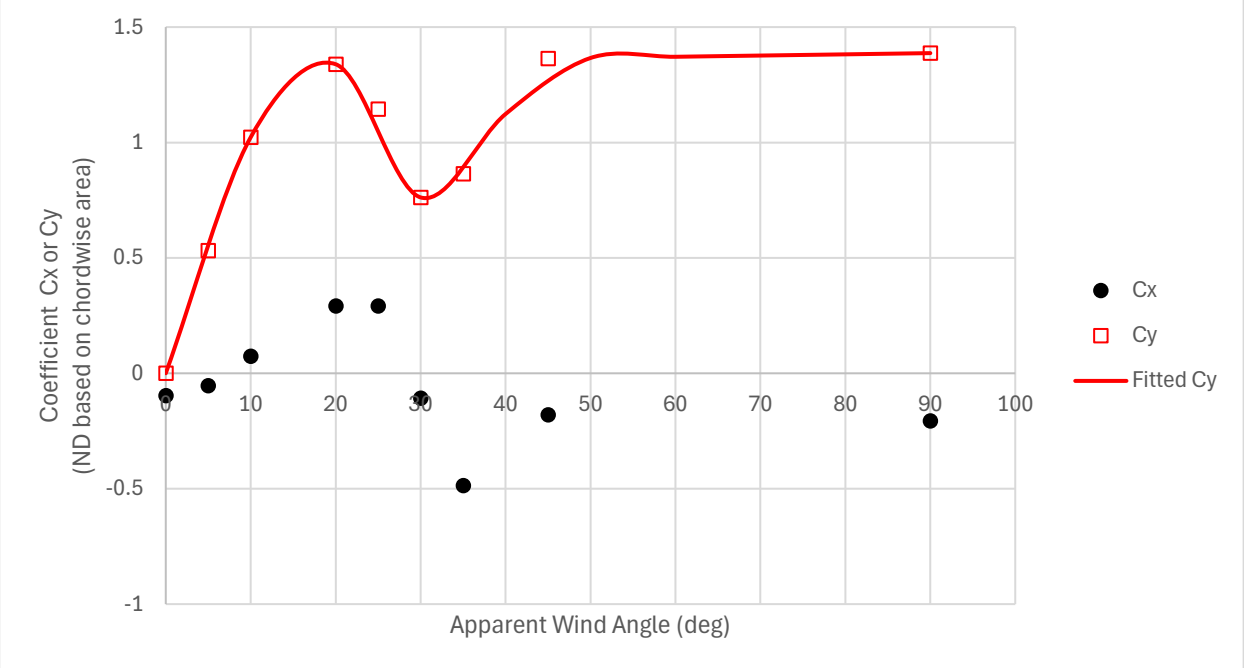
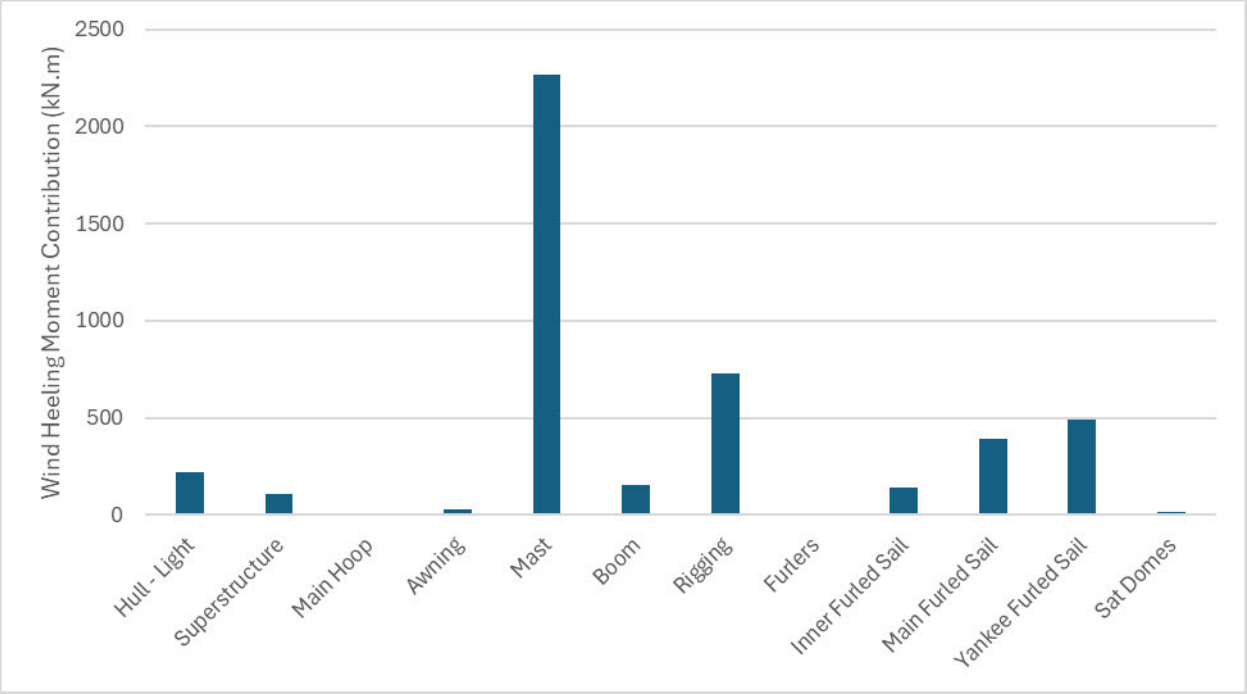


Figure 13 - Breakdown of wind heeling element contributions at 90° apparent wind angle



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APPENDIX 1 – STABILITY AT SEAGOING LOADING CONDITIONS

All VCGs fluid unless otherwise stated

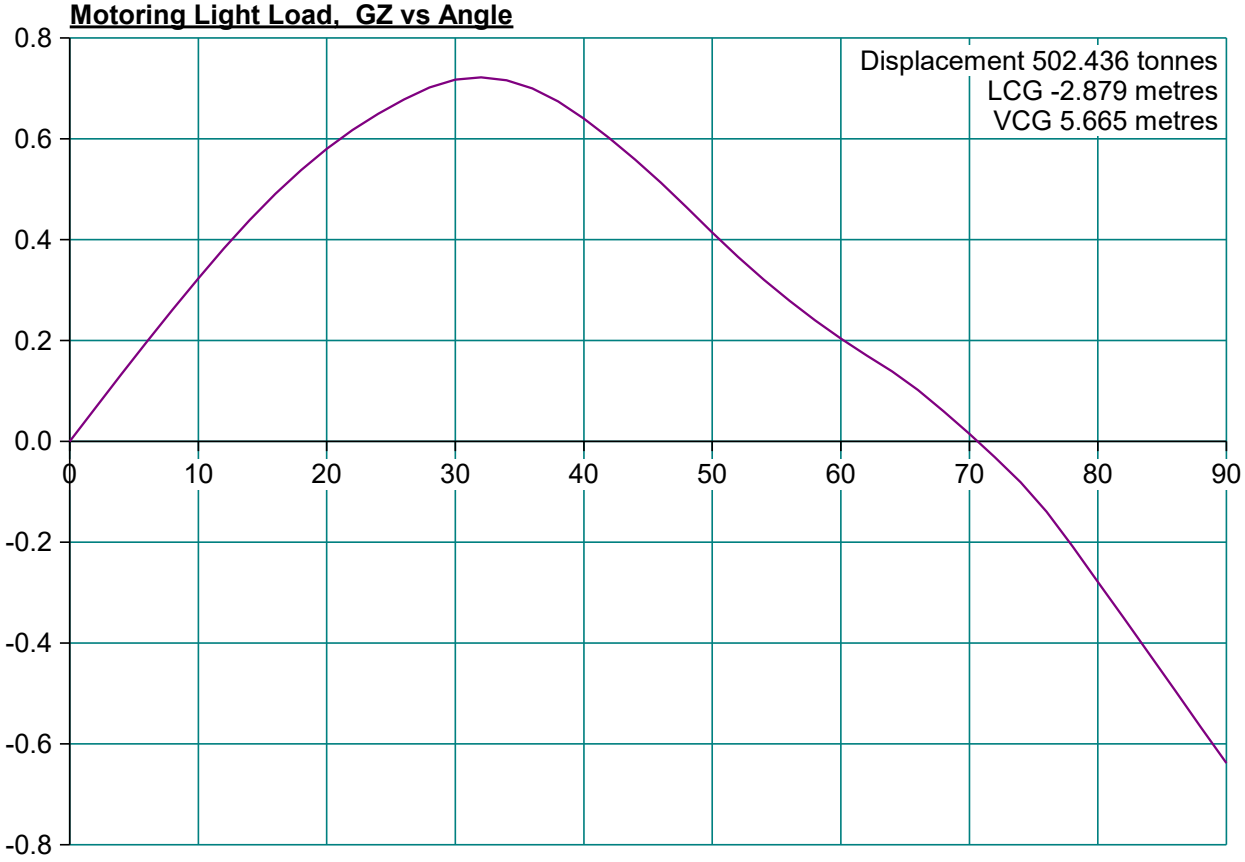
Motoring Light Load

Displacement	502.436 tonnes
Longitudinal Centre of Gravity	-2.879 metres
Vertical Centre of Gravity	5.665 metres
Transverse Centre of Gravity	0.000 metres
Equilibrium GM	1.910 metres
Equilibrium Heel Angle	0.000 degrees
Equilibrium Draught	3.795 metres
Equilibrium Trim Between Marks	0.357 metres by the stern
Angle of Vanishing Stability	70.6 degrees
Maximum GZ	0.722 metres
Maximum GZ Angle	31.9 degrees

Heel Angle	Righting GZ	Lever KN	Waterline	Trim	VCB	GZ Curve Area
degrees	metres	metres	metres	metres	metres	metres.rad
0.0	0.000	0.000	3.795	0.357	2.903	0.000
10.0	0.323	1.307	3.705	0.287	2.973	0.029
20.0	0.580	2.518	3.426	0.086	3.165	0.109
30.0	0.717	3.549	2.943	-0.204	3.437	0.224
40.0	0.640	4.282	2.327	-0.482	3.695	0.346
50.0	0.414	4.754	1.612	-0.744	3.924	0.439
60.0	0.204	5.110	0.814	-0.963	4.214	0.492
70.0	0.015	5.338	0.001	-1.120	4.560	0.512
80.0	-0.278	5.300	-0.853	-1.240	4.826	--
90.0	-0.638	5.027	-1.723	-1.288	5.027	--

Downflooding and Margin Line Points			Freeboard	Stbd Angle	Port Angle	Type	Description
X	Y	Z	metres	degrees			
-23.400	3.750	6.120	2.144	45.1	175.5	Downflood	A
-19.980	3.200	6.750	2.800	64.9	166.4	Downflood	B
-10.320	4.075	6.850	2.975	47.0	167.8	Downflood	C
-8.000	4.100	7.900	4.043	56.5	157.4	Downflood	D
-3.000	4.130	7.950	4.132	55.2	156.9	Downflood	E
9.900	4.600	6.510	2.792	34.7	173.5	Downflood	F
10.080	-3.560	7.050	3.333	164.5	50.5	Downflood	G
19.200	1.340	7.670	4.024	86.9	137.0	Downflood	H

Motoring Light Load, GZ vs Angle

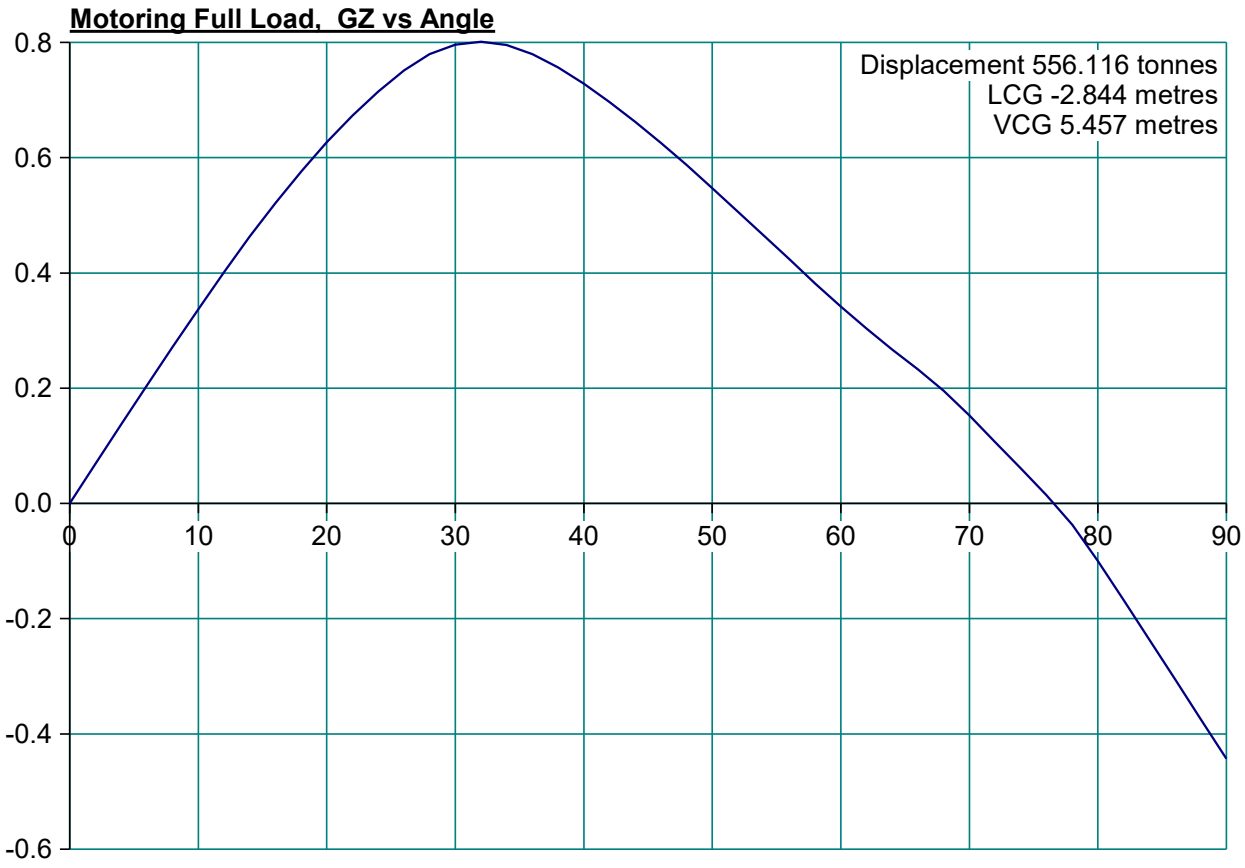


Motoring Full Load

Displacement	556.116 tonnes
Longitudinal Centre of Gravity	-2.844 metres
Vertical Centre of Gravity	5.457 metres
Transverse Centre of Gravity	0.000 metres
Equilibrium GM	1.974 metres
Equilibrium Heel Angle	0.000 degrees
Equilibrium Draught	3.951 metres
Equilibrium Trim Between Marks	0.288 metres by the stern
Angle of Vanishing Stability	76.5 degrees
Maximum GZ	0.801 metres
Maximum GZ Angle	32.0 degrees

Heel Angle	Righting GZ	Lever KN	Waterline	Trim	VCB	GZ Curve Area
degrees	metres	metres	metres	metres	metres	metres.rad
0.0	0.000	0.000	3.951	0.288	2.998	0.000
10.0	0.337	1.285	3.862	0.227	3.065	0.030
20.0	0.627	2.493	3.583	0.045	3.253	0.115
30.0	0.796	3.524	3.107	-0.211	3.516	0.242
40.0	0.728	4.236	2.513	-0.459	3.752	0.378
50.0	0.547	4.727	1.809	-0.693	3.980	0.490
60.0	0.341	5.067	1.011	-0.901	4.241	0.567
70.0	0.153	5.280	0.206	-1.021	4.552	0.611
80.0	-0.100	5.274	-0.621	-1.118	4.825	--
90.0	-0.443	5.013	-1.484	-1.162	5.013	--

Downflooding and Margin Line Points			Freeboard	Stbd Angle	Port Angle	Type	Description
X	Y	Z	metres	degrees			
-23.400	3.750	6.120	2.022	40.0	173.6	Downflood	A
-19.980	3.200	6.750	2.674	59.6	164.3	Downflood	B
-10.320	4.075	6.850	2.834	43.6	166.0	Downflood	C
-8.000	4.100	7.900	3.899	53.5	155.6	Downflood	D
-3.000	4.130	7.950	3.980	52.5	155.1	Downflood	E
9.900	4.600	6.510	2.621	32.4	171.7	Downflood	F
10.080	-3.560	7.050	3.162	162.3	47.6	Downflood	G
19.200	1.340	7.670	3.839	83.2	133.7	Downflood	H

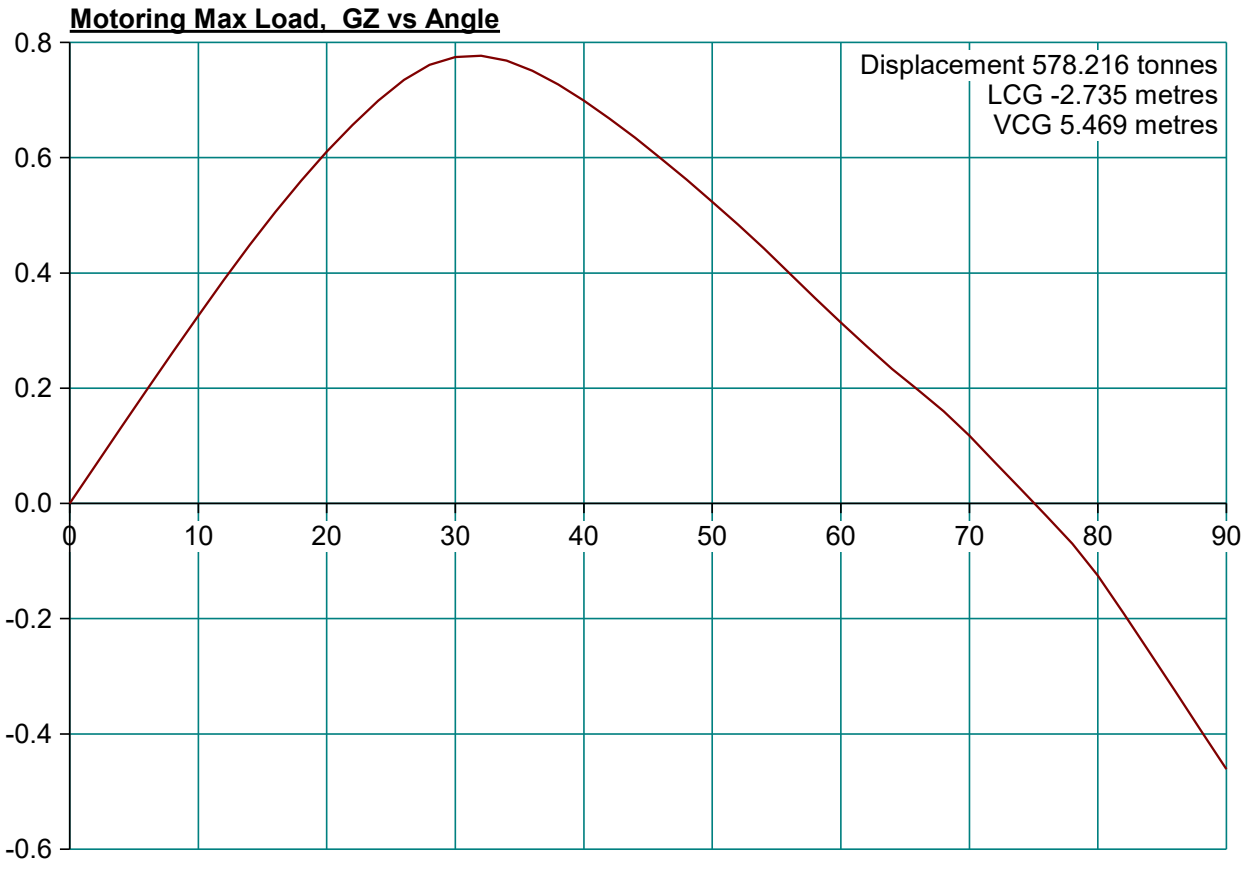

Motoring Full Load, GZ vs Angle
Displacement 556.116 tonnes
LCG -2.844 metres
VCG 5.457 metres
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
0
10
20
30
40
50
60
70
80
90

Motoring Max Load

Displacement	578.216 tonnes
Longitudinal Centre of Gravity	-2.735 metres
Vertical Centre of Gravity	5.469 metres
Transverse Centre of Gravity	0.000 metres
Equilibrium GM	1.899 metres
Equilibrium Heel Angle	0.000 degrees
Equilibrium Draught	4.019 metres
Equilibrium Trim Between Marks	0.199 metres by the stern
Angle of Vanishing Stability	75.1 degrees
Maximum GZ	0.777 metres
Maximum GZ Angle	31.6 degrees

Heel Angle	Righting GZ	Lever KN	Waterline	Trim	VCB	GZ Curve Area
degrees	metres	metres	metres	metres	metres	metres.rad
0.0	0.000	0.000	4.019	0.199	3.036	0.000
10.0	0.326	1.275	3.929	0.142	3.101	0.029
20.0	0.610	2.481	3.651	-0.031	3.287	0.111
30.0	0.775	3.509	3.178	-0.274	3.546	0.235
40.0	0.699	4.214	2.590	-0.512	3.774	0.366
50.0	0.523	4.713	1.890	-0.734	4.001	0.474
60.0	0.314	5.050	1.095	-0.940	4.252	0.547
70.0	0.118	5.257	0.291	-1.050	4.549	0.585
80.0	-0.125	5.260	-0.527	-1.137	4.822	--
90.0	-0.461	5.008	-1.386	-1.181	5.008	--

Downflooding and Margin Line Points			Freeboard	Stbd Angle	Port Angle	Type	Description
X	Y	Z	metres	degrees			
-23.400	3.750	6.120	2.000	38.8	173.1	Downflood	A
-19.980	3.200	6.750	2.644	58.0	163.7	Downflood	B
-10.320	4.075	6.850	2.786	42.5	165.4	Downflood	C
-8.000	4.100	7.900	3.846	52.5	155.0	Downflood	D
-3.000	4.130	7.950	3.918	51.4	154.4	Downflood	E
9.900	4.600	6.510	2.534	31.3	170.9	Downflood	F
10.080	-3.560	7.050	3.074	161.3	46.2	Downflood	G
19.200	1.340	7.670	3.734	81.2	131.8	Downflood	H


Motoring Max Load, GZ vs Angle
Displacement 578.216 tonnes
LCG -2.735 metres
VCG 5.469 metres
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
0
10
20
30
40
50
60
70
80
90

APPENDIX 2 – MAX KG CRITERIA AT SEAGOING LOADING CONDITIONS

All VCGs fluid unless otherwise stated

Specific Gravity of Water	1.0250
Mean Shell Thickness	0.0060 metres
Longitudinal Datum	Midships
Vertical Datum	Base Line

Maximum KG Data

Calculated with heel to starboard

Criteria:

1: The area up to 30 degrees shall be 0.055 m.rad

2: The area up to 40 degrees or downflooding angle shall be 0.09 m.rad

3: The area from 30 - 40 degrees or downflooding angle shall be 0.03 m.rad

4: The angle of maximum GZ shall not be less than 25 degrees

5: GZ shall be at least 0.2 metres at angles of 30 degrees or more

6: GM shall be at least 0.15 metres

Maximum KG Values

	Criteria No.					
Condition	**1** metres	**2** metres	**3** metres	**4** metres	**5** metres	**6** metres
1: Motoring Light Load	6.927	6.764	6.584	6.557	6.699	7.422
2: Motoring Full Load	6.851	6.691	6.517	6.624	6.649	7.282
3: Motoring Max Load	6.813	6.655	6.482	6.615	6.618	7.218

Condition No.	Displacement tonnes	LCG metres	VCG metres	TCG metres	Maximum KG metres	Deadweight Moment tonnes.metres	Critical Number	Pass/Fail
1	502.44	-2.879	5.665	0.000	6.557	527.62	4	pass
2	556.12	-2.844	5.457	0.000	6.517	857.41	3	pass
3	578.22	-2.735	5.469	0.000	6.482	981.17	3	pass

Motoring Light Load

Displacement	502.44 tonnes
LCG	-2.879 metres
VCG	5.665 metres
TCG	0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.224 m.rad	0.055 m.rad	pass
2	The area under the GZ curve from 0.0 degrees to 40.0 degrees	0.346 m.rad	0.09 m.rad	pass
3	The area under the GZ curve from 30.0 degrees to 40.0 degrees	0.122 m.rad	0.03 m.rad	pass
4	The maximum value of GZ occurs at	31.9 degrees	25 degrees	pass
5	The value of GZ at an angle of heel of 31.9 degrees	0.722 metres	0.2 metres	pass
6	The value of the upright GM	1.910 metres	0.15 metres	pass

Motoring Full Load

Displacement	556.12 tonnes
LCG	-2.844 metres
VCG	5.457 metres
TCG	0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.242 m.rad	0.055 m.rad	pass
2	The area under the GZ curve from 0.0 degrees to 40.0 degrees	0.378 m.rad	0.09 m.rad	pass
3	The area under the GZ curve from 30.0 degrees to 40.0 degrees	0.136 m.rad	0.03 m.rad	pass
4	The maximum value of GZ occurs at	32.0 degrees	25 degrees	pass
5	The value of GZ at an angle of heel of 32.0 degrees	0.801 metres	0.2 metres	pass
6	The value of the upright GM	1.974 metres	0.15 metres	pass

Motoring Max Load

Displacement	578.22 tonnes
LCG	-2.735 metres
VCG	5.469 metres
TCG	0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.235 m.rad	0.055 m.rad	pass
2	The area under the GZ curve from 0.0 degrees to 40.0 degrees	0.366 m.rad	0.09 m.rad	pass
3	The area under the GZ curve from 30.0 degrees to 40.0 degrees	0.131 m.rad	0.03 m.rad	pass
4	The maximum value of GZ occurs at	31.6 degrees	25 degrees	pass
5	The value of GZ at an angle of heel of 31.6 degrees	0.777 metres	0.2 metres	pass
6	The value of the upright GM	1.899 metres	0.15 metres	pass

APPENDIX 3 – MAX KG CRITERIA AT SEAGOING LOADING CONDITIONS WITH DOWNFLOOD POINTS

All VCGs fluid unless otherwise stated

Specific Gravity of Water	1.0250
Mean Shell Thickness	0.0060 metres
Longitudinal Datum	Midships
Vertical Datum	Base Line

Maximum KG Data

Calculated with heel to starboard

Criteria:

1: The area up to 30 degrees shall be 0.055 m.rad

2: The area up to 40 degrees or downflooding angle shall be 0.09 m.rad

3: The area from 30 - 40 degrees or downflooding angle shall be 0.03 m.rad

4: The angle of maximum GZ shall not be less than 25 degrees

5: GZ shall be at least 0.2 metres at angles of 30 degrees or more

6: GM shall be at least 0.15 metres

Maximum KG Values

	Criteria No.					
Condition	**1** metres	**2** metres	**3** metres	**4** metres	**5** metres	**6** metres
1: Motoring Light Load	6.927	6.750	6.318	6.557	6.699	7.422
2: Motoring Full Load	6.851	6.647	5.621	6.624	6.649	7.282
3: Motoring Max Load	6.813	6.587	4.439	6.615	6.618	7.218

Condition No.	Displacement tonnes	LCG metres	VCG metres	TCG metres	Maximum KG metres	Deadweight Moment tonnes.metres	Critical Number	Pass/Fail
1	502.44	-2.879	5.665	0.000	6.318	407.66	3	pass
2	556.12	-2.844	5.457	0.000	5.621	359.10	3	pass
3	578.22	-2.735	5.469	0.000	4.439	-200.13	3	fail

Motoring Light Load

Displacement	502.44 tonnes
LCG	-2.879 metres
VCG	5.665 metres
TCG	0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.224 m.rad	0.055 m.rad	pass
2	The area under the GZ curve from 0.0 degrees to 34.7 degrees	0.283 m.rad	0.09 m.rad	pass
3	The area under the GZ curve from 30.0 degrees to 34.7 degrees	0.058 m.rad	0.03 m.rad	pass
4	The maximum value of GZ occurs at	31.9 degrees	25 degrees	pass
5	The value of GZ at an angle of heel of 31.9 degrees	0.722 metres	0.2 metres	pass
6	The value of the upright GM	1.910 metres	0.15 metres	pass

Motoring Full Load

Displacement	556.12 tonnes
LCG	-2.844 metres
VCG	5.457 metres
TCG	0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.242 m.rad	0.055 m.rad	pass
2	The area under the GZ curve from 0.0 degrees to 32.4 degrees	0.275 m.rad	0.09 m.rad	pass
3	The area under the GZ curve from 30.0 degrees to 32.4 degrees	0.034 m.rad	0.03 m.rad	pass
4	The maximum value of GZ occurs at	32.0 degrees	25 degrees	pass
5	The value of GZ at an angle of heel of 32.0 degrees	0.801 metres	0.2 metres	pass
6	The value of the upright GM	1.974 metres	0.15 metres	pass

Motoring Max Load

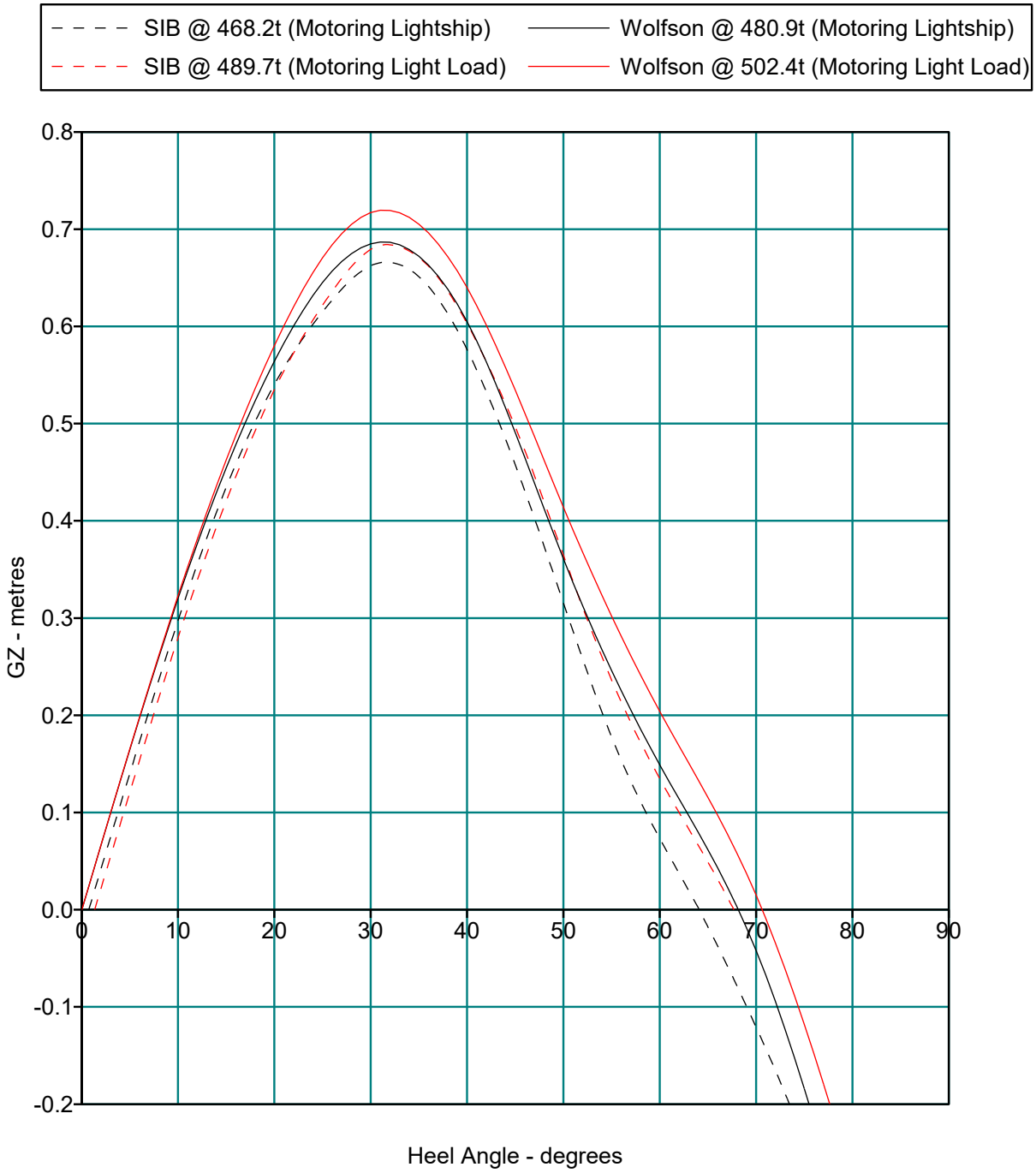
Displacement	578.22 tonnes
LCG	-2.735 metres
VCG	5.469 metres
TCG	0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.235 m.rad	0.055 m.rad	pass
2	The area under the GZ curve from 0.0 degrees to 31.3 degrees	0.253 m.rad	0.09 m.rad	pass
3	The area under the GZ curve from 30.0 degrees to 31.3 degrees	0.018 m.rad	0.03 m.rad	fail
4	The maximum value of GZ occurs at	31.6 degrees	25 degrees	pass
5	The value of GZ at an angle of heel of 31.6 degrees	0.777 metres	0.2 metres	pass
6	The value of the upright GM	1.899 metres	0.15 metres	pass

APPENDIX 4 – RIGHTING LEVER (GZ) CURVES AT SELECTED MOTORING CONDITIONS

Motoring Lightship: SIB (468.2 t & 0.73° heel) v Wolfson Loss Model (480.9 & 0° heel)

Motoring Light Load: SIB (489.7 t & 1.35° heel) v Wolfson Loss Model (502.4t & 0° heel)



Wolfson Unit Report No. 2980mp-ms_Rev9, dated 27 March 2026: *Bayesian*: Probable loss condition



WOLFSON UNIT
FOR MARINE TECHNOLOGY & INDUSTRIAL AERODYNAMICS

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Report No. 2980mp-ms_Rev9

Date : 27th March, 2026
Compiled By : [redacted]

Marine Accident Investigation Branch

Further Stability and Windage Analysis of S/Y Bayesian

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University of Southampton

EXECUTIVE SUMMARY

Between January and April 2025, the Wolfson Unit created the preliminary stability and windage model of S/Y Bayesian from hydrostatics and loading data presented in the vessel's approved Stability Information Book (SIB), various technical drawings of the hull, rigging and superstructure, and a digital hull form definition by the Maritime and Coastguard Agency (MCA). The preliminary stability and windage model enabled the Wolfson Unit to estimate the maximum gust velocity magnitude the vessel could withstand given its stability characteristics. These results are presented in Wolfson Unit report ref. 2950mp-ms_Rev3 dated 24th April, 2025 and incorporated in the MAIB interim report on the S/Y Bayesian accident (MAIB, 2025).

This report presents further stability and windage analysis of S/Y Bayesian based on additional input data provided by MAIB between May 2025 and March 2026. These data include a 3d scan of the wreck, a deadweight survey and manual measurements of the vessel's arrangements and rigging, all performed by MAIB.

These data were used to update the digital stability model of the vessel, which was then calculated to derive its probable loading, flotation and stability characteristics near the time of its loss.

The windage model of the hull, superstructure and rigging was also updated to include the effect of spreaders and other items not previously modelled, updating of element dimensions based on information provided by MAIB and reflected the revised, probable stability characteristics of S/Y Bayesian near the time of its loss. A limiting steady wind speed envelope between 43 – 48 knots is predicted when beam on to the wind, which represents a gust speed of 60 – 68 knots.

ABBREVIATIONS AND ACRONYMS

AP	Aft Perpendicular
AVS	Angle of Vanishing Stability
AWA	Apparent Wind Angle
AWS	Apparent Wind Speed
BL	Base Line
CFD	Computational Fluid Dynamics
Cx	Aerodynamic Drive Force Coefficient
Cy	Aerodynamic Side Force Coefficient
FP	Forward Perpendicular
Fr.	Frame
GHS	General Hydrostatics software suite by Creative Systems, Inc.
GZ	Righting Lever
HST	Hydrostatics and Stability software suite by the Wolfson Unit
INAB	Ingenieros Navales Asociados de Baleares S.L.
LBP	Length Between Perpendiculars
LCB	Longitudinal Centre of Buoyancy
LCF	Longitudinal Centre of Flotation
LCG	Longitudinal Centre of Gravity
MAIB	Marine Accident Investigation Branch
MCA	Maritime and Coastguard Agency
MP	Midships Position
REG	Red Ensign Group
SIB	Stability Information Book
USK	'Underside of Keel' or 'Keel Line'
VCG	Vertical Centre of Gravity

GLOSSARY

Capacity Plan	a 2D technical drawing showing size and position of a vessel's tanks
Displacement	weight of water that is displaced by the underwater portion of a floating body taking into account the specific gravity of the water
General Arrangement	a 2D technical drawing showing a vessel's layout and internal subdivision
Lines Plan	a 2D technical drawing of a vessel's hull and its appendages
Sail Plan	a 2D technical drawing showing the mast, rigging and sails in the hoisted position

1 HULL MODELLING AND VALIDATION

This section discusses the hull lines definition of S/Y Bayesian from hull lines survey data, its comparison with the 'Wolfson loss model' described in (Wolfson, 2025) and the selection of the best hull definition for conducting further stability / windage analysis in support of the MAIB investigation.

1.1 Wolfson initial stability modelling (Phase 1)

The Wolfson loss model of S/Y Bayesian (Wolfson, 2025) was produced by the Wolfson Unit from hydrostatics and loading data presented in the vessel's approved Stability Information Book (SIB), various technical drawings of the hull, rigging and superstructure, and a digital hull form definition by the Maritime and Coastguard Agency (MCA).

The above loss model was prepared in Wolfson's hydrostatics and stability suite HST and designated as "***HULL H.8 - Copy 2 of CM 65000 -Salute' - Perini Navi C2095_Loss Model.hst***". It consists of the vessel's appended hull and buoyant superstructure, with buoyancy deductions in way of the centreboard case and cockpits. The centreboard was modelled as fully raised and, therefore, contained within its partially flooded case. The starboard profile of the model is shown in Figure 1.

The Wolfson loss model enabled the stability assessment of S/Y Bayesian over a range of load conditions and was combined with an aerodynamic loading tool to estimate the maximum gust velocity magnitude the vessel could withstand given its stability characteristics. These results are presented in the MAIB interim report on the S/Y Bayesian accident (MAIB, 2025).

1.2 3D laser survey of S/Y Bayesian

Following its raising in June 2025, the wreck of S/Y Bayesian was delivered to Termini Imerese, Italy where MAIB conducted a 3D laser survey of the appended hull, superstructure and rigging.

At the time of the survey, the vessel was on the hard, resting on its keel and supported as shown in Figure 2. The MAIB survey was performed with a RIEGL laser scanner that produced a point cloud definition of the appended hull, superstructure and rigging, see Figure 3.

This new data was compared with the hull definition of the Wolfson loss model, to assess any significant deviations between the as-built and the as-designed vessel, and to confirm/adjust the digital stability model as appropriate. This process is described in the following sections 1.3 and 1.4.

1.3 Definition of a new stability model from 3D laser survey data

The 3D laser survey of S/Y Bayesian was processed by MAIB and Wolfson to produce a family of transverse sections through the appended hull and superstructure at the appropriate longitudinal positions, to enable the subsequent stability analysis in Wolfson's HST software. The MAIB/Wolfson processing consisted of the following key steps:

1. **Transformation** of the scanned data from world axes $(O, X, Y, Z)_w$ to ship axes $(O, X, Y, Z)_s$ using the vessel's surveyed draught marks. To this end, the ship axes' origin was positioned at the vessel's centre plane, at 4200mm above the keel line and at the longitudinal location of the aft draught marks, Frame 3. The ship axes were orientated as follows: X_s +ve forward, Y_s +ve port and Z_s +ve upwards. The surveyed, port side, aft draught marks and the Y_s axis at the 4200mm waterline are shown in Figure 3.

2. **Validation** of the ship axes. Regression of the surveyed draught marks at 3.8m, 4.0m and 4.2m above keel plate produced three planes parallel to the X_sY_s plane. The average deviation of the 4.2m 'regressed' plane from the four draught marks (aft marks to port and starboard & forward marks to port and starboard) it was derived from, was 0.1mm. The average deviations at the 4.0m and 3.8m waterlines were 0.50mm and 0.63mm respectively. Such draught deviations are entirely acceptable for the purpose of a stability assessment, because the potential displacement volume error resulting from the draught error is less than 0.05%, which is well within the standard Wolfson tolerance of 0.5%.

3. **Manual removal** of supports, shafts, propellers and other features from the vessel's scanned point cloud. Any chocks positioned under the keel were retained, and their upper face used to locate the underside of keel.

4. **Automatic generation** of transverse sections through the scanned point cloud at Frames -3 to 36 and at additional positions in way of the rudder and skeg trailing edge. Such sections were lifted to port and to starboard, to capture the potential asymmetry of the scanned hull.

5. Automatic, section-wise application of **vertex reduction and smoothing** processes via Rhinoceros Grasshopper® scripts, followed by **automatic curve fitting** through the residual points. These routines were developed as part of this work package and enabled a user-independent, repeatable process. This resulted in low-oscillation, transverse sections and therefore reduced computational overheads in the subsequent hydrostatics and stability analysis.

6. **Vertical and longitudinal offsetting** for transforming ship axes to HST axes and correction of small deviations of the scanned USK line from the horizontal. Such deviations are likely due to concurrent factors such as reduced density of the surveyed 3D points in way of the USK due to its proximity to the ground, approximations inherent in the point cloud filtering and sectioning process, presence of chocks that hindered a clear view of the keel edge, and potential sagging of the hull. All sections were then clipped at the deck edge for hydrostatics calculation purposes.

7. **Minor adjustments** were made to the Phase 1 transverse sections in way of the superstructure, namely the main saloon sides were moved inboard by 140mm on average (over Frames 7 to 17) in accordance with the 3D scan data. The scanned sections were vertical and parallel in body plan, which indicates that no crush damage occurred because of the salvage process. The 140mm delta was likely caused by the low resolution of the vessel's drawings used for the Phase 1 superstructure measurement. The scan confirmed the main saloon design length and height above deck.

The transverse sections obtained from the above process are shown in Figure 4 and Figure 5(b).

1.4 Comparison of Wolfson Loss Model (Phase 1) and new model (Phase 2)

The initial Wolfson loss model of (Wolfson, 2025) and that obtained from the 3d laser survey are shown in Figure 5(a) and Figure 5(b) respectively. These two models were compared based on their hydrostatics characteristics and flotation over a range of nominal loading conditions. The stability characteristics exhibited by each model at the assumed loss condition presented in (Wolfson, 2025) were also compared.

These data are presented in the following Figures:

Figure 6: Variation of Displacement, LCB ad LCF with Draught at Level Trim
Figure 7: Variation of Displacement % change with Draught at Level Trim
Figure 8: Variation of LCB and LCF % change with Draught at Level Trim
Figure 9: Variation of Draught at Mid Marks with Displacement at Motoring Load Conditions
Figure 10: Variation of Keel Trim with Displacement at Motoring Load Conditions
Figure 11: Variation of Righting Lever (GZ) with heel angle at assumed loss condition of (Wolfson, 2025)

1.5 Discussion

a. Figure 6 and Figure 7 show that, at zero trim, the Phase 2 displacement is within 0.3% of the Phase 1 displacement over the entire range of calculated draughts ie 3.5 to 4.2m. This percentage change reduces as the draught increases.

b. The above trend is consistent at all the calculated trims, and is within the range 0.10 - 0.22% over the range of seagoing draughts and trims presented in the SIB that are, 3.8 to 4.0m draught and 0.0 (level) to 0.2m stern trim.

c. Displacement changes of 0.5% or less from approved data are deemed acceptable by the Wolfson Unit when validating stability models produced by third parties. It should be noted that the Wolfson Unit's 0.5% permitted displacement change is more onerous than the change permitted by (Red Ensign Group, 2019) paragraph 11.5.3 for lightship validation purposes. The REG permitted change in the lightship weight is up to 2%.

d. At zero trim, where LCB = LCG, the Phase 2 LCB is within 0.37% of the Phase 1 LCB over the entire range of calculated draughts ie 3.5 to 4.2m. The LCG change permitted by (Red Ensign Group, 2019) paragraph 11.5.3 for lightship validation purposes is up to 1%.

e. When loaded to the assumed loss condition (Wolfson, 2025) ie displacement = 502.436t, LCG = -2.879m, VCG (fluid) = 5.665m and TCG=0.000m, the calculated equilibrium heel angle of the Phase 2 model is 0.315° to port. This is due to a small asymmetry in the scanned hull definition resulting in excess buoyancy to starboard.

f. In the assumed loss condition (Wolfson, 2025), offsetting the TCG to starboard by 0.011m reduces the equilibrium heel to zero. This is useful for the direct comparison of the Phase 1 and Phase 2 models discussed below, items g. and h.

g. Figure 9 and Figure 10 compare the vessel's calculated equilibrium flotation at the four motoring load conditions presented in the SIB and, also, at the assumed loss condition (Wolfson, 2025). Comparison of the flotations shows that, when the Phase 1 and 2 stability models are both loaded to the assumed loss displacement 502.436t and LCG -2.879m, they float at the same draught (within 2mm of each other) and trim (within 0.1° of each other). For this comparison, the Phase 2 model has been assessed with 0.011m TCG correction applied (see item f. above).

h. Figure 11 presents the calculated righting lever (GZ) curves of the Phase 1 and 2 models. To enable a direct comparison, both the Phase 1 and the Phase 2 models were loaded to 502.436t, LCG = -2.879m and VCG (fluid) = 5.665m, and the Phase 2 model was calculated with 0.011mm TCG correction applied (see item f. above). Inspection of the GZ curve properties affecting large angle stability when heeled to starboard shows that the Phase 2 model has:

   1. Angle of Vanishing Stability = 69.6° as opposed to the Phase 1 AVS of 70.6°. This 1° delta is likely caused by the slightly reduced main saloon breadth described in Section 1.3.7
   2. Maximum GZ = 0.733m which is 11mm greater than the Phase 1 Maximum GZ (a 1.5% increase)
   3. Maximum GZ Angle = 31.8° which is virtually the same as the Phase 1 Maximum GZ Angle = 31.9°

   It should be noted that the Phase 2 loading will be modified in Section 2 of this report, where updated tank contents are considered. Therefore, the resulting stability characteristics 1. 2. & 3. above will change.

i. Comments a. to h. above indicate virtually no differences in the hydrostatics and flotation of the Phase 1 and 2 models, and notable but not significant differences in the large angle stability characteristics. The impact of these differences on the critical wind speed predictions derived from the windage model are discussed in Section 4.

j. Based on the discussion between Wolfson and MAIB held on 12/12/2025, the consensus is that the Phase 2 model obtained from the 3D lased scan will be used for the subsequent analysis.

k. It should be borne in mind that all GZ curves are idealized, as they assume no transverse shifts of the deadweight towards the low side as the vessel heels over. If the net heeling moment resulting from the offset weights were significant, and were incorporated in the analysis, they would erode the vessel's "nominal" stability reserves, resulting in reduced righting levers at large angles of heel (ie beyond the angle where deadweight would start to shift) and therefore reduced AVS.

2 IMPACT OF NEW DATA ON LOSS ANALYSIS

2.1 Impact of updated tank contents

In the assumed loss condition of (Wolfson, 2025), all tanks were assumed filled at 10% of their respective capacities except the Black & Grey Water tank, Sludge tank and Bilge tank which were assumed 98% full.

MAIB estimates of the tank contents and their likely distribution at the time of the loss were shared with Wolfson between December 2025 and February 2026. It is understood that:

a) the fresh water tanks (3P & 4S) were filled in the early evening of the accident and water makers turned off at approximately 1900hrs;

b) the vessel carried approximately 18000 litres of fuel at the time of its loss;

c) fuel was routinely used from aft storage tanks (7P & 8S) to forward storage tanks (5P & 6S) to manage stern trim;

d) the centreline fuel tank (78C) was used as a storage for cleaned fuel and typically filled at the end of the day;

e) the day fuel tanks (11P & 12S) were filled late on the evening of the accident, then approximately 120 litres were used up until the time of the accident;

f) the content of the lube oil tank (910C) may have been as low as 400 litres;

g) the crew did not correct list by internal movement of the tank contents.

The tank contents were therefore adjusted in accordance with this new information, as follows:

1. **Fresh Water tanks '3.P' and '4.S':** 98% full as per working assumption a)
2. **Fuel Oil tanks '5.P' and '6.S':** 45% full, as per working assumptions b) & c)
3. **Fuel Oil tanks '7.P' and '8.S':** 10% full, as per working assumptions b) & c)
4. **Fuel Oil tank '78.C':** 98% full, as per working assumption d)
5. **Day Fuel Oil tanks '11.P' and '12.S':** 87% full, as per working assumption e)
6. **Centreline lube oil tank '910C':** 20% full, as per working assumption f)

The capacity data of each tank are given in Table 1. The CG and FSM of the fluid mass within the tanks were obtained from the capacity tables presented in the SIB.

These additional tank contents resulted in a displacement of 522.19 t in the probable loss condition. This is a 3.9% displacement increase on the assumed loss condition of (Wolfson, 2025), whose tank contents were obtained from the 'Motoring Light Load' arrival condition declared in the SIB.

With these additional tank contents applied to the Phase 2 stability model, the calculated equilibrium data were 0.31 deg of heel to port and 0.45 deg stern trim. The port heel is caused by the excess hull buoyancy to starboard discussed at paragraph 1.5.e combined with a virtually symmetrical deadweight distribution. These figures agree with the equilibrium data of the Phase 1 hull model presented in the MAIB interim report (MAIB, 2025) that are, 0 deg of heel and 0.44 deg stern trim respectively.

2.2 Impact of offset deadweight

The MAIB deadweight survey data were analysed to produce the additional heeling moment exerted by the loose items that might have shifted to starboard (ie the vessel's low side) as the vessel heeled over, just before its loss. These weights and the respective heeling moments applied are listed at Table 2. As can be seen:

- For each deadweight item, assumptions were made as to the effective weight displaced due to heel. Such assumptions were dictated by type and initial location of each deadweight. For example, 50kg of loose effects were assumed for each cabin, but only 80% was assumed as displaced, because the content of cupboards, wardrobes etc. would likely remain within those spaces.

- For each offset weight, the transverse offset was measured on the vessel's General Arrangement between the assumed initial position and the first bulkhead to starboard, or the vessel's side.

The total heeling moment estimate due to the offset weight is 2.45 t.m

2.3 Impact of potential rainwater in lazarette

MAIB evidence indicates the potential for rainwater entering the vessel's full breadth lazarette through the forward facing, hinged, deck hatch of Figure 12. This hatch leads to the port side of the lazarette and is positioned by the aft cockpit beneath the flybridge overhang. When viewed in plan, the hatch is just outboard of the overhang and, therefore, is not protected by it. Hence rainwater may have potentially entered the lazarette, had the hatch been left open.

There is evidence that the hatch remained partially open for ~6 minutes during intense rainfall just before the vessel's loss, but the exposed area is currently not known.

Rainwater ingress through the hatch opening could have occurred through three mechanisms:

1. directly, as precipitation through the exposed opening,
2. indirectly, as overhang runoff through the exposed opening, and
3. water on deck, flowing into the exposed opening.

The MAIB survey shows that the perimeter of the opening leading to the lazarette is protected by a recess that would collect deck water and discharge it outboard, so mechanism #3 was ignored in this analysis.

(MET Office, 2012) states that: *"For synoptic purposes, showers are classified as 'slight', 'moderate', 'heavy' or 'violent' for rates of accumulation of about 0 to 2 mm/h, 2 to 10 mm/hr, 10 to 50 mm/hr, or greater than 50 mm/hr respectively"*.

In addition, (WMO, 2025) states that *"Showers are further classified as being violent if the rate exceeds 50mm per hour, normally considered to be rates typical for tropical regions"*.

Regarding mechanism #1 above: had the lazarette hatch been left fully open, 50 mm/hr rainwater entering the lazarette through a 1.83m^2 exposed opening over 6 minutes, would have resulted in ~9 litres of flood water.

Regarding mechanism #2 above: 50 mm/hr rainwater landing over a 4.25m^2 region of the flybridge overhang over 6 minutes, and discharged directly into the lazarette, would have resulted in ~21 litres of flood water.

To assess the stability impact of the resultant 30 kg rainwater in the lazarette, the free surface correction technique is too inaccurate for satisfactory use given the large plan area of this space. Therefore, the lazarette was modelled in the HST software as a large, slack tank with 30 kg rainwater in it. The rainwater was then allowed to find its own level at each heel angle within the lazarette, the stability was re-calculated accordingly, and a new righting lever (GZ) curve was produced. As expected, the calculated Maximum GZ, Maximum GZ Angle and AVS of the GZ curve with 30kg rainwater in the lazarette, coincided with those calculated for the dry lazarette case (Appendix 2).

In conclusion, the assumed 30 kg of rainwater in the lazarette due to mechanisms #1 and #2 combined, would have a negligible impact on the vessel's flotation and stability in the probable loss condition, and may therefore be ignored.

3 PROBABLE LOSS CONDITION

The updated tank contents described in Sect. 2.1 were first incorporated in the Phase 2 loss model, and the vessel's stability was recalculated. The resultant loading condition and stability data are given in Appendix 1 and Appendix 2 respectively.

Subsequently, the effect of offset deadweight described in Sect. 2.2 was added. The resultant stability data are given in Appendix 3.

4 PREDICTION OF WIND HEELING MOMENT

The macro based Excel spreadsheet tool created during the Phase 1 which estimates the maximum gust velocity magnitude and heel angle that the vessel is predicted to withstand was updated to include:

- The impact of spreaders
- Additional windage items not included in the Phase 1 analysis
- Updated windage element dimensions based on information retrieved by MAIB during the vessel inspection
- Updated loading condition and stability characteristics "Probable Loss, No Offset Deadweight", detailed in Appendix 1 and Appendix 2 respectively

In summary, the tool comprises of the vessel GZ curve(s) and wind heeling lever(s) and allows for the limiting steady state wind velocity (i.e. gust velocity / $\sqrt{2}$) to be calculated. The steady state wind velocity and associated heel angle represent the limits at which a gust is likely to cause capsize.

This approach has been influenced by the method laid out in (Red Ensign Group, 2019) Sailing Vessel Monohulls, but includes all hydrostatic and stability information relating to the loading condition in question and ignores the impact of downflooding.

The following windage elements have been included in the tool.

- Hull
- Superstructure
- Other deck features such as main hoop, awning
- Mast tube
- Spreaders
- Boom
- Rigging elements
- Furlers and furled sails
- Satellite domes
- Tender Lifting Pole

These represent the main contributing windage items of the vessels, elements that have been omitted include stanchions and all other detailed items.

Frontal and side areas and vertical levers of all windage elements used have been updated based on MAIB onsite measurements and MAIB scanned data, supplemented with other data taken from the Sail Plan (Perini Navi, 2005).

Force coefficients for each of these windage elements have been estimated, using Phase 1 CFD 2-D lift and drag predictions for the mast and references including (Hoerner, 1965) and (ORC, 2024) for other elements.

A wind gradient of a power law (1/9) has been adopted for the analysis in this report, this represents 'unstable air above a flat open coast' as per (Kaltschmitt, 2007).

The wind heeling arm uses the $\cos^{1.3}\theta$ term with heel, in keeping with references such as (Deakin, 2001). This has been modified in the case of the treatment of spreaders, where an increasing contribution of heeling moment with heel angle is incorporated.

The tool allows for a range of AWAs to be analysed, 0° - 180°.

The appropriate factors have been applied to some of the element force coefficients to represent ranges of blanketing and interactive effects between adjacent modelled components. This has resulted in likely envelopes of predicted limiting wind speeds at each AWA.

4.1 Results

The tool predictions of limiting wind speeds envelopes for a range of AWAs are presented in Table 3 for the vessel in the probable loss condition (522t). These highlight the decreasing limiting wind speeds with increasing AWA towards 90°, along with the lift production (which results in increased side force) from the mast at AWAs of 20° and less. A limiting steady wind speed envelope between 43 – 48 knots is predicted at an AWA of 90° (i.e. beam on to the wind), which represents a gust/squall speed of 60 – 68 knots.

The associated limiting heel angles are presented below in Table 4 and in Figure 14.

Table 4 highlights a relatively low limiting heel angle in a gust. This represents the angle at which the wind applied heeling moment can no longer be counteracted by the vessel's stability reserves. This means that a wind force sufficient to heel the vessel to 36° is therefore also sufficient to capsize it.

Figure 15(a) & (b) provide a breakdown of the wind heeling moment percentage contributions from each of the windage elements at 90° AWA, upright (i.e. 0° heel) and 36° (wind heeling moment limiting angle) respectively. These highlight the high influence of the mast which equates to in excess of 56% of the total heeling moment.

For context, the mast side profile area represents the upwind sail area of a typical 35 foot sailing yacht, and at least 25 metres above the waterline.

In comparison to the results of Phase 1, there is an increase in predicted limiting wind speeds. The majority of this change relates to the increases in displacement and GZ for the updated loss condition.

Figure 1 – Wolfson loss model (Wolfson, 2025): board up and rudder fitted, cambered deck, cockpits and buoyant superstructure

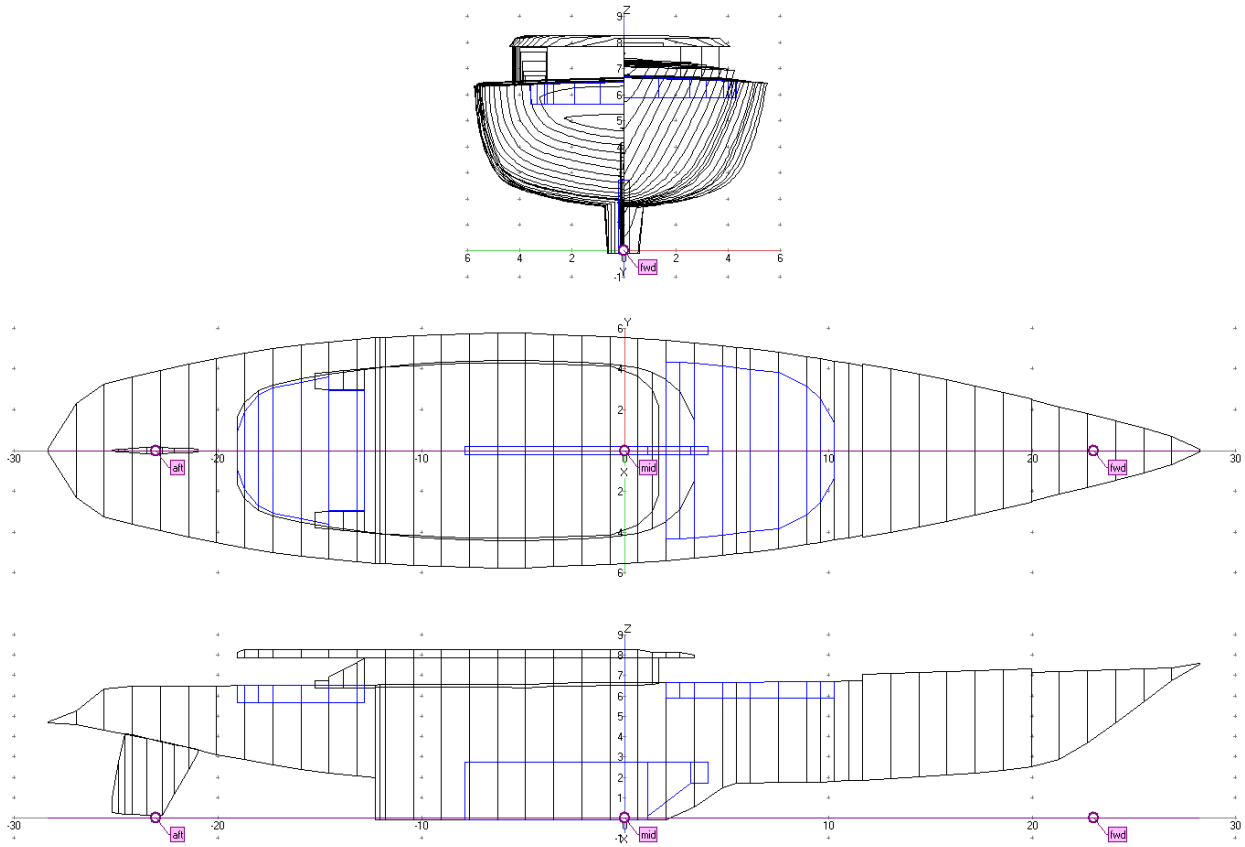


Figure 2 – Wreck of S/Y Bayesian in Termini Imerese, Italy (credit: TMC Marine).

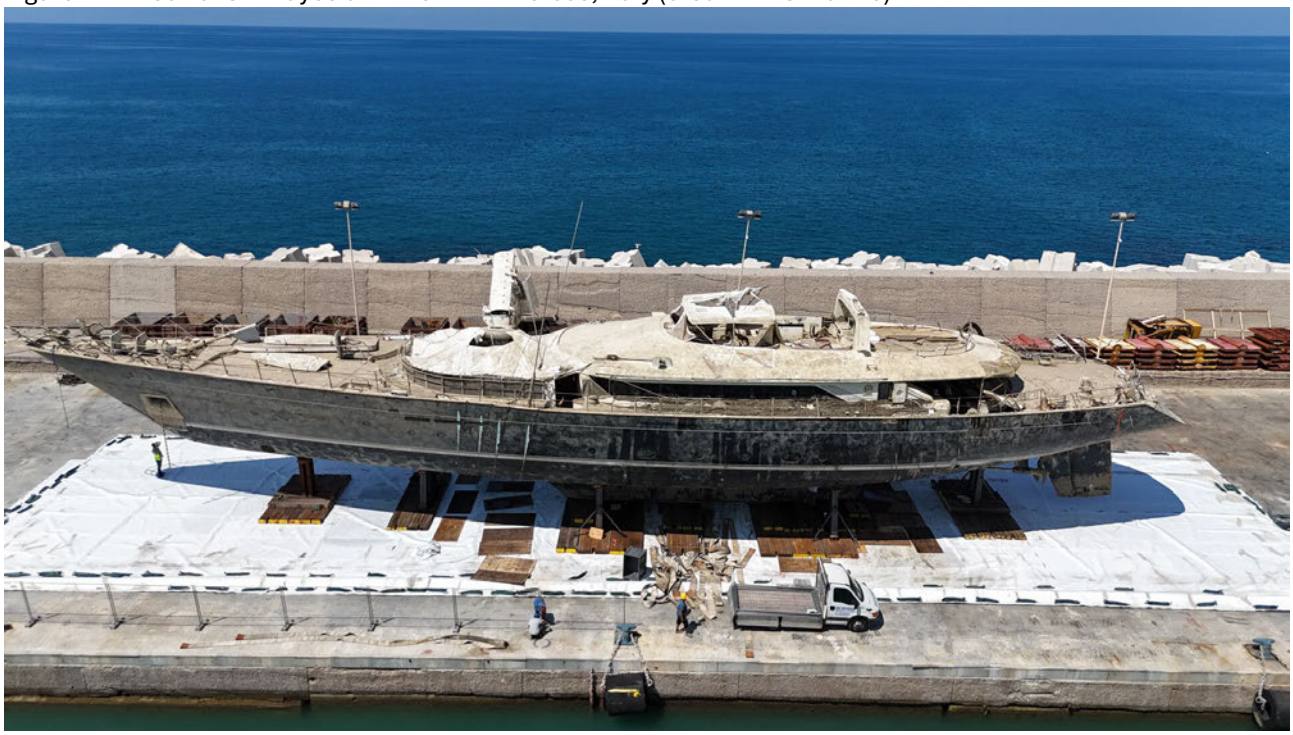


Figure 3 - Surveyed point cloud, showing Ship Axes and Aft Draught Marks (3.8m to 4.2m) on port side

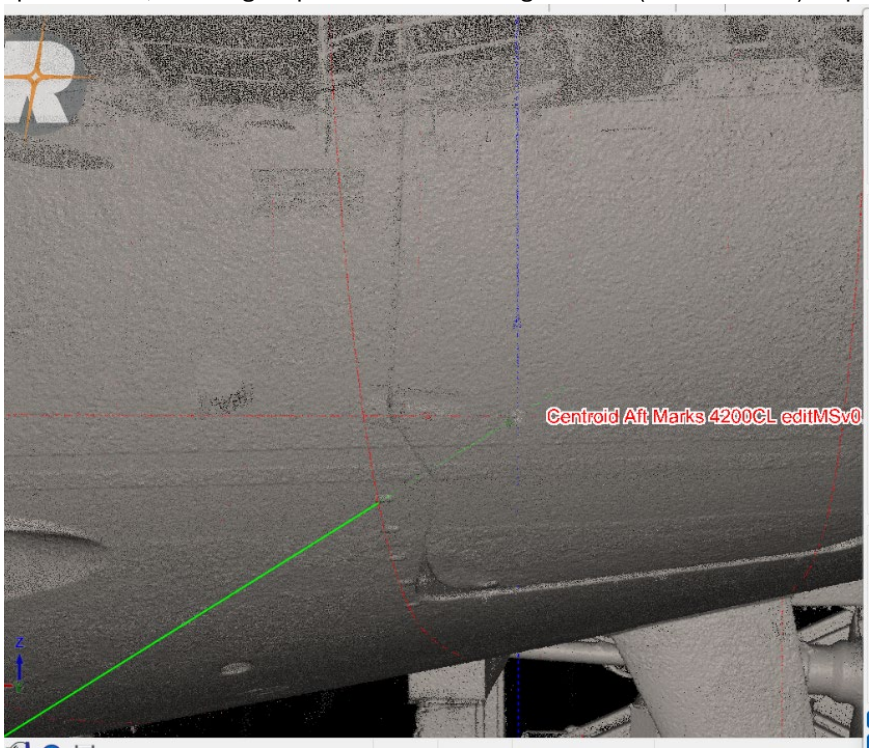


Figure 4 – Transverse sections through the hull at Frames -3 to 36, derived from MAIB hull lines survey and clipped at deck edge

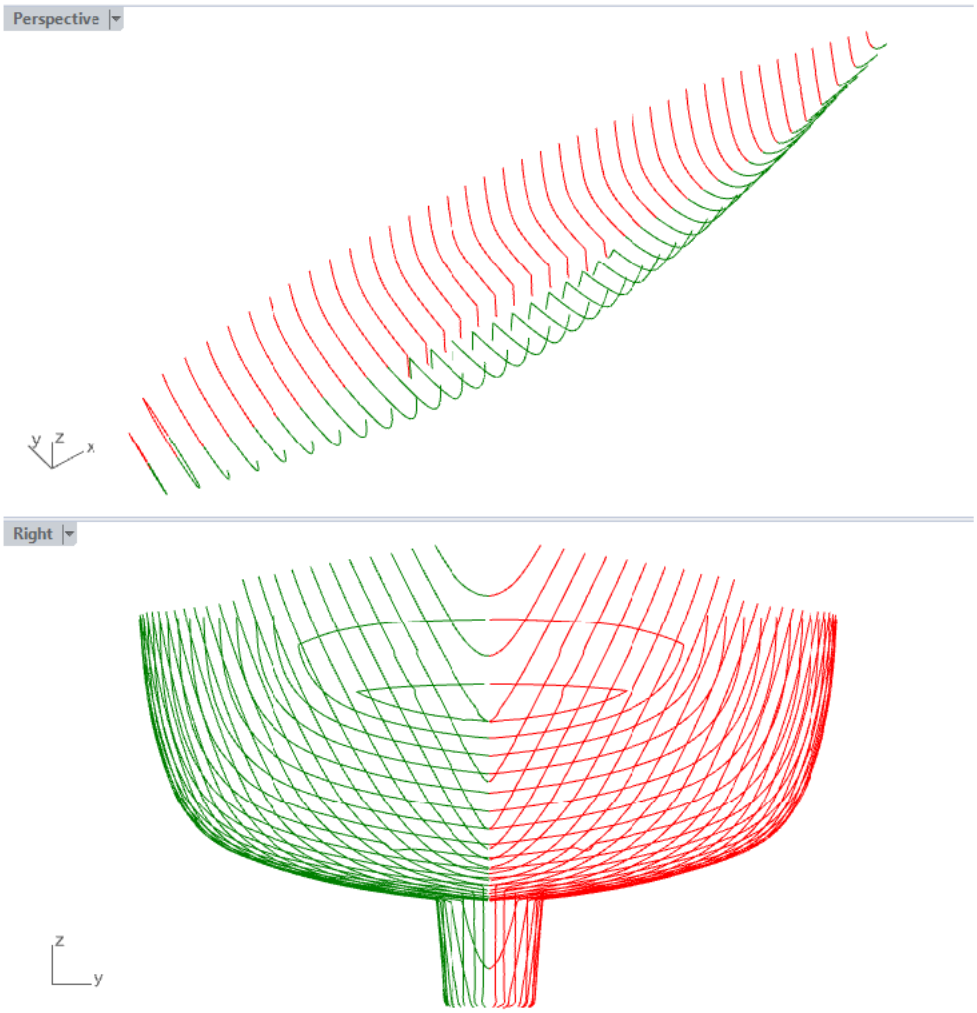


Figure 5 – Hull geometries used for hydrostatics' comparison: Wolfson loss model (a) and scanned hull form (b).

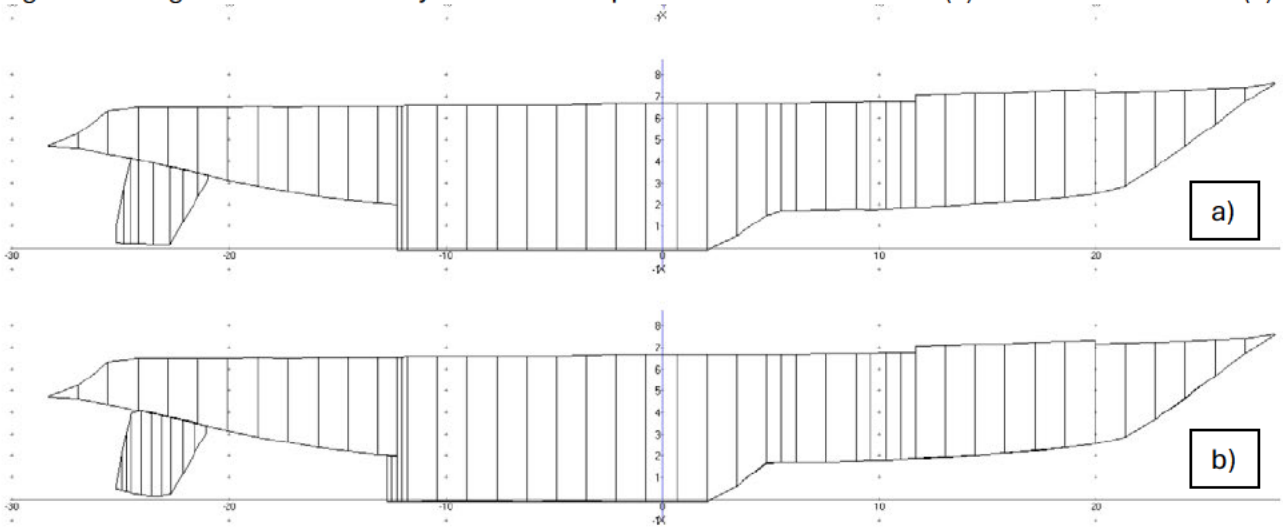


Figure 6 – Variation of Displacement, LCB and LCF with Draught (all data at level trim)

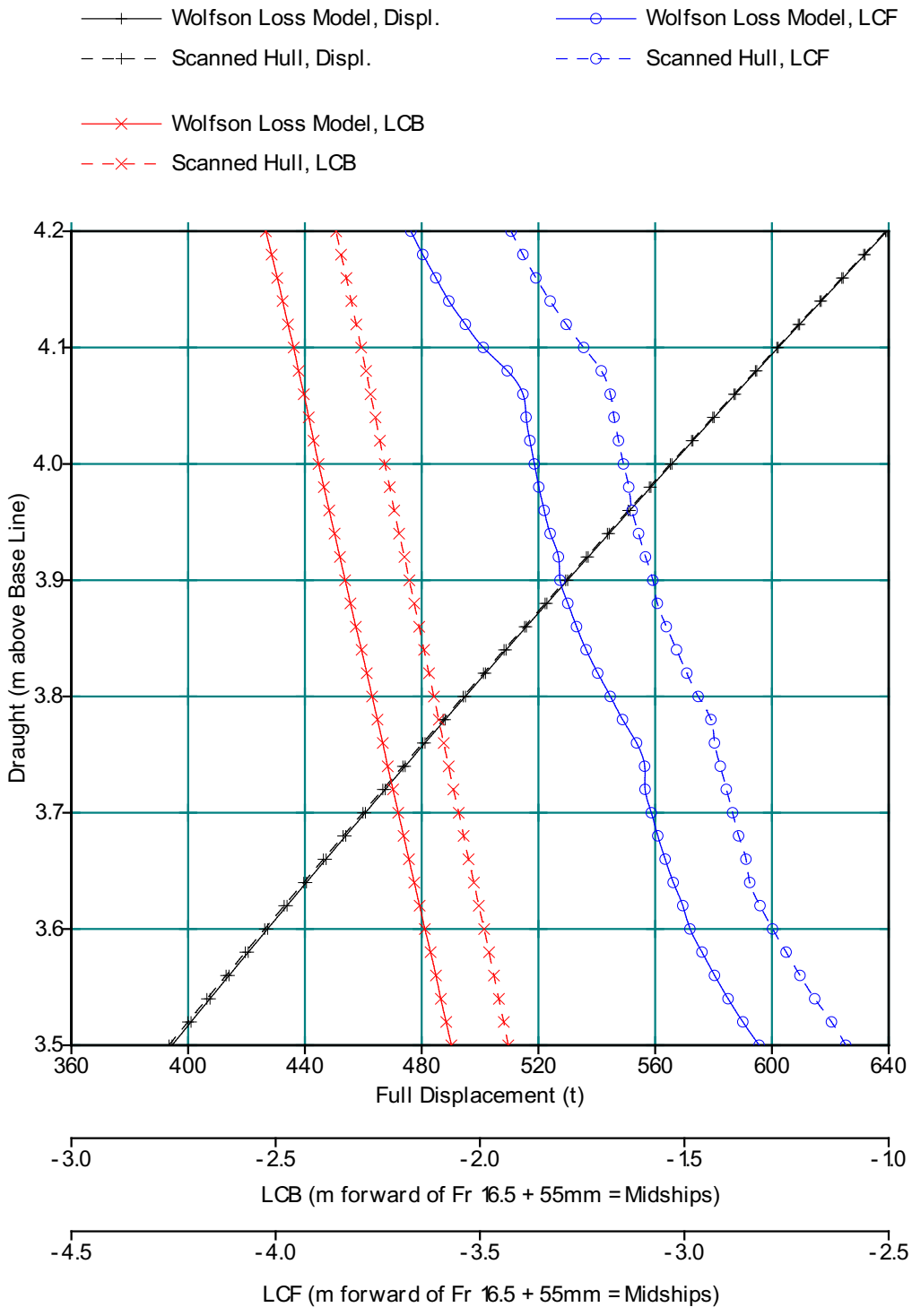


Figure 7 – Variation of Displacement % change with Draught (all data at level trim), where:
Displ. Change = Displ. Scanned Hull – Displ. Wolfson Loss Model

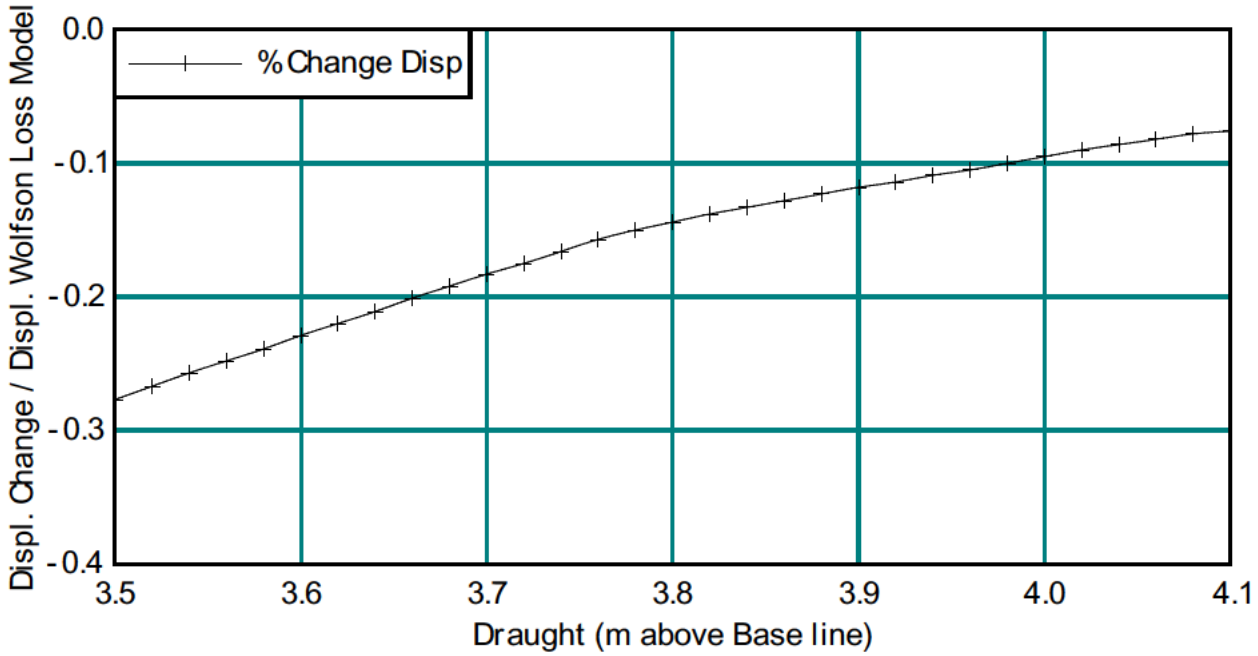


Figure 8 - Variation of LCB % Change & LCF % Change with Draught (all data at level trim), where:
LCB Change = LCB Scanned Hull – LCB Wolfson Loss Model
LCF Change = LCF Scanned Hull – LCF Wolfson Loss Model
LBP = 46.06 m

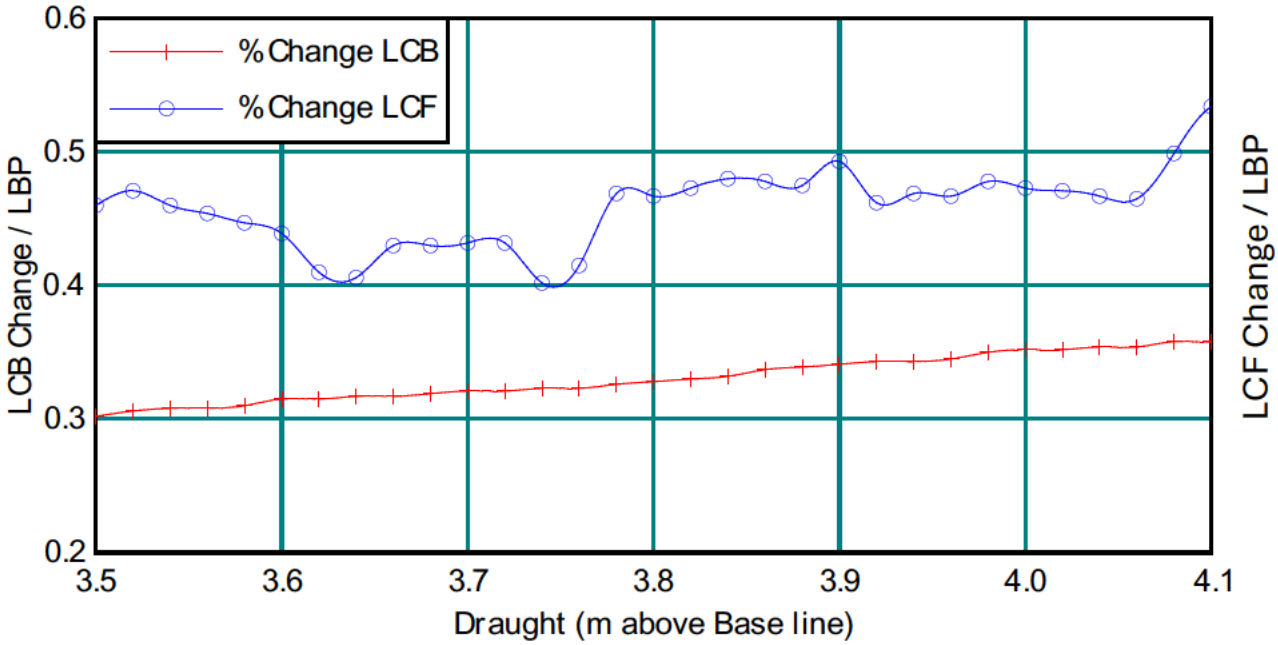


Figure 9 – Variation of Draught at Mid Marks with Displacement at Motoring Load Conditions

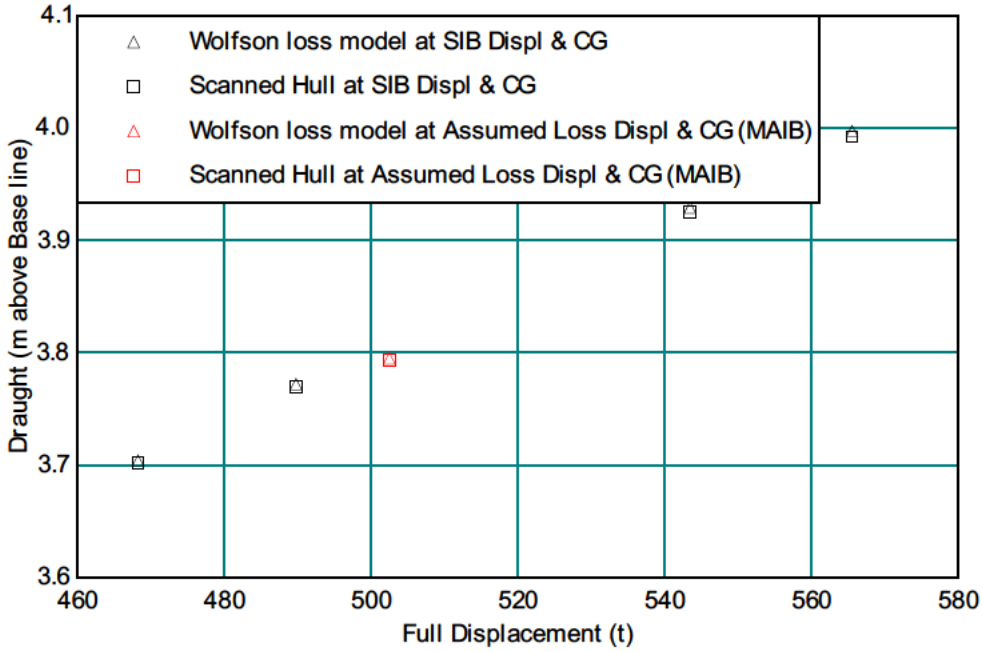


Figure 10– Variation of Keel Trim with Displacement at Motoring Load Conditions

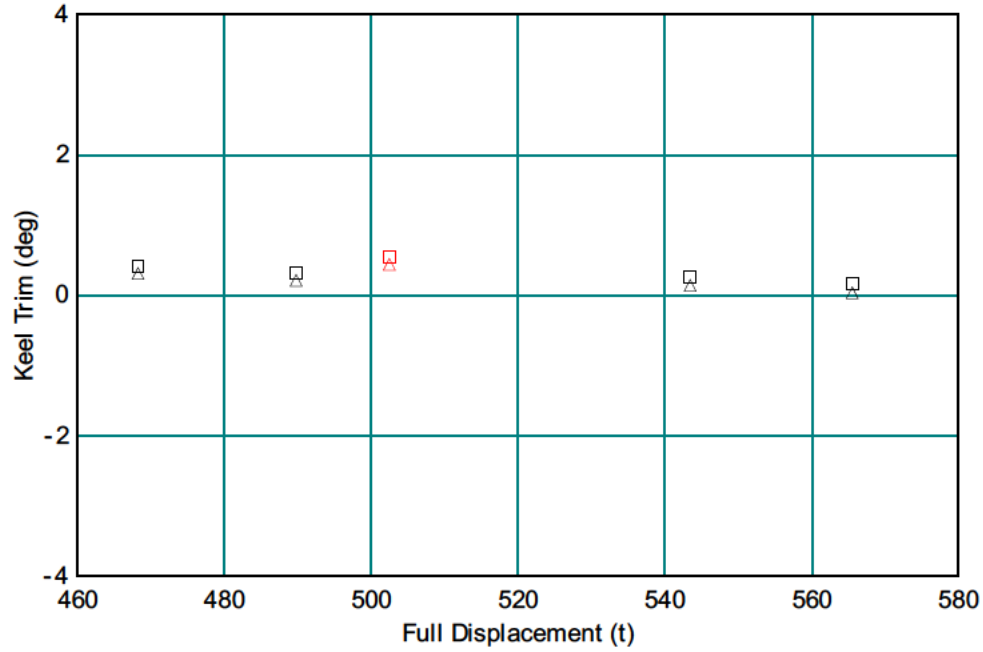


Figure 11 – Variation of Righting Lever (GZ) with Heel Angle at Assumed Loss Condition
Wolfson Loss Model (Phase 1): Displ = 502.4t, LCG = -2.879m, VCGfluid = 5.665m, TCG = 0.000m
Scanned Model (Phase 2): Displ = 502.4t, LCG = -2.879m, VCGfluid = 5.665m, TCG = 0.011m

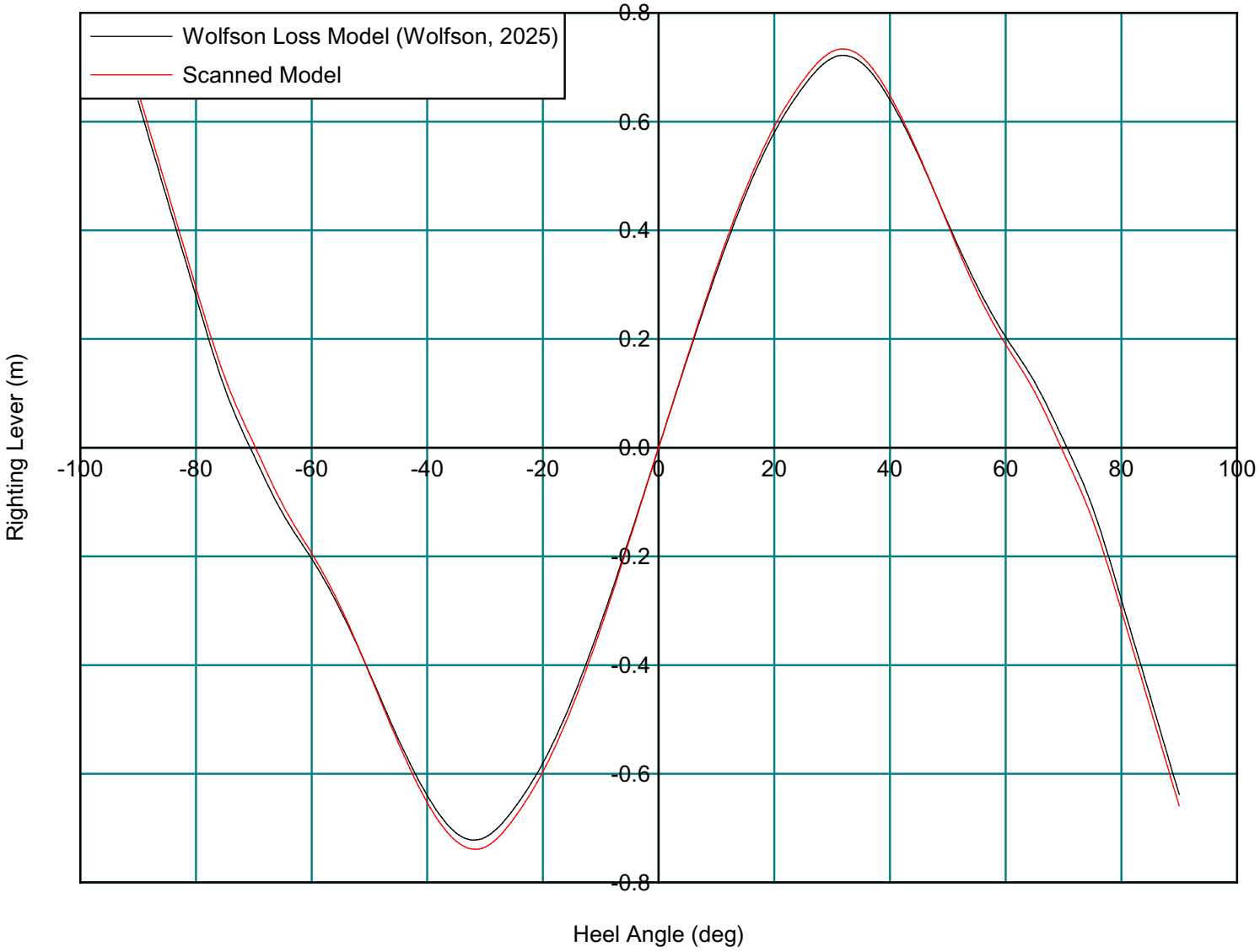
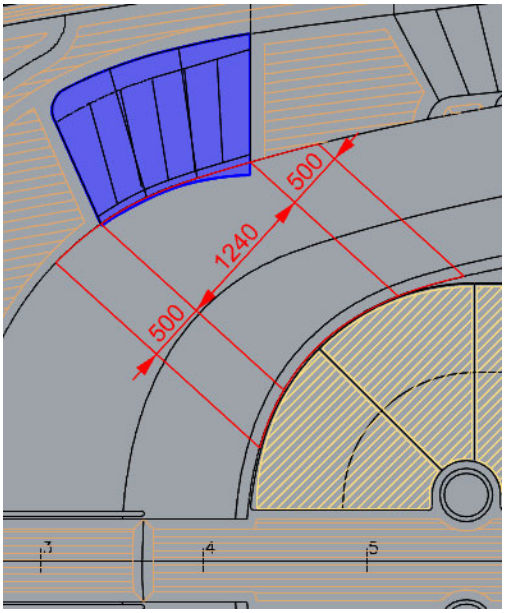


Figure 12 - Lazarette hatch, as surveyed by MAIB in December 2025



Figure 13 - Plan view of ~1.8m^2 hatch opening and ~4.3m^2 region of flybridge overhang, dimensions in mm.



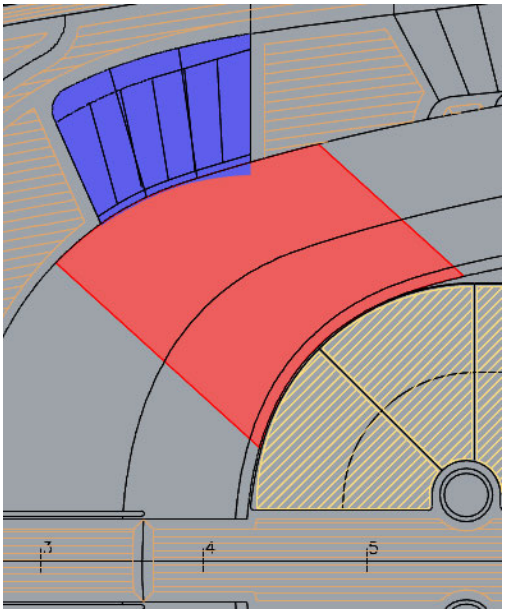


Figure 14 – Derived wind heel data in Phase 2 probable loss condition at 90° apparent wind angle

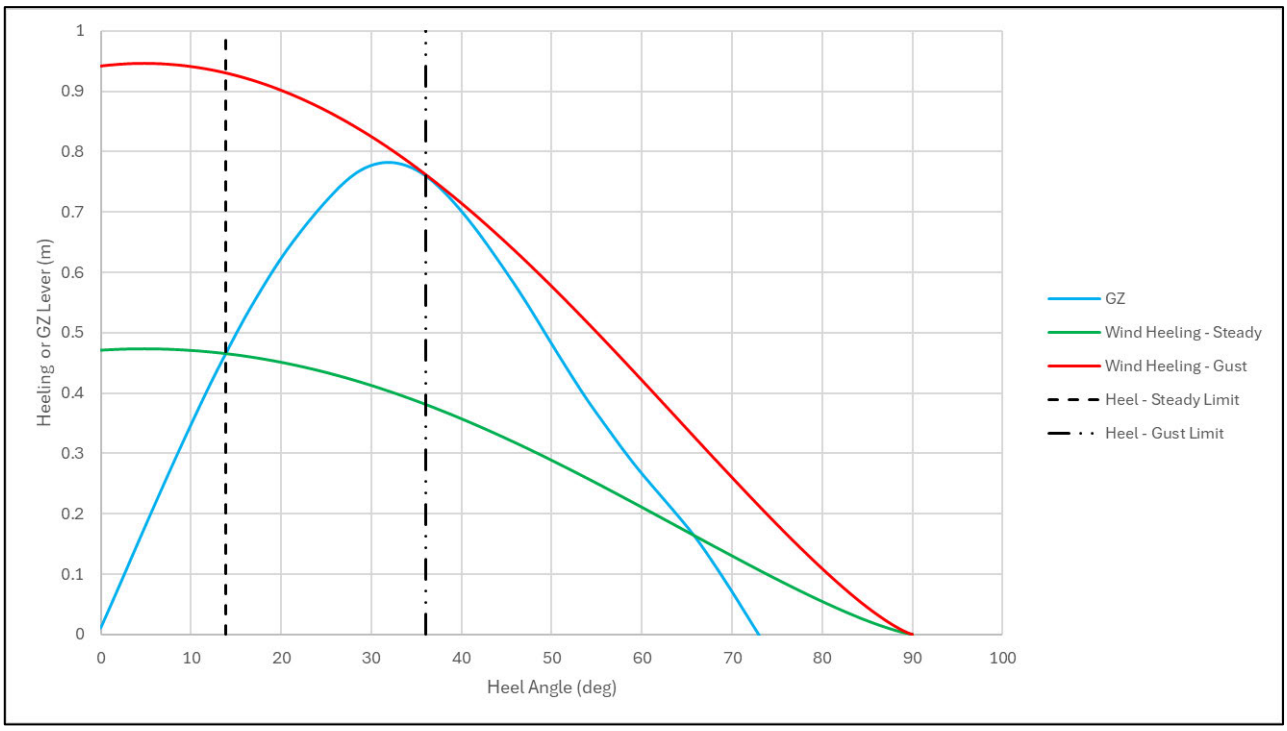
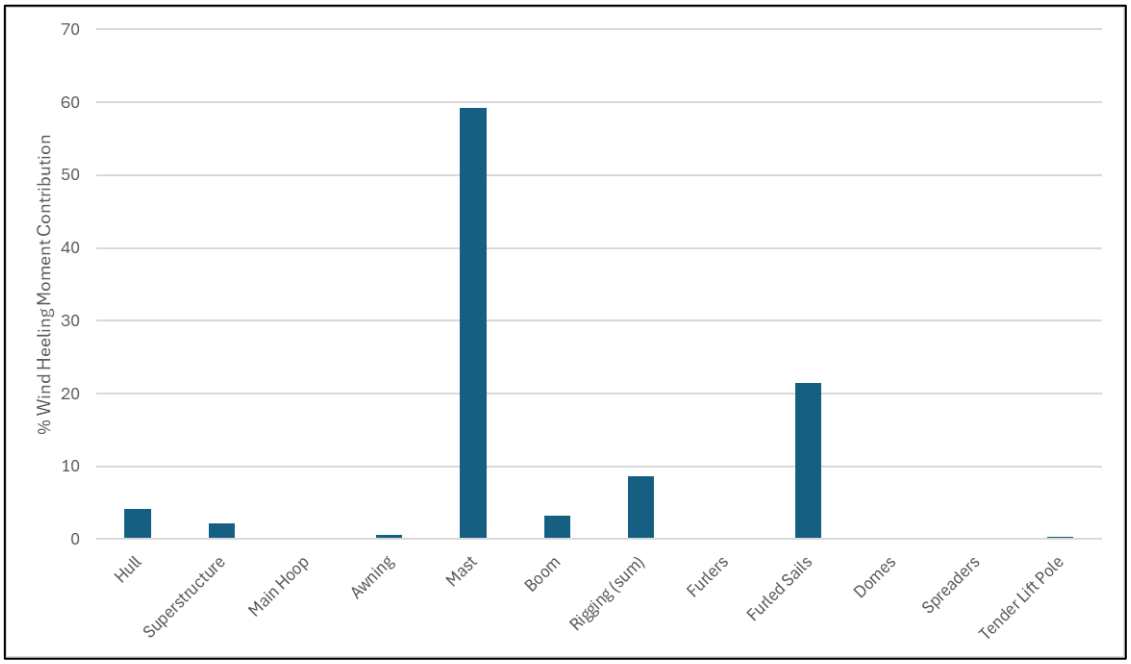


Figure 15 - Breakdown of % wind heeling moment contribution at 90° apparent wind angle

a) Upright : 0° heel



b) Limiting heel angle : 36°

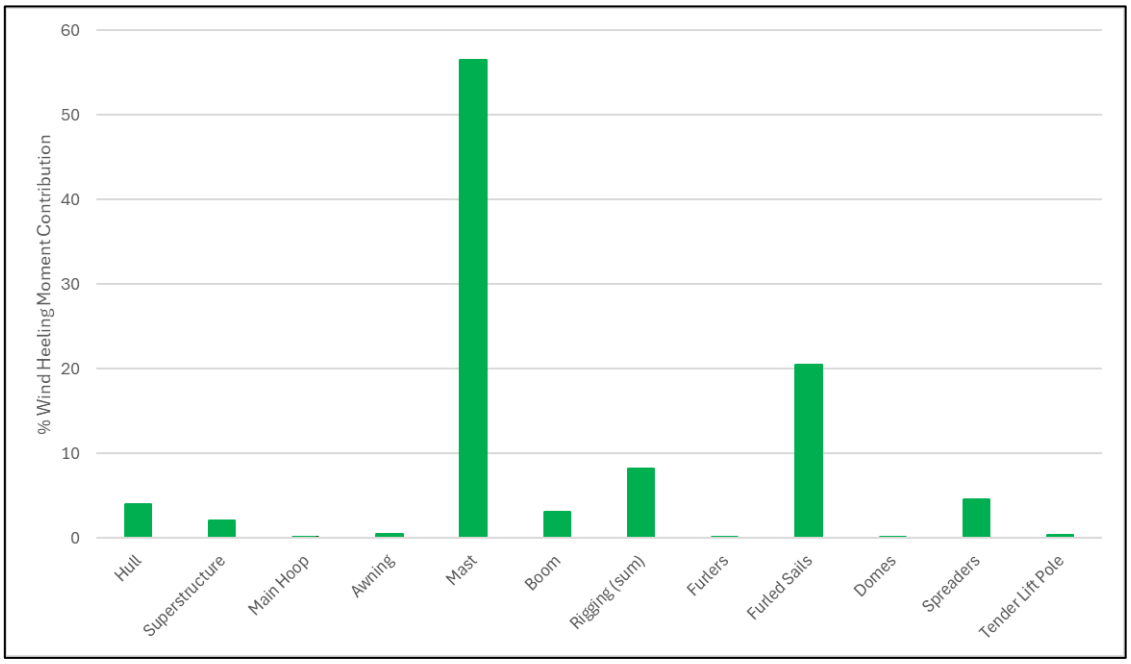


Table 1 – Probable tank contents near the time of the loss

SIB Designation	Content	Specific Gravity	% full	Weight	Capacity	LCG	VCG	TCG	FSM
				t	lt	m	m	m	t.m
TANK 2.S	Black & Grey W	1.000	12.9	0.50	500	6.38	2.34	2.37	0.18
TANK 3.P	Fresh Water	1.000	98.0	9.41	9408	4.02	2.31	-1.48	3.13
TANK 4.S	Fresh Water	1.000	98.0	6.13	6125	3.32	2.31	1.63	1.90
TANK 5.P	Fuel Oil (Storage)	0.830	45.3	3.96	4770	-0.81	2.08	-1.63	8.60
TANK 6.S	Fuel Oil (Storage)	0.830	45.3	3.96	4770	-0.81	2.08	1.63	8.60
TANK 7.P	Fuel Oil (Storage)	0.830	10.0	1.35	1623	-5.18	1.89	-1.08	2.93
TANK 8.S	Fuel Oil (Storage)	0.830	10.0	1.35	1623	-5.18	1.89	1.08	2.93
TANK 78.C	Fuel Oil (Storage)	0.830	98.0	3.69	4451	-8.79	2.28	0.00	0.75
TANK 9.P	Sludge	0.850	22.8	0.34	400	-10.70	2.16	-1.66	0.47
TANK 10.S	Bilge	1.010	98.0	1.73	1717	-10.69	2.42	1.92	0.21
TANK 910.C	Lube Oil	0.850	19.9	0.34	400	-10.48	2.00	0.00	0.86
TANK 11.P	Fuel Oil (Day)	0.830	86.6	0.32	386	-10.50	4.76	-1.69	0.07
TANK 12.S	Fuel Oil (Day)	0.830	86.6	0.32	386	-10.50	4.76	1.69	0.07

Table 2 - Assumed heeling moments due to loose deadweight

No.	Location	Initial TCG position	Description	Loose Weight	Loose Wt. displaced	Loose Wt. displaced	LCG	Average VCG	Initial TCG	Final TCG	Heeling moment
				kg	%	kg	m forward of (Fr.16.5 + 55mm)	m above Base Line	m (+ve stbd)	m (+ve stbd)	t.m
1	Flybridge	SS	Bar Area	25	100%	**25**	-8.55	8.39	1.33	2.79	0.04
2	Main Deck	PS	Drinks in aft cockpit PS bar	40	20%	**8**	-14.30	5.63	-1.84	2.90	0.04
		PS	Books / Old log books in saloon cnr storage, PS	20	50%	**10**	-10.79	5.63	-3.60	2.94	0.07
		PS	Misc. items along saloon PS storage	80	100%	**80**	-5.75	5.63	-3.71	3.49	0.58
		PS	Drinks in saloon PS bar	40	50%	**20**	-2.98	5.63	-2.03	-1.05	0.02
		CL	Wheelhouse books & local storage	50	50%	**25**	0.00	5.63	0.00	2.78	0.07
3	Lower deck (Laz & ER)	PS	C/E & Deckhand storage	50	100%	**50**	-21.59	4.27	-2.29	-1.29	0.05
		SS	Lazarette SS aft storage	100	20%	**20**	-22.66	4.27	1.48	1.86	0.01
		SS	Lazarette fwd storage, tools etc.	200	50%	**100**	-18.54	4.27	0.00	2.89	0.29
		SS	ECR Misc / Manuals	25	80%	**20**	-16.43	3.58	2.16	3.32	0.02
4	Lower deck (pax area)	PS	Master suite dressing area	50	80%	**40**	-6.04	3.42	-1.31	0.48	0.07
		PS	PS aft single occupancy cabin	30	80%	**24**	-4.33	3.42	-2.91	-1.09	0.04
		SS	Misc. items in SS storage (vacuum cleaner etc.)	10	80%	**8**	-3.76	3.42	2.00	4.46	0.02
		PS	PS midships dbl occupancy cabin	50	80%	**40**	-0.70	3.42	-2.76	-1.07	0.07
		SS	SS midships dbl occupancy cabin	50	80%	**40**	-1.93	3.42	2.68	4.21	0.06
		PS	PS fwd dbl occupancy cabin	50	80%	**40**	3.65	3.42	-2.30	0.59	0.12
		SS	SS fwd dbl occupancy cabin	50	80%	**40**	3.26	3.42	2.44	4.06	0.06
5	Lower deck (crew area)	CL	CL storage by mast	10	100%	**10**	5.17	3.85	0.00	1.15	0.01
		SS	Freezer compt.	100	0%	**0**	5.12	3.85	0.00	0.00	0.00
		SS	Galley fridges (3 x)	90	0%	**0**	6.70	3.85	0.00	0.00	0.00
		SS	Galley equipment	50	50%	**25**	8.76	3.85	2.00	3.93	0.05
		PS	Crew & misc. stowage in crew mess	50	100%	**50**	8.22	3.85	-2.36	-0.88	0.07
		PS	Crew items in PS aft cabin	30	80%	**24**	12.00	4.08	-2.04	-0.75	0.03
		SS	Crew items in SS aft cabin	50	80%	**40**	12.00	4.08	1.66	3.24	0.06
		PS	Laundry in utility room	25	100%	**25**	15.35	4.08	-1.38	-0.77	0.02
		SS	Misc. in ironing room	50	100%	**50**	15.35	4.08	1.08	2.24	0.06
		PS	Crew items in PS fwd cabin	50	80%	**40**	17.55	4.08	-1.47	-0.36	0.04
		SS	Crew items in SS fwd cabin	50	80%	**40**	17.55	4.08	0.77	2.24	0.06
6	Forepeak	CL	Gen space storage	25	100%	**25**	20.46	4.08	0.00	0.88	0.02
		CL	Misc items in garbage locker	25	100%	**25**	24.05	4.08	0.00	0.65	0.02
7	Below lower deck	CL	Underdeck stowage	100	100%	**100**	-4.12	3.42	0.00	3.86	0.39

Table 3 - Prediction of limiting wind speeds (measured at 10m height) envelopes at a range of apparent wind angles

	Steady		*Gust*	
AWA	***Low***	***High***	***Low***	***High***
deg	***knots***	***knots***	***knots***	***knots***
0	-	-	-	-
10	61.2	73.7	86.6	104.2
20	51.2	61.6	72.3	87.1
30	58.0	69.5	82.0	98.3
40	48.9	57.9	69.2	81.9
50	44.6	52.2	63.1	73.8
60	43.6	50.4	61.7	71.3
70	43.0	49.3	60.9	69.7
80	42.7	48.6	60.4	68.7
90	42.6	48.4	60.2	68.4
100	43.0	48.9	60.8	69.1
110	44.2	50.5	62.5	71.4
120	46.5	53.5	65.8	75.7
130	50.3	58.6	71.2	82.8
140	56.5	66.7	79.9	94.4
150	67.0	80.3	94.7	113.6
160	86.5	105.5	122.3	149.2
170	133.9	166.1	189.4	234.9
180	-	-	-	-

Table 4 - Limiting heel angles

Parameter	***Units***	***Steady***	***Gust***	***AVS***
Heel Angle	deg	13.9	36.0	73.0

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APPENDIX 1 PROBABLE LOSS CONDITION, NO OFFSET DEADWEIGHT

Specific Gravity of Water	1.0250
Mean Shell Thickness	0.0000 metres
Longitudinal Datum	Midships
Vertical Datum	Base Line
Trim Length	38.640 metres

Draught Marks	Name	X metres	Z metres
Aft Marks	Fr.3	-18.685	0.000
Mid Marks	Fr.16.5	-0.055	0.000
Fwd Marks	Fr.31	19.955	0.000

Phase 2 Probable Loss, No Offset Deadweight

Item	Weight	LCG	LMom	VCG	VMom	TCG	FSM	Perc.Full
TANK 2.S	0.500	6.377	3.19	2.342	1.17	2.366	0.184	12.9
TANK 3.P	9.408	4.021	37.83	2.310	21.73	-1.481	3.128	98.0
TANK 4.S	6.125	3.322	20.35	2.313	14.17	1.634	1.901	98.0
TANK 5.P	3.959	-0.809	-3.20	2.079	8.23	-1.626	8.601	45.3
TANK 6.S	3.959	-0.809	-3.20	2.079	8.23	1.626	8.601	45.3
TANK 7.P	1.347	-5.181	-6.98	1.886	2.54	-1.080	2.933	10.0
TANK 8.S	1.347	-5.181	-6.98	1.886	2.54	1.080	2.933	10.0
TANK 78.C	3.694	-8.792	-32.48	2.284	8.44	0.000	0.746	98.0
TANK 9.P	0.340	-10.699	-3.64	2.163	0.74	-1.656	0.470	22.8
TANK 10.S	1.734	-10.689	-18.54	2.422	4.20	1.917	0.211	98.0
TANK 910.C	0.340	-10.479	-3.56	1.998	0.68	0.000	0.860	19.9
TANK 11.P	0.320	-10.495	-3.36	4.755	1.52	-1.690	0.070	86.6
TANK 12.S	0.320	-10.495	-3.36	4.755	1.52	1.690	0.070	86.6
Standard Load	7.890	2.370	18.70	3.890	30.69	0.000	0.000	--
Deadweight	41.285	-0.127	-5.24	2.577	106.40	0.001	30.708	
Lightship	480.906	-2.992	-1438.87	5.753	2766.65	0.000	0.000	
Displacement	522.191	-2.765	-1444.11	5.502	2873.05	0.000	30.708	

Draught	Aft	4.001 metres
	Mid	3.855 metres
	Fwd	3.697 metres
Trim Between Marks	0.304 metres by the stern	

GM Solid	2.033 metres
GM Fluid	1.974 metres
Fluid VCG	5.561 metres

APPENDIX 2 STABILITY AT PROBABLE LOSS CONDITION, NO OFFSET DEADWEIGHT

All VCGs fluid unless otherwise stated

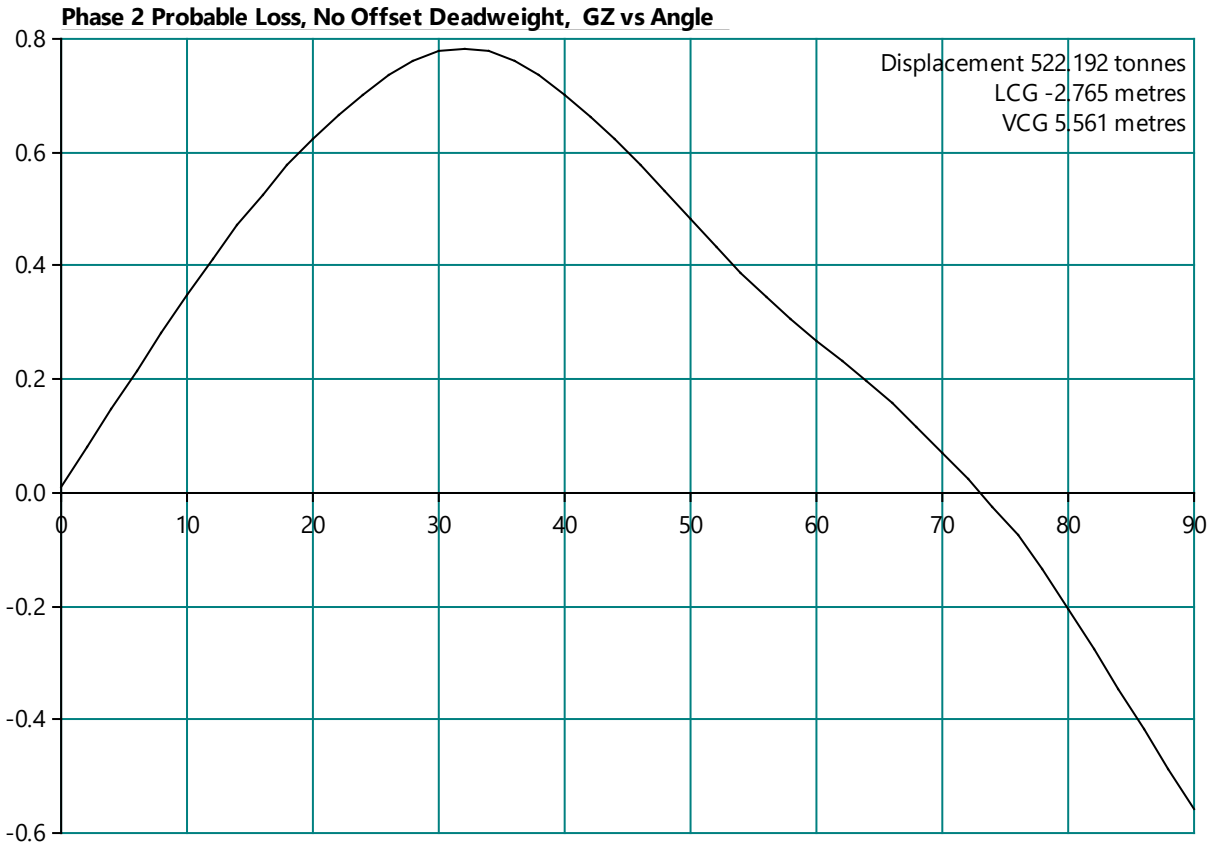
Specific Gravity of Water	1.0250
Mean Shell Thickness	0.0000 metres
Longitudinal Datum	Midships
Vertical Datum	Base Line
Trim Length	38.640 metres

Draught Marks	Name	X metres	Z metres
Aft Marks	Fr.3	-18.685	0.000
Mid Marks	Fr.16.5	-0.055	0.000
Fwd Marks	Fr.31	19.955	0.000

Phase 2 Probable Loss, No Offset Deadweight

Displacement	522.192 tonnes	
Longitudinal Centre of Gravity	-2.765 metres	
Vertical Centre of Gravity	5.561 metres	
Transverse Centre of Gravity	0.000 metres	
Equilibrium GM	1.974 metres	
Equilibrium Heel Angle	0.305 degrees to port	
Equilibrium Waterline	3.855 metres	
Equilibrium Trim Between Marks	0.304 metres by the stern	
Angle of Vanishing Stability	73.0 degrees to stbd	72.8 degrees to port
Maximum GZ	0.783 metres to stbd	0.770 metres to port
Maximum GZ Angle	31.9 degrees to stbd	32.0 degrees to port

Heel Angle degrees	Righting GZ metres	Lever KN metres	Waterline metres	Trim metres	VCB metres	GZ Curve Area metres.rad
0.0	0.011	0.011	3.854	0.304	2.943	0.000
10.0	0.348	1.314	3.839	0.255	3.012	0.032
20.0	0.624	2.526	3.783	0.103	3.204	0.118
30.0	0.778	3.559	3.669	-0.117	3.473	0.242
40.0	0.702	4.276	3.562	-0.327	3.719	0.375
50.0	0.482	4.742	3.475	-0.520	3.940	0.479
60.0	0.267	5.083	3.394	-0.690	4.211	0.544
70.0	0.071	5.296	3.373	-0.800	4.536	0.574
80.0	-0.205	5.272	3.373	-0.878	4.807	--
90.0	-0.559	5.001	3.375	-0.913	5.001	--


Phase 2 Probable Loss, No Offset Deadweight, GZ vs Angle
Displacement 522.192 tonnes
LCG -2.765 metres
VCG 5.561 metres
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
0
10
20
30
40
50
60
70
80
90

APPENDIX 3 STABILITY AT PROBABLE LOSS CONDITION, WITH OFFSET DEADWEIGHT

All VCGs fluid unless otherwise stated

Roll Centre	5.000 metres
Specific Gravity of Water	1.0250
Mean Shell Thickness	0.0000 metres
Longitudinal Datum	Midships
Vertical Datum	Base Line
Trim Length	38.640 metres

Draught Marks	Name	X metres	Z metres
Aft Marks	Fr.3	-18.685	0.000
Mid Marks	Fr.16.5	-0.055	0.000
Fwd Marks	Fr.31	19.955	0.000

Phase 2 Probable Loss, With Offset Deadweight

Displacement	522.192 tonnes	
Longitudinal Centre of Gravity	-2.765 metres	
Vertical Centre of Gravity	5.561 metres	
Transverse Centre of Gravity	0.005 metres	
Equilibrium GM	1.974 metres	
Equilibrium Heel Angle	0.169 degrees to port	
Equilibrium Waterline	3.855 metres	
Equilibrium Trim Between Marks	0.304 metres by the stern	
Angle of Vanishing Stability	72.9 degrees to stbd	72.9 degrees to port
Maximum GZ	0.779 metres to stbd	0.774 metres to port
Maximum GZ Angle	32.0 degrees to stbd	32.0 degrees to port

Heel Angle degrees	Righting GZ metres	Lever KN metres	Waterline metres	Trim metres	VCB metres	GZ Curve Area metres.rad
0.0	0.006	0.011	3.854	0.304	2.943	0.000
10.0	0.343	1.314	3.839	0.255	3.012	0.031
20.0	0.619	2.526	3.783	0.103	3.204	0.116
30.0	0.774	3.559	3.669	-0.117	3.473	0.240
40.0	0.698	4.276	3.562	-0.327	3.719	0.372
50.0	0.479	4.742	3.475	-0.520	3.940	0.476
60.0	0.265	5.083	3.394	-0.690	4.211	0.540
70.0	0.069	5.296	3.373	-0.800	4.536	0.570
80.0	-0.205	5.272	3.373	-0.878	4.807	--
90.0	-0.559	5.001	3.375	-0.913	5.001	--


Phase 2 Probable Loss, With Offset Deadweight, GZ vs Angle
Displacement 522.192 tonnes
LCG -2.765 metres
VCG 5.561 metres
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
0
10
20
30
40
50
60
70
80
90



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MAIB interim report on the investigation into the foundering of *Bayesian*, issued May 2025

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

INTERIM REPORT

VERY SERIOUS MARINE CASUALTY

MAY 2025

Extract from The United Kingdom Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 – Regulation 5:

"The sole objective of a safety investigation into an accident under these Regulations shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of such an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

As the full investigation report will not be published within 12 months of the accident date, this interim report is published, pursuant to Regulation 14(2)(b) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012.

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

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Interim report on the investigation into the foundering of the yacht *Bayesian*, with the loss of seven lives, 0.5 nautical miles south-east of Porticello, Italy on 19 August 2024

This interim report contains information from the investigation completed to date, including a simplified narrative of events; factual detail and analysis of the environmental conditions; details of *Bayesian*'s stability, as documented; and a summary of a study into how the yacht was likely impacted by the environmental conditions experienced.

The 'desktop' assessment of *Bayesian*'s capsize is based on available documents and information that will be validated and, as necessary, iterated and improved following detailed examination of the wreck once it is salvaged.

Readers are cautioned that there is the possibility that new evidence may become available that might alter the circumstances as depicted in this report.

INVESTIGATION

Following the accident the Marine Accident Investigation Branch (MAIB) initiated a safety investigation into the circumstances of the loss of *Bayesian*. This safety investigation is being conducted in parallel to a criminal investigation being led by the Termini Imerese Public Prosecutor's Office, Sicily, Italy. That criminal investigation has restricted the safety investigation's access to the wreck and other material elements of primary evidence. Consequently, this interim report is based on a limited amount of verified evidence. The circumstances depicted in this report may alter following the release of evidence held by the Italian authorities at the time of publication or following examination of the wreck.

Image courtesy of Karsten Börner (skipper of *Sir Robert Baden Powell*)



Bayesian

Some information about this accident, not otherwise available to the MAIB, has appeared in the public domain and there has been much speculation as to the circumstances of the accident. The safety investigation has purposefully not included information it has been unable to verify.

The MAIB's ongoing safety investigation is considering all aspects of the accident to determine its causes and circumstances. These include *Bayesian*'s design, stability, escape routes, operation and emergency procedures. The safety investigation has also considered the forecast weather and that experienced during the accident, as well as the available guidance to mariners on actions to be taken in extreme weather.

NARRATIVE

On 14 August 2024, the privately owned and operated yacht *Bayesian* **(Figure 1)** sailed from the port of Milazzo for a short excursion around the Aeolian Islands and the north coast of Sicily. There were 12 guests and 10 crew on board. The intention was to disembark the guests on 19 August before proceeding to Naples for a period of maintenance. On 18 August, *Bayesian* was anchored at Cefalù on the northern coast of Sicily.

Image courtesy of Perini Navi S.p.A.

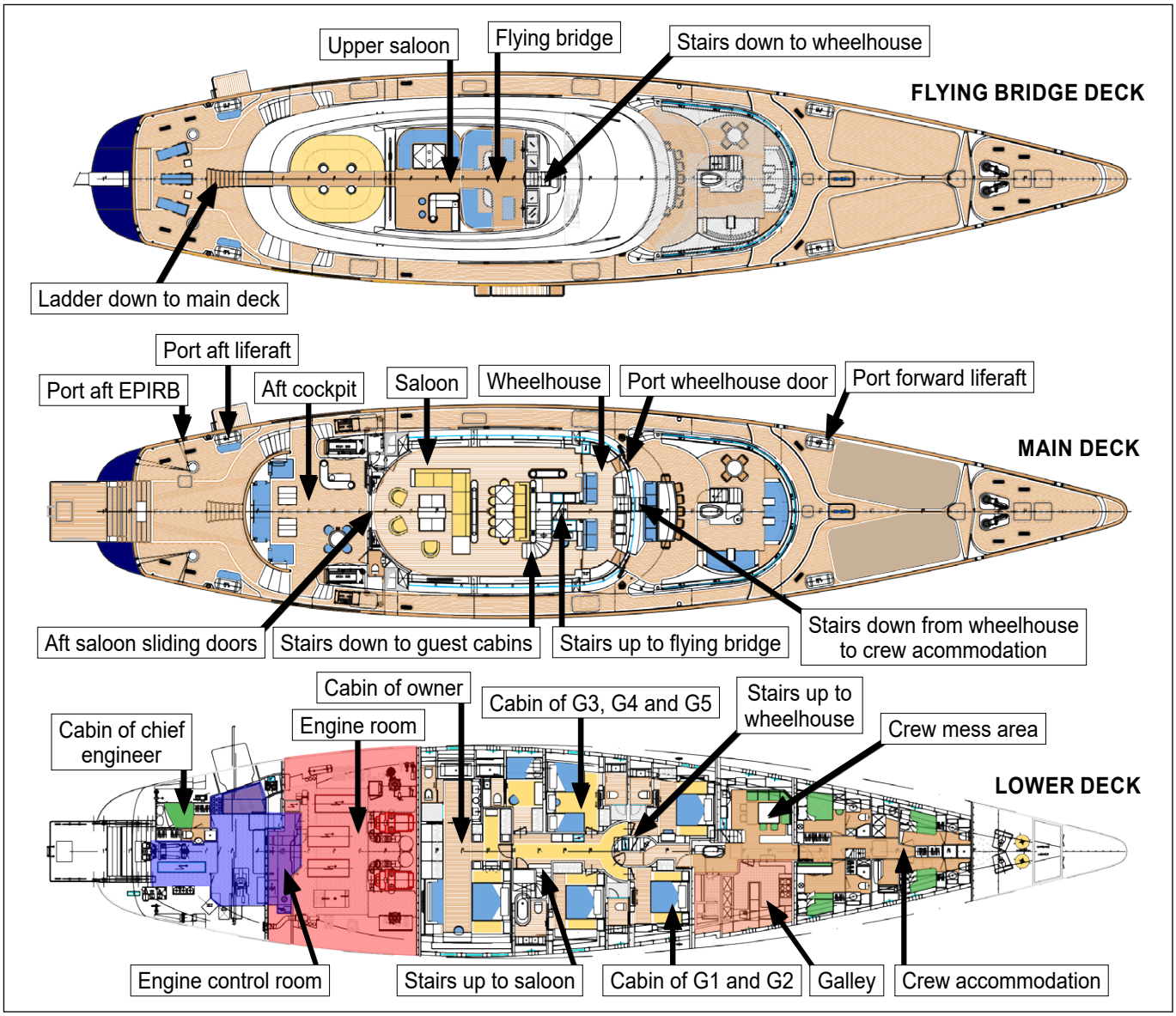


Figure 1: *Bayesian* general arrangement

With the wind increasing, it was decided to motor towards Porticello, 25 nautical miles (nm) to the west, to anchor for the night. This was both to shelter from the forecast weather and to allow for easy disembarkation of guests the following day. At 2124[1], *Bayesian* anchored to the east of the main breakwater. The centreboard[2] was in the raised position. The yacht *Sir Robert Baden Powell* was also at anchor nearby.

The seas were calm and there was a very light wind from the north-west. Thunderstorms had been forecast, and those on board *Bayesian* could see occasional flashes of lightning away to the west. *Bayesian*'s skipper left instructions to be woken by the overnight watchkeepers (deckhands DH1 and DH2) if the wind speed increased above 20 knots (kts) or if there were signs that *Bayesian* was dragging anchor. Having checked the latest weather forecast the skipper then went to bed. By 0030 the last guest had retired, leaving DH1 and the evening steward (S1) on duty. At 0100, DH2 took over the watch from DH1. The wind at this time was noted as being no more than 8kts, and there were no signs of *Bayesian* dragging anchor.

At 0300, DH2 noted the wind as being at 8kts from the west but thought that the thunderclouds and lightning seemed to be getting closer. At about 0330, two of the guests (G1 and G2) awoke but remained resting in

[1] All times are universal time coordinated (UTC)+2, unless otherwise stated.

[2] Also known as a swing keel.

their cabin. At approximately 0355, DH2 videoed the advancing storm and posted it to their social media feed. DH2 then went onto the deck and closed the forward hatches and cockpit windows to protect *Bayesian*'s interior from the rain that had started falling. DH2 noted that the wind had picked up to 30kts and was broad on the port bow. *Bayesian* was now listing to starboard and DH2 thought the vessel was dragging its anchor.

At around 0357, both *Bayesian* and *Sir Robert Baden Powell* started dragging their anchors in the rapidly worsening weather.

At around 0400, DH2 ran below and woke the skipper. Together they returned to the flying bridge. At about the same time, the chief engineer (C/E) woke up. Having experienced bad weather at anchor before, the C/E got up and walked to the engine control room to prepare the vessel for manoeuvring. After making sure that all three generators were running, the C/E went to the wheelhouse to start the steering pumps and hydraulic pumps for the controllable pitch propeller.

The chief officer (C/O), chief steward (CS), chef and stewards had also all been woken by the yacht's change of motion. They dressed and made their way out of the crew accommodation. At this time *Bayesian* was estimated by those on board to be listing between 10° and 20° to starboard. The owner started to make their way to the flying bridge to see if the taxis that were arranged for 0800 would have to be cancelled due to the weather.

The CS secured some loose items in the crew mess area then went to the upper deck to secure other items. The C/O went to the flying bridge, where the skipper gave an instruction for the rest of the crew to be woken as the anchor was dragging. Returning below, the C/O told the bosun and DH1 to go on deck to secure any loose items and standby for further orders. The chef was in the galley stowing cutlery, pots and pans and shouted, "*Good morning!*" to the C/O and the nearby stewards.

Bayesian was lying with the wind about 60° off the port bow and moving at 1.8kts south-south-east of its original position **(Figure 2)**. *Sir Robert Baden Powell* was also dragging its anchor at a similar rate in a similar direction.

Two of the guests (G3 and G4) had been woken as *Bayesian* took on the list and decided to head to the saloon with their baby (G5).

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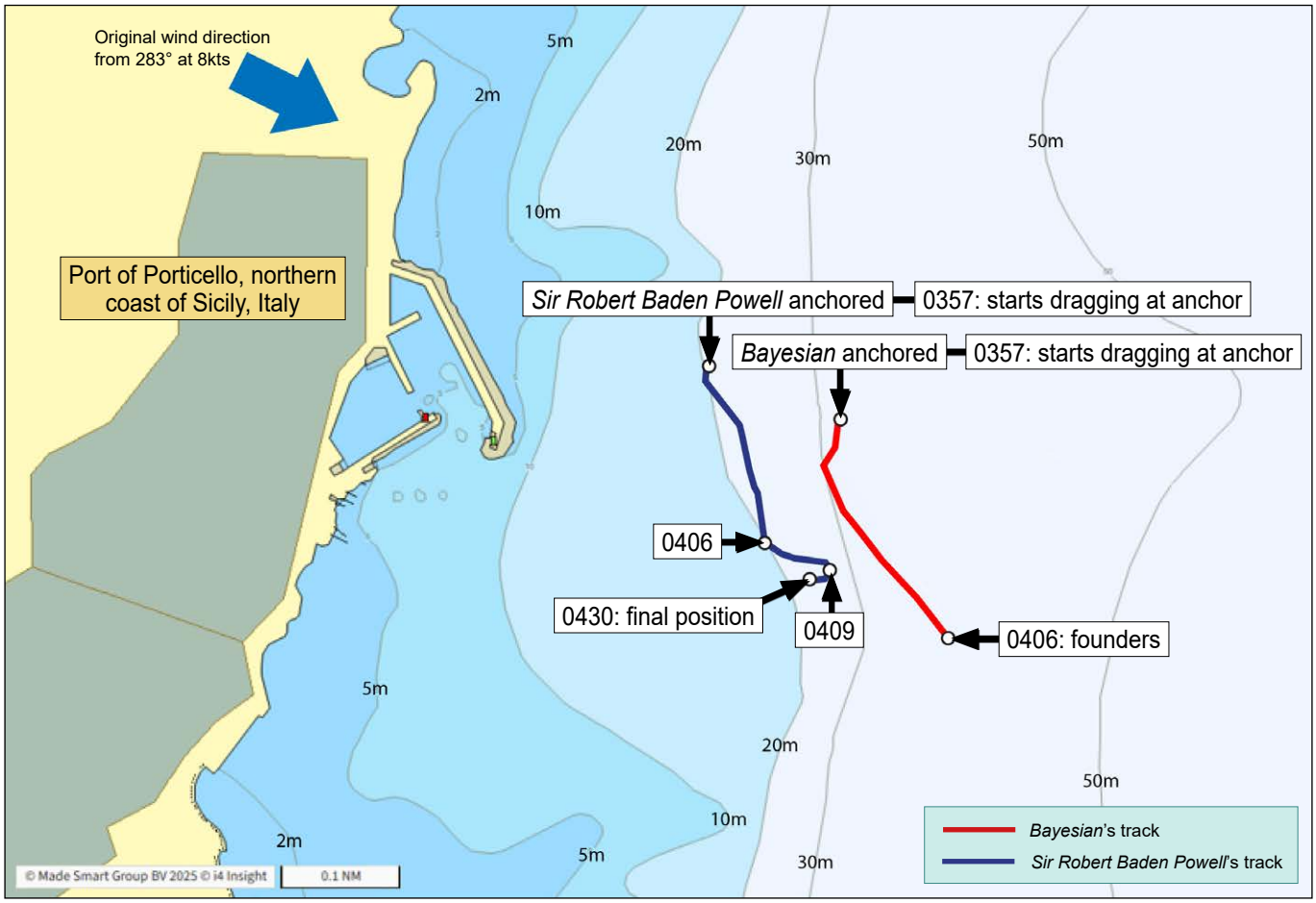


Figure 2: Location and tracks for *Bayesian* and *Sir Robert Baden Powell* on 19 August 2024

The C/O returned to the flying bridge and briefed the skipper on the crew activities. The skipper told the C/O to check to see if the C/E had started the engines and pumps so that they could manoeuvre *Bayesian* into the wind. On arriving in the wheelhouse, the C/O saw the C/E there and was informed that *Bayesian* was ready to manoeuvre. The C/O then shouted up to the flying bridge to inform the skipper.

The owner, G3, and G4 (carrying G5) arrived in the saloon and wheelhouse area as the rain-soaked CS came in from the upper deck.

As the skipper prepared to manoeuvre *Bayesian* up into the wind from their position on the flying bridge, the wind suddenly increased to more than 70kts. The awning over the flying bridge ripped from port to starboard. At 0406, *Bayesian* violently heeled over to 90° to starboard, taking less than 15 seconds to do so. People, furniture, and loose items fell across the deck. The generators shut down immediately and battery-supplied emergency lighting came on.

The skipper, G4, the owner, the bosun and S2 were all injured, either by falling or from things falling on them. DH2 had been thrown into the sea from their position by the helm on the flying bridge. In their cabin, G1 and G2 used the furniture drawers as an improvised ladder to exit the space, escaping along the internal walls of the central alleyway and climbing out into the saloon area. S1 and DH1 climbed up the walls of the forward staircase, exiting from the crew mess area into the wheelhouse. There was no indication of flooding inside *Bayesian* until water came in over the starboard rails and, within seconds, entered the internal spaces down the stairwells.

The C/E managed to exit through the port forward wheelhouse door. Once clear, they helped DH1 out before heading aft to launch an Emergency Position Indicating Radio Beacons (EPIRB), one of two on board, from its position on the port aft quarter of the main deck. DH1 stayed by the port forward wheelhouse door and, reaching down through the open doorway, lifted both S1 and then S2 onto the upper deck. Looking down through the door, DH1 could not see anyone else so the three of them made their way aft and into the sea.

Separately, the C/O had found the owner and pushed them through the cascading water up to the skipper on the flying bridge. The C/O and skipper managed to evacuate G3 and G5 by the same route.

The bosun and DH2 climbed down into the wheelhouse and lifted G1 and G2 into the flying bridge where they were joined by G4, assisted by the C/O and skipper. With *Bayesian* rotating to starboard and sinking, the CS, bosun and DH2 found themselves in an air pocket by the closed port forward wheelhouse door. With the assistance of the injured G4 on the outside, they were able to open the door and escape. The C/O, who had been swept to the back of the saloon and into another air pocket, dived down to open the sliding doors at the aft end of the saloon and managed to swim clear of the vessel. The skipper organised the abandonment from the flying bridge and instructed the guests and crew present there to swim clear of the mast and boom as the vessel was sinking.

By 0422, the C/E had launched the EPIRB and was sitting on the hull, near the rudder. They noted that the wind had eased and that *Bayesian* was only a short distance from shore. The C/E heard shouts from the skipper and jumped into the sea and swam towards the gathering survivors. The CS counted those present and checked for injuries. DH2 improvised a tourniquet for G4's gashed arm and G2 made sure that G5 had a cushion as a flotation device. Some of the survivors were treading water and others held on to some cushions that had floated free from *Bayesian*. G1 was using the torch from their phone to search the water for other survivors.

The skipper and DH1 swam to *Bayesian* and attempted, without success, to release the port aft liferaft from its stowage. The C/O swam to the port forward liferaft and released it from the sinking wreck. They towed the liferaft to the gathered survivors. At approximately 0424, the liferaft was inflated and DH1 boarded it and assisted the survivors in the water to board. From the liferaft, the CS saw the bows of *Bayesian* rise up and then sink below the surface. The C/O and CS began organising the liferaft and delivering first aid to the injured people on board. The C/E searched for flares and DH1 and the skipper tried to raise the alarm by shouting at and then paddling towards *Sir Robert Baden Powell*. *Bayesian* had sunk in approximately 50m of water.

The skipper on board *Sir Robert Baden Powell* noted that, despite the application of engine power, their vessel had dragged anchor around 400m in 11 minutes. The yacht's crew initially thought that *Bayesian* had put to sea to avoid the sudden storm. Their skipper briefly saw a dark triangular shape descending into the water, later believing this to be *Bayesian*'s bow sinking.

At 0434, *Bayesian*'s C/E fired a red parachute flare from the liferaft. Despite the winds being calm at the surface, the flare was carried sideways as it rose up into an area of stronger wind. The C/E used the

liferaft's torch to signal towards a hotel on the cliffs above them, passing cars, and *Sir Robert Baden Powell*. At 0443, the C/E fired a second parachute flare that was seen by the crew of *Sir Robert Baden Powell*. Responding to the flare, the skipper of *Sir Robert Baden Powell* dispatched its tender towards the visible lights of the EPIRB and liferaft. On arrival, the tender's crew transferred the liferaft's occupants on board. At 0453, the tender returned to *Sir Robert Baden Powell*. A brief search was made of the accident site to check for other survivors.

At 0456, the tender from *Sir Robert Baden Powell* returned to the scene with *Bayesian*'s C/E on board to search for other survivors. After approximately 20 minutes, the tender returned to *Sir Robert Baden Powell* and *Bayesian*'s skipper joined the crew on the tender to continue the search. *Sir Robert Baden Powell*'s skipper called the local coastguard to arrange to transfer the survivors to shore.

The accident on *Bayesian* resulted in the deaths of six guests and one crew member. All of the bodies were subsequently recovered by the local authorities.

Environment

The investigation examined the published weather forecasts for the period, some actual weather observations from the night of 18/19 August 2024, evidence from local closed-circuit television (CCTV) footage and witness testimony. This was combined with the output of an Italian weather report for the area.

The Météo-France weather bulletin for the western part of the Mediterranean Sea (METAREA III W) issued at 0900 UTC on Sunday 18 August 2024 mentioned a deepening low-pressure feature moving towards Italy from the Gulf of Genoa during the period. Specifically, this 24-hour forecast included the Lipari sea area (the north coast of Sicily and offshore areas) and predicted *westerly 3 or 4* [winds], temporarily north-west overnight, then increasing 4 or 5 in south at end. Seas *smooth or slight, becoming slight or moderate in the second part of the night*. There was forecast to be *poor visibility in showers or thunderstorms*.

Early Italian weather forecasts ahead of the accident predicted *intense and persistent rain, mainly in the form of showers or thunderstorms*…[with] *storms* [being] *accompanied by strong wind gusts*[3]. At 2100 UTC on 18 August, Italian forecasters issued a gale warning of *northwesterly gale force 8* winds for Sardinia and Corsica with associated *isolated thunderstorms with local gusts* for Sicily. This was updated and reiterated at 0000 UTC on 19 August 2024.

At 0352 on 19 August 2024, around 5nm to the north-west of the Porticello anchorage, winds were recorded to have suddenly increased from around 5kts to 41kts from the north-west. These strong winds were associated with a storm front that passed quickly towards the rugged coastline near Bagheria and Porticello. This was observed on a nearby vessel's navigational radar **(Figure 3)**. Several CCTV cameras in Porticello showed an intense squall of wind and heavy rain arriving, throwing debris around violently before moving on. This intense squall was associated with lightning strikes, thunder and very poor visibility. Land weather readings (recorded at 5-minute or hourly intervals) captured a peaking of wind strength as the intense squall passed.

The investigation commissioned the Met Office, the UK's national meteorological service, to analyse the weather conditions over the seas north of Sicily on 19 August 2024.

The Met Office study concluded that a trough of low pressure transited the area overnight on 18/19 August 2024. It noted that local data suggested there was a large amount of convective available potential energy (CAPE)[4] in the atmosphere. Sufficient wind shear[5] was evident in the atmosphere, and the conditions were borderline for the development of supercells[6]. High inshore sea-surface temperatures may also have contributed energy to the development of weather systems.

The Met Office study of satellite imagery indicated that the mesocyclonic storm front was demonstrating the properties of a significant supercell with associated downdrafts and possible near-surface winds in excess of 100 miles per hour (87kts). The study concluded that a mesocyclonic storm was *highly likely* with

[3] Centro Nazionale di Meteorologia e Climatologia Aerospaziale (CNMCA): the Italian National Centre for Aerospace Meteorology and Climatology forecast of intense phenomena, issued at 1200 UTC on 18 August 2024.

[4] CAPE, measured in joules per kg, describes the instability of the atmosphere and provides an approximation of updraft strength within a thunderstorm. Higher CAPE values generally indicate a greater potential for strong thunderstorms.

[5] Wind shear is the change of wind speed or direction with increasing altitude or around local geographic features.

[6] A supercell is an isolated mesocyclonic storm that contains updrafts of wind that rotate about a vertical axis. Supercells produce damaging winds and hail and can produce tornados, or tornadic waterspouts. The thunderstorms have associated updrafts and downdrafts. Updraft associated winds can be tornadic in character and can be associated with winds from 56kts to over 175kts. A downdraft is where precipitation and wind "falls" from the storm. Downdraft associated winds can be intense and cause damage when they reach the ground.

an associated supercell being *probable*. It also concluded that tornadic waterspouts and downdrafts were *possible* where local winds could reach extreme hurricane force well in excess of 64kts. Such tornadic waterspout features could be of very limited horizontal extent (50m to 100m wide).

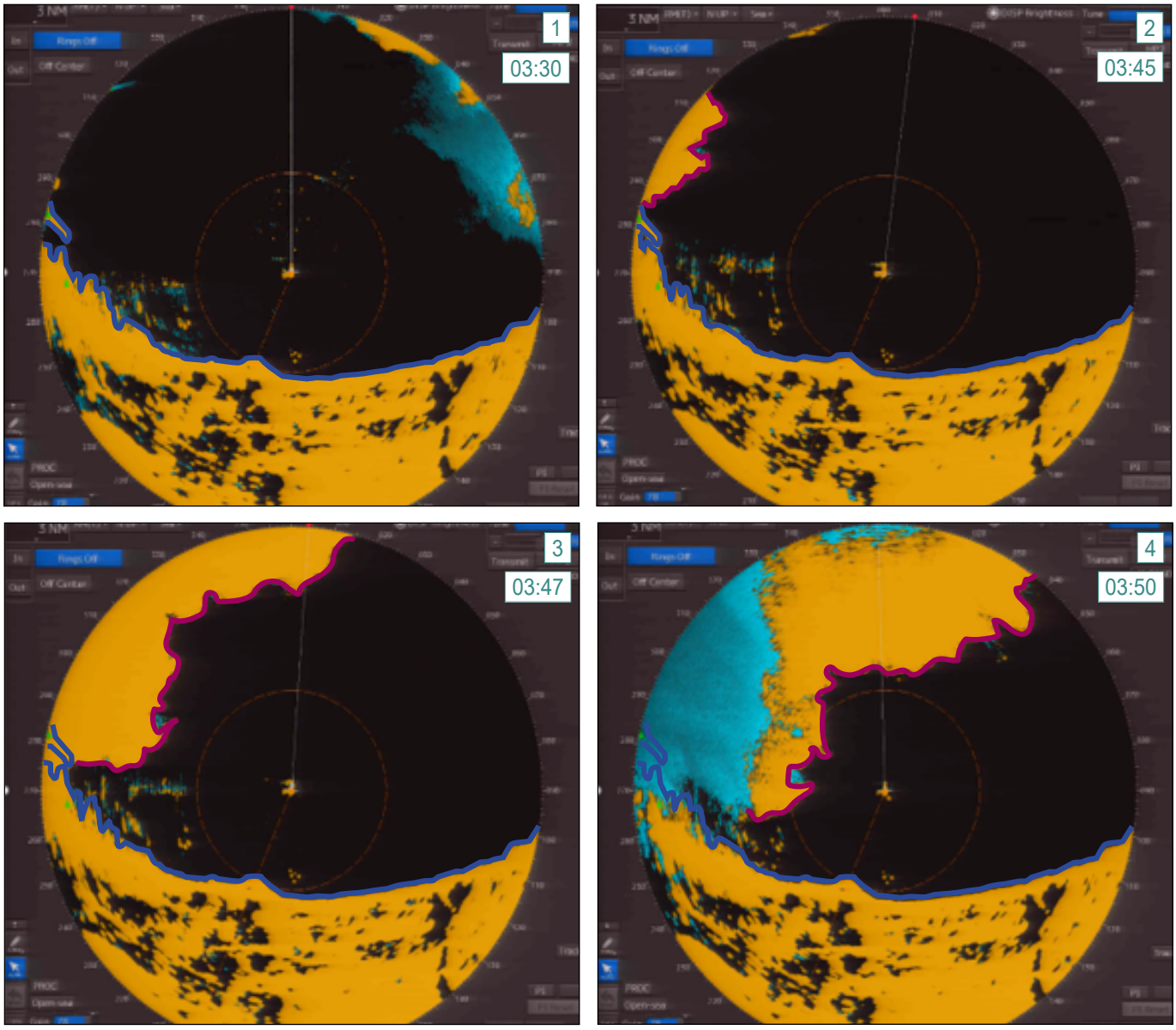


Image courtesy of Google Maps



Figure 3: Radar images, showing passage of rain across the Bay of Palermo on 19 August 2024

Vessel stability

Bayesian was built in 2008 as sailing yacht *Salute*. A stability information booklet (SIB) was submitted for approval to Ensign, the then large yacht service of the UK Maritime and Coastguard Agency (MCA). On 3 July 2008, the SIB was approved against the requirements of Section 11 of Merchant Shipping Notice (MSN) 1792 (M) – The Large Commercial Yacht Code (LY2)[7].

The approved SIB was required to include *Curves of statical stability (GZ curves)*[8] for specific loaded conditions, including at least the loaded departure and arrival conditions with 100% and 10% consumables respectively. GZ curves were required to have a positive range of not less than 90°; however, LY2 allowed for vessels of more than 45m in length to have a GZ range of less than 90° subject to agreed operational criteria. Derived wind heeling levers were also to be calculated for sailing vessels. *Bayesian*'s SIB contained curves for the sailing conditions when at maximum load, contractual full load and in the light load condition. In all three of these conditions the centreboard had to be lowered. The respective angles of vanishing stability[9] for the three conditions, recorded in the SIB, were 91.4°, 92.3° and 84.3°.

The SIB contained *Curves of Maximum Steady Heel Angle to Prevent Downflooding in Squalls*. These curves provided a safe operating range for a sailing vessel, indicating the maximum heel angle it could withstand before there was a risk of downflooding occurring in a sudden gust or squall. The SIB did not contain such curves for when *Bayesian* was operating in the motoring condition where the centreboard was raised and no sails were up.

The investigation commissioned a stability and windage study for *Bayesian*. The University of Southampton's Wolfson Unit for Marine Technology and Industrial Aerodynamics (Wolfson Unit) undertook the study and first built a stability model for *Bayesian* that replicated the information contained in the approved SIB. The stability model was subsequently adjusted to replicate the assumed loss condition; assessed as being similar to the motoring condition, with the centreboard raised and in the loaded arrival state (with 10% consumables on board).

The study determined that the angle of vanishing stability in this condition was 70.6°.

Environmental impact on vessel stability

The Wolfson Unit's study of *Bayesian* determined that the 72m tall mast accounted for 50% of the total wind heeling moment of the vessel when the wind was exactly on the beam. The remainder was predominantly made up of the rigging and furled sails. The profile of the mast also produced a degree of effective lift, delivering an increase in the heeling moment applied by the wind, peaking in winds about 20° off the bow.

Examination of a possible loss condition determined that the limiting heel angle[10] for a steady wind was 14.2° and that the limiting heel angle for the associated gust was 36.3° **(Figure 4)**. The study predicted the wind speeds that would produce those limiting heel angles for a range of apparent wind angles (AWA) relative to the bows, shown at **Table 1**. The table shows a high limit of wind speed, which included the impact of interactions and blanketing effects between different elements of the mast and rigging. The low limit describes the wind speed required to achieve the limiting heel angle with no blanketing or interaction effects included. Less wind is required to achieve the limiting heel angles if all the different elements of the mast and rigging are treated individually. More wind is required to reach that limiting heel angle when considering the blanketing effect that some of the rigging might have on the mast, for example.

The study indicated that if the wind was blowing directly onto *Bayesian*'s beam and the yacht was in the 'motoring' condition, a gusting wind speed in excess of 63.4kts would likely result in the vessel capsizing, irrespective of any interactions and blanketing effects.

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[7] MSN 1792 (M) Edition 2, published in September 2007.

[8] A GZ curve is a depiction of how the transverse distance between the centre of gravity (G) and the centre of buoyancy (B) varies across a range of heel angles. GZ is indicative of the strength of the righting lever induced by the angle of heel.

[9] The angle of vanishing stability is the angle of heel where the righting moment has reached zero. Beyond this angle the vessel could not recover to an upright position.

[10] Derived from the wind heeling moment that would cause the vessel to capsize, representing the 'gust' condition. To determine a steady state wind speed condition, this limiting wind speed is divided by the gust factor (1.4142, or the square root of 2). The position where the steady state wind heeling moment curve intersects the GZ curve indicates the limiting heel angle for a steady wind. The limiting heel angle in the gust condition is determined by the position where the gust heeling moment coincides with the GZ curve at its greatest extent **(Figure 4)**.

Image courtesy of Wolfson Unit

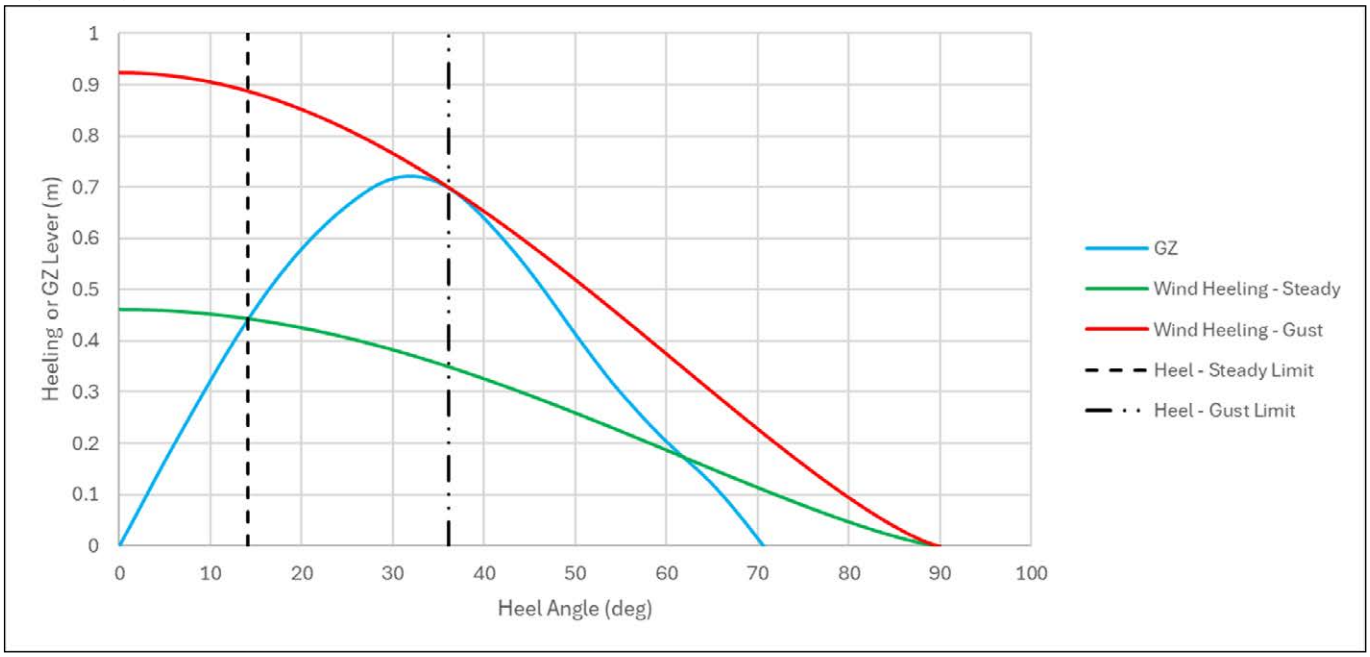


Figure 4: Derived wind heel data in assumed loss condition

	Predicted limiting wind speed (kts)			
AWA	**Steady wind speed**		**Gusting wind speed**	
Degrees (°)	**Low limit**	**High limit**	**Low limit**	**High limit**
0	Not applicable	Not applicable	Not applicable	Not applicable
10	55.9	66.7	79.1	94.4
20	46.1	55.0	65.3	77.8
30	50.6	60.2	71.6	85.2
40	43.0	51.2	60.8	72.4
50	39.3	46.9	55.6	66.3
60	38.4	45.8	54.4	64.8
70	37.9	45.2	53.7	64.0
80	37.7	44.9	53.3	63.5
90 (on the beam)	37.6	44.8	53.2	63.4
100	40.4	48.1	57.2	68.1
110	41.3	49.2	58.4	69.6
120	43.0	51.3	60.9	72.5
130	46.0	54.7	65.0	77.4
140	50.9	60.5	71.9	85.6
150	59.3	70.5	83.9	99.7
160	75.3	89.4	106.4	126.4
170	114.2	135.7	161.5	191.8
180	Not applicable	Not applicable	Not applicable	Not applicable

Table 1: Limiting wind speeds at a range of apparent wind angles

SUMMARY OF FINDINGS

The investigation has established the timeline of events on board *Bayesian* and documented these to the extent possible with the information gathered.

The stability information presented is based on documents recovered and information gathered, and the assumption that the yacht's condition when lost (the loss condition) was similar to the 'loaded arrival' condition (i.e. 10% consumables on board).

The effects of wind on the mast, boom, rigging and upperworks of *Bayesian* have been assessed using the available information on the yacht's construction and equipment.

Through 'desktop' assessment, the safety investigation has established that, in the assumed loss condition, once *Bayesian* heeled over to an angle greater than 70.6° (the angle of vanishing stability) there was no chance of a return to an even keel.

The investigation has also established that, in the assumed loss condition, wind speeds in excess of 63.4kts on the beam were sufficient to knock *Bayesian* over. It is possible that *Bayesian* was similarly vulnerable to winds of less than 63.4kts.

These vulnerabilities (when in the motoring condition with sails lowered, the centreboard raised and 10% consumables on board) were not identified in the stability information book carried on board. Consequently, these vulnerabilities were also unknown to either the owner or the crew of *Bayesian*.

The Met Office study and local observations indicated the probable transient presence of hurricane force winds well in excess of 64kts at the time of the accident. These winds were sufficient to knock *Bayesian* beyond its angle of vanishing stability.

ONGOING ACTION

The safety investigation into the foundering of *Bayesian* is ongoing. Examination of the wreck of the yacht, when salvaged, should improve the investigators' understanding of the yacht's actual loss condition, including its loading, deadweight carried, downflooding points and the position of the centreboard, in order to validate or improve the theoretical assessment already conducted. A fuller understanding of the access and egress routes, internal layout and liferaft status will enable the investigation to reach safety conclusions related to survivability.

Until the investigative work is complete, and the final report published, the contents of this interim report should be taken as indicative of the circumstances of the accident.

VESSEL PARTICULARS	
Vessel's name	*Bayesian*
Flag	UK
Classification society	American Bureau of Shipping
IMO number/fishing numbers	9503392
Type	Private sailing yacht
Registered owner	Revtom Limited
Manager(s)	Camper and Nicholsons International
Construction	Aluminium alloy
Year of build	2008
Length overall	55.9m
Registered length	49.7m
Gross tonnage	473
Minimum safe manning	Not applicable
Authorised cargo	Not applicable

VOYAGE PARTICULARS	
Port of departure	Naples, Italy
Port of arrival	Naples, Italy (intended)
Type of voyage	International
Cargo information	Not applicable
Manning	10

MARINE CASUALTY INFORMATION	
Date and time	19 August 2024 at 0406
Type of marine casualty or incident	Very Serious Marine Casualty
Location of incident	0.5nm south-east of Porticello, Italy
Place on board	Ship
Injuries/fatalities	7 fatalities
Damage/environmental impact	Vessel loss, negligible pollution
Vessel operation	At anchor
Voyage segment	Anchored
External & internal environment	Sudden, violent winds associated with a mesocyclonic thunderstorm within a general background of force 4 to 5 north-westerly winds and gusts up to force 6; sea smooth to slight; sea temperature 32°C
Persons on board	22

MAIB safety flyer to the yachting industry

MAIB

MARINE ACCIDENT INVESTIGATION BRANCH

SAFETY FLYER TO THE YACHTING INDUSTRY

Foundering of the sailing yacht *Bayesian* with, the loss of seven lives, 0.5 nautical miles south-east of Porticello, Italy on 19 August 2024

Image from British Marine



Narrative

At 0406 on 19 August 2024, the private yacht *Bayesian* was knocked down in hurricane force winds. 15 people survived the accident, although one crew member and six passengers lost their lives as the vessel capsized and sank in 50m of water.

Bayesian was at anchor for the night, 0.5 nautical miles from Porticello, Italy, when it was knocked down onto its starboard side by extreme winds. Unable to right itself, the yacht flooded, capsized and sank. The surviving crew assisted six of the passengers clear of *Bayesian* as it foundered and manually released a liferaft. They delivered first aid to those injured before assisting in a search for any other survivors. The crew of the sailing vessel *Sir Robert Baden Powell* had seen the distress flares and sent their tender to investigate. They recovered the survivors from their liferaft. Recovery efforts were terminated on 23 August 2024.

Safety lessons

1. Knockdown of sailing vessels is a recognised hazard. The risk is generally managed by changing the apparent wind angle or letting go, reefing or dropping the sails. On *Bayesian*, when under sail, the risk was managed automatically through a system that monitored the sail loading and eased the sheets as necessary. However, the risk of knockdown still existed when *Bayesian* was not under sail, and this risk had not been recognised and guidance was lacking.

2. Thunderstorms were forecast for the night of 18/19 August 2024, but none of the information available to the crew on board provided guidance on the possible severity of the winds that could accompany them.

3. The MAIB advises owners, managers and crew on board large yachts to fully examine the vulnerability of their vessels to the effects of extreme weather. They should ensure that measures are in place to both recognise the potential for such weather, and ensure that onboard procedures account for any risks presented.

This flyer and the MAIB's investigation report are posted on our website: www.gov.uk/maib

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Extract from The United Kingdom Merchant Shipping (Accident Reporting and Investigation) Regulations 2026 – Regulation 5:

The sole objective of a safety investigation into an accident under these Regulations is the prevention of future accidents through the ascertainment of its causes and circumstances. It is not the purpose of such an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame.

NOTE

This safety flyer is not written with litigation in mind and, pursuant to Regulation 19(1) of The Merchant Shipping (Accident Reporting and Investigation) Regulations 2026, shall be inadmissible in any judicial proceedings concerning liability unless the Chief Inspector of Marine Accidents or a court of law determine otherwise.

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Marine Accident Report

INVESTORS IN PEOPLE