ACCIDENT REPORT

Report on the investigation into

the listing, flooding and grounding of

Hoegh Osaka

Bramble Bank, The Solent, UK

on 3 January 2015

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

SERIOUS MARINE CASUALTY   REPORT NO 6/2016   MARCH 2016

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2012 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of 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 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.

All MAIB publications can be found on our website: www.gov.uk/maib

For all enquiries:

Marine Accident Investigation Branch
Spring Place
105 Commercial Road
Southampton
United Kingdom
SO15 1GH
Press enquiries during office hours: 020 7944 3021
Press enquiries out of hours: 020 7944 4292

Email: maib@dft.gsi.gov.uk
Telephone: +44 (0) 23 8039 5500
Fax: +44 (0) 23 8023 2459

CONTENTS

FIGURES

TABLES

ANNEXES

GLOSSARY OF ABBREVIATIONS, ACRONYMS AND TERMS

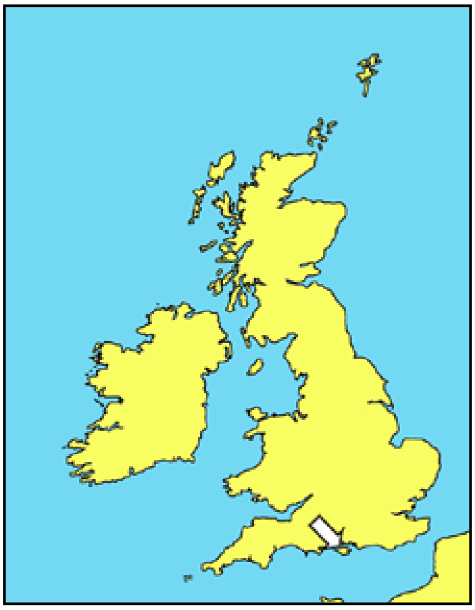
AB	-	Able Seaman
AIS	-	Automatic Identification System
CoC	-	Certificate of Competency
CSM	-	Cargo Securing Manual
CSS Code	-	Code of Safe Practice for Cargo Stowage and Securing
DB	-	Double Bottom (tanks)
DNV	-	Det Norske Veritas
DoC	-	Document of Compliance
EUME	-	Europe to Middle East
GM	-	Metacentric height - distance between a ship's metacentre and vertical centre of gravity, a measure of a ship's initial stability
GVM	-	Gross Vehicle Mass
GZ	-	Righting lever – horizontal distance between the lines of buoyancy and gravity – a measure of a ship's stability
High and heavy	-	Cargo, particularly construction equipment such as cranes, bulldozers, quarry trucks and excavators
ILB	-	Inshore Lifeboat
IMO	-	International Maritime Organization
ISM	-	International Safety Management
kg	-	kilogram
kN	-	Kilonewton
kt	-	knot
LCG	-	Longitudinal Centre of Gravity
LOF	-	Lloyd's Open Form
LR	-	Lloyd's Register
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Note
MPZ	-	Moving Prohibited Zone

MSL	-	Maximum Securing Load. MSL can be expressed in kN, kg or t; e.g. a 100kN lashing is also referred to as a 10,000kg or 10t lashing. The variations in quantifier in the report reflects the variation in the source documentation. It is a term used to define the allowable load capacity for a device used to secure cargo to a ship.
PC	-	Port Captain
PCC	-	Pure car carrier
PCTC	-	Pure car and truck carrier
RAF	-	Royal Air Force
RFA	-	Royal Fleet Auxiliary
RNLI	-	Royal National Lifeboat Institution
Ro-Ro	-	Roll on, Roll off
Ro-Ro cargo	-	Vehicles that can be driven on, or cargo carried on trailers, or break bulk cargo carried on trailers
Ro-Ro ship	-	A ship designed to allow cargo to be driven on and driven off
SCH	-	Southampton Cargo Handlers
SCU	-	Salvage Control Unit
SOLAS	-	International Convention for the Safety of Life at Sea, 1974, as amended
SOSREP	-	Secretary of State’s Representative
SMC	-	Safety Management Certificate
SMS	-	Safety Management System
SP	-	Southampton Patrol
STCW	-	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended (STCW Convention)
SWL	-	Safe Working Load
t	-	tonne
TCG	-	Transverse Centre of Gravity
UK	-	United Kingdom

USB	-	Universal Serial Bus
UTC	-	Universal Co-ordinated Time
VCG	-	Vertical Centre of Gravity
VDR	-	Voyage Data Recorder
VHF	-	Very High Frequency
VTS	-	Vessel Traffic Services
Wallem	-	Wallem Shipmanagement Ltd

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

SYNOPSIS



At 2109 on 3 January 2015, the pure car and truck carrier *Hoegh Osaka* was rounding West Bramble buoy in The Solent when it developed a significant starboard list causing some cargo shift and consequent flooding. With the list in excess of 40°, the ship lost steerage and propulsion, and subsequently drifted onto Bramble Bank, grounding at 2115.

Hoegh Osaka had sailed from the port of Southampton, bound for Bremerhaven, at 2006. A pilot was embarked and there were 24 crew on board. Following the accident, all crew were successfully evacuated from the ship or recovered from the surrounding waters. There was no pollution. A major salvage operation successfully refloated *Hoegh Osaka* and it was subsequently taken to a safe berth in Southampton on 22 January.

Stability modelling and analysis following the accident show that *Hoegh Osaka* heeled heavily to starboard while turning as a result of having departed port with inadequate stability. Cargo distribution was such that the upper vehicle decks were full while the lower vehicle decks were lightly loaded. *Hoegh Osaka* was low on bunker fuel oil, which was stored low down in the ship. With no additional ballast having been loaded prior to departure, the ship's overall centre of gravity was relatively high. The analysis also concluded that it was most likely that the cargo shifted due to the ship's excessive list and was not causal to the accident.

Hoegh Osaka's itinerary had changed from its routine loading rotation between three north-west European ports. The actual cargo weight and stowage were significantly different from the final cargo tally supplied to the ship. Ballast tank quantities were estimated on board and differed significantly from actual tank levels. Cargo unit vertical centres of gravity were routinely not allowed for in the ship's calculated stability condition. These factors all combined to result in the ship leaving Southampton with insufficient stability for the voyage.

A key finding of the MAIB investigation is that no departure stability calculation had been carried out on completion of cargo operations and before *Hoegh Osaka* sailed. Witness and anecdotal evidence suggests that this practice extends to the car carrier sector in general. The fundamental requirements for establishing before departure that a ship has a suitable margin of stability for the intended voyage had been eroded on board *Hoegh Osaka* such that unsafe practices had become the norm.

The owner and manager of *Hoegh Osaka* have taken a number of actions aimed at preventing a recurrence, and the MAIB has made recommendations to both to further enhance their respective instructions and procedures.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *HOEGH OSAKA* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	*Hoegh Osaka*
Flag	Singapore
Classification society	Lloyd's Register
IMO number/fishing numbers	9185463
Type	Pure car and truck carrier (PCTC)
Registered owner	Hoegh Autoliners Shipping Pte
Manager(s)	Wallem Shipmanagement, Pte Ltd, Singapore
Construction	Steel
Year of build	2000
Length overall	179.9 m
Gross tonnage	51770
Minimum safe manning	12
Authorised cargo	Ro-Ro cargo
VOYAGE PARTICULARS	
Port of departure	Southampton
Port of arrival	Bremerhaven (intended)
Type of voyage	Short international voyage
Cargo information	Mixed ro-ro cargo
Manning	24
MARINE CASUALTY INFORMATION	
Date and time	3 January 2015, 2109
Type of marine casualty or incident	Serious Marine Casualty
Location of incident	Bramble Bank, The Solent, UK
Place on board	Not applicable
Injuries	One serious injury
Damage/environmental impact	Material damage to the ship, no environmental impact
Ship operation	Under pilotage
Voyage segment	Transit
External & internal environment	Wind south-west force 3-4
Persons on board	25

Image courtesy of DK Mistral and vesseltracker.com

Figure 1: *Hoegh Osaka*

1.2 BACKGROUND

Hoegh Osaka was engaged on Hoegh Autoliners' Europe to Middle East (EUME) trade. This involved loading vehicles in three north-west European ports for discharge in 11 ports in the Middle East. Hoegh Autoliners operated an EUME service every 10 days. Cargo loaded in Europe was predominantly new and used construction equipment, and new cars. The EUME service took 50-60 days to complete.

In accordance with usual practice, the ship's staff had expected Southampton to be the final north-west European port, with the ship first loading vehicles at Hamburg and then Bremerhaven. However, on 19 December 2014, *Hoegh Osaka*'s master was advised that the itinerary had changed; he was instructed to first load a cargo at Southampton on 31 December, and then proceed to Hamburg and then Bremerhaven. Bunker fuel was ordered for delivery in Hamburg. The change in loading rotation was to accommodate a commercial preference to load the cargo in Southampton before the end of the year. However, subsequent delays during the previous voyage ultimately made it impossible for *Hoegh Osaka* to arrive in Southampton as planned.

Shortly before arriving off Southampton, the master of *Hoegh Osaka* received new orders which changed the ship's loading rotation once more. He was instructed to proceed first to Bremerhaven after loading cargo in Southampton, and then proceed to Hamburg.

1.3 NARRATIVE

1.3.1 At Southampton

Hoegh Osaka arrived at Southampton during the afternoon of 2 January 2015 and secured starboard side alongside berth 40. The ship was partly loaded with ro-ro cargo from the previous voyage. Cargo operations were scheduled to commence at 0600 the next morning.

During the evening of 2 January, *Hoegh Osaka*'s master received an email, sent earlier in the day by the port captain[1], that contained a copy of the pre-stowage plan. The pre-stowage plan detailed what type and quantity of cargo was to be loaded on each deck, its stowage position and port of discharge.

At 0550 on 3 January, the port captain boarded and met the chief officer, who advised him that he had not received the pre-stowage cargo plan. The port captain confirmed that the pre-stowage plan had been sent to the ship, by email, the day before. The cargo list and loading sequence was not discussed. The chief officer went to speak with the master, and obtained the pre-stowage cargo plan. He then went to the ship's control centre, positioned on deck 13, starboard side forward.

The port captain went to the ship's stern ramp and met with the stevedore supervisor from Southampton Cargo Handlers (SCH). The pre-stowage cargo plan was discussed, cargo for discharge identified and a loading sequence planned. The chief officer was not present at this meeting but had met the stevedore supervisor separately.

[1] The port captain was the Hoegh Autoliners' representative and had responsibility for preparing the pre-stowage cargo plan and supervising the loading operations.

At 0621, cargo operations commenced. Two cargo units were discharged and then cargo loading started. Stevedores employed by SCH loaded all of the cargo onto the ship, and secured it using the ship's own equipment. SCH had supervisors on board who monitored the cargo securing. One of the ship's deck officers was on duty at all times throughout loading. The deck officer monitored the loading sequence and kept the chief officer apprised. He also checked the securing of cargo. Ship's crew were on duty on the vehicle decks throughout loading, ensuring that there was adequate cargo securing equipment available for the stevedores to use.

The chief officer spent the majority of the day in the ship's control centre, where he used the ship's ballast system to ensure that *Hoegh Osaka* remained upright throughout loading and maintained a favourable trim. It is reported that, during the morning, the chief officer carried out a departure stability calculation using the pre-stowage cargo plan figures, which he entered into the Loadstar[2] program on the ship's loading computer. The calculation is reported to have indicated that the ship would have a metacentric height (GM)[3] on departure of 1.46m. Although the calculated GM indicated *Hoegh Osaka* would have an acceptable margin of stability on departure from Southampton, the chief officer noted that it was smaller than he would normally expect.

As the loading progressed the port captain, in conjunction with the stevedore supervisor, made arrangements to load some additional high and heavy cargo[4] that was on the reserve cargo list. Neither the ship's duty deck officer nor the chief officer was advised of the intention to load additional cargo.

At 1750, cargo operations were completed, although four additional cars were loaded onto deck 6 at 1857. The deck cadet went ashore and took forward and aft draughts, which he reported to the chief officer. The chief officer made a standard adjustment to the reported aft draught to allow for the stern ramp still being on the quay, to produce departure draughts of 9.0m forward and 8.4m aft. However, draughts of 8.4m forward and 9.0m aft were subsequently recorded on the bridge noticeboard and on the pilot card.

At 1930, a pilot embarked through the stern door and was escorted to the bridge. The final cargo tally and stowage plan was delivered at the stern door around this time. The chief officer began to lift the stern ramp, which caused the ship to list to starboard. The pilot commented on the list, which was estimated as 7° and well in excess of the usual 1-2° normally experienced.

The chief officer went to the ship's control centre and transferred ballast water from the starboard heeling tank to the port heeling tank to bring the ship upright. He then proceeded to the forward mooring deck to supervise the unmooring operation there. The second officer was stationed on the aft mooring deck for the ship's departure. The master, pilot, third officer and helmsman were on the bridge.

Following a master/pilot exchange, in which there were no reported defects, the pilot contacted Southampton Vessel Traffic Services (VTS) on very high frequency (VHF) radio to advise that *Hoegh Osaka* was ready to depart from berth 40, and

[2] Loadstar was a Windows-based stability and loading program that had been developed by Maersk. It was installed on a 'stand-alone' loading computer in *Hoegh Osaka*'s control centre.

[3] Metacentric height (GM) – distance between a ship's metacentre and vertical centre of gravity, a measure of a ship's initial stability.

[4] High and heavy cargo is typically construction equipment such as cranes, bulldozers, quarry trucks and excavators; but also agricultural tractors, trucks, diggers and military equipment.

to report the number of crew on board. A tug was made fast forward, and another made fast aft.

1.3.2 Departure from Southampton

At 2006, *Hoegh Osaka*'s mooring ropes were let go and the ship was manoeuvred off the berth with the assistance of the two tugs. Both tugs were let go and stood down once the ship had swung off the berth and was proceeding outbound in the main channel.

At 2025, the chief officer and the deck cadet went to the ship's control centre to commence the calculation of the ship's departure stability. Due to a large number of changes between the planned load and the actual load, the chief officer decided to re-enter all of the cargo figures rather than amend the departure stability condition that he had used for his calculation earlier in the day.

As *Hoegh Osaka* proceeded along Southampton Water, the master telephoned the chief officer and told him that he thought the ship did "*not feel right*". The chief officer replied "*I'm working on it*".

The Southampton harbourmaster patrol launch (SP[5]) took up station ahead of *Hoegh Osaka* as it passed Hook buoy **(Figure 2)**.

At 2059, the pilot gave the first helm order to starboard to start the Calshot turn, at which time the ship was making good a speed of 10 knots (kt).

The pilot moved around the wheelhouse, although he had a radar allocated for his own use on the port side of the bridge **(Figure 3)**. The third officer was on the starboard side of the bridge, monitoring the navigation and operating the telegraph as necessary. The helmsman was at the helm position on the centre line and was steering the ship manually. The master was moving around the bridge to maintain an overview of the operation.

The Calshot turn was completed without incident, the ship heeling to port and returning upright as expected.

At 2102, as *Hoegh Osaka* entered the Thorn Channel, the pilot requested that the ship's speed be increased.

When the chief officer had entered the cargo figures into the ship's loading computer, he became concerned that the indicated GM was less than his earlier departure stability calculation had predicted. He sent the deck cadet to take soundings of the three aft peak tanks in preparation for loading additional ballast water.

The chief officer began setting up the ballast system using the mimic panel in the ship's control centre. He anticipated that he would require an additional 300t of ballast in the aft peak tanks.

[5] The role of SP in this case was to ensure that no small craft impeded the passage of large vessels by entering the moving prohibiting zone (MPZ), defined as an area 1000m ahead and 100m each side of vessels over 150m in length when navigating the precautionary area between the Isle of Wight and Southampton Water **(Figure 4)**. (ABP Southampton Notice to Mariners No3 of 2014.)

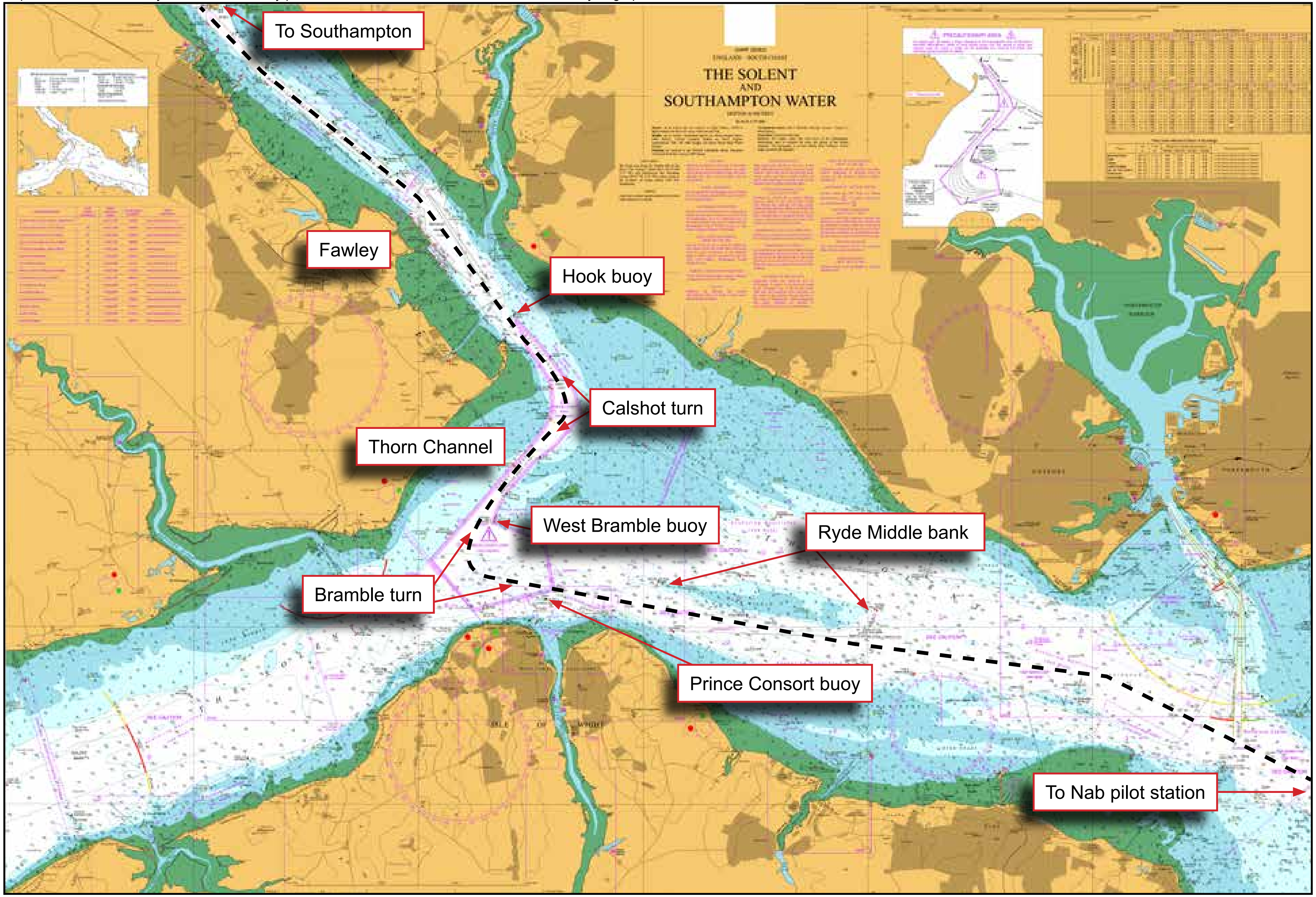


Figure 2: *Hoegh Osaka* planned route

Figure 3: The bridge

1.3.3 Listing and flooding

The master of the ferry *Red Osprey,* which was departing from East Cowes, called *Hoegh Osaka'*s pilot on VHF radio advising that he had a medical patient being transferred in an ambulance on board and requested a green-to-green passing, to which the pilot agreed. There was no other traffic of concern to *Hoegh Osaka'*s bridge team.

Hoegh Osaka was making good a speed of 12kt when the pilot gave the following sequence of orders to the helmsman:

2107:32 "*Port 10*"

2108:20 "*Port 5*"

2109:10 "*Midships*" immediately followed by the comment "*She's very tender captain*"

The ship progressively heeled to starboard and the rate of turn increased rapidly.

2109:36 "*Hard a starboard''*

At 2110, SP's coxswain reported to Southampton VTS by VHF radio that *Hoegh Osaka* had developed a serious list and required assistance. The VTS operator, looking at his radar, noted how quickly *Hoegh Osaka* appeared to be swinging around West Bramble buoy.

At 2110:30, the pilot gave the order to "*stop engines*", and soon afterwards he asked "*what the hell is the GM of this vessel?*"

SP's coxswain then called VTS back advising that *Hoegh Osaka* had blacked out. *Hoegh Osaka*'s starboard list continued to increase as the ship swung, exposing its rudder and propeller clear of the water.

There was no communication from *Hoegh Osaka*, as no one on the bridge could reach a VHF radio due to the angle of list.

Several cargo units and items of ship's equipment broke free from their lashings and shifted as the ship heeled. This resulted in a hole being punctured through the shell plating in way of the ship's gangway recess, allowing sea water to enter deck 6 when it became submerged.

Two tugs that were operational on Southampton Water, *Svitzer Ferriby* and *Svitzer Surrey,* were tasked by VTS to proceed towards *Hoegh Osaka* and assist as required. VTS contacted the Coastguard, advising of the incident and requesting assistance. At 2119, the first Royal National Lifeboat Institution (RNLI) lifeboat, Calshot inshore lifeboat (ILB), was tasked. Soon afterwards, additional RNLI lifeboats were tasked from Yarmouth and Cowes. Calshot's second lifeboat was launched to assist.

1.3.4 Grounding

At 2115, *Hoegh Osaka* grounded on Bramble Bank **(Figure 4)**. The pilot observed the inclinometer on the bridge, which was indicating a list of 40° to starboard. This angle was not increasing and it was clear to the pilot that the ship was now aground.

After considerable effort, the pilot managed to recover his mobile phone from his coat pocket as he was on the high side of the bridge, and his coat had fallen to the low side. He made contact with VTS by mobile phone, reporting that the ship had a 40° list, and stressed that it was important that the ship remain on the bank. This message was relayed to the Coastguard and to the tugs that were on their way to the scene.

Coastguard helicopter R104, based at Daedalus at Lee-On-The-Solent, was tasked. *Apex,* a large tug based at Fawley Oil Terminal, was also tasked to proceed and assist.

SP's coxswain reported to VTS that crew were under *Hoegh Osaka*'s port side lifeboat and shouting for help.

At 2154, the first tug, *Svitzer Ferriby*, arrived on scene and tried to manoeuvre into a position to push *Hoegh Osaka*'s stern further onto the bank. However, there were too many mooring ropes floating in the water around the stern of *Hoegh Osaka* for the tug to approach. SP then cleared the ropes, allowing the tug to manoeuvre into position and gently push the ship's stern.

Reproduced from Admiralty Chart BA 2036-0 by permission of the Controller of HMSO and the UK Hydrographic Office.

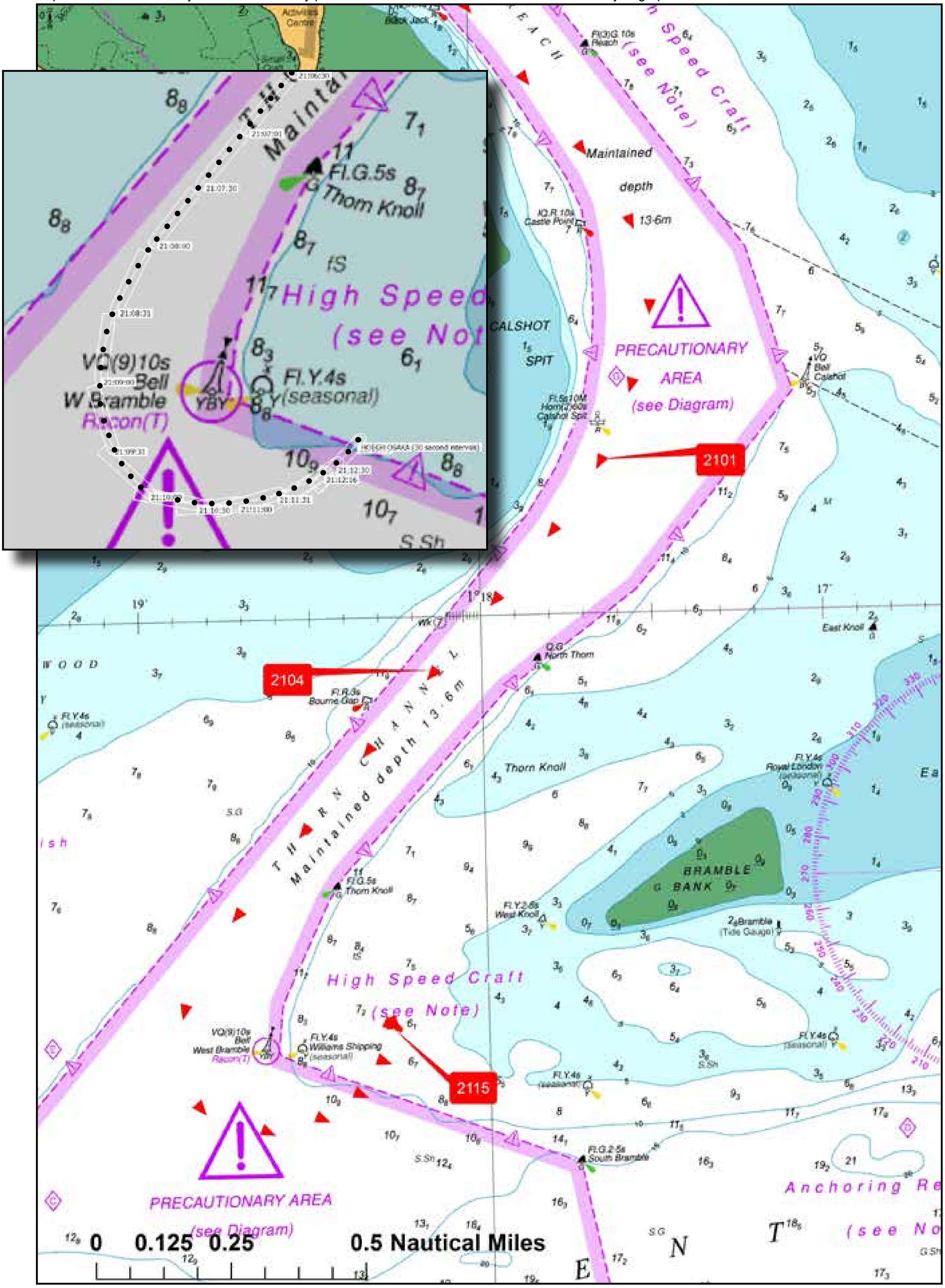


Figure 4: AIS track showing grounding position (with inset showing reconstruction of track)

1.3.5 Onboard consequences

At the time of the accident, there were three crew and the pilot on *Hoegh Osaka*'s bridge and five crew in the engine room. The chief officer was in the ship's control centre, and the deck cadet was getting changed in his cabin on his way to take soundings of the aft peak tanks. The bosun was on the forward mooring deck. The remainder of the ship's crew were in their cabins or in the mess room.

Following the accident, it was not possible to stand or walk on the bridge. The pilot was initially on the port side, the high side of the bridge. He was able to brace himself against the port side of the forward chart table **(Figure 5)**. The master had slid along the bridge deck and found himself on the low side of the bridge, against the starboard bridge wing door. The third officer was able to wedge himself between the bridge consoles, and the helmsman was able to remain between the helm console and the pilot radar. The fire alarms sounded throughout the ship.

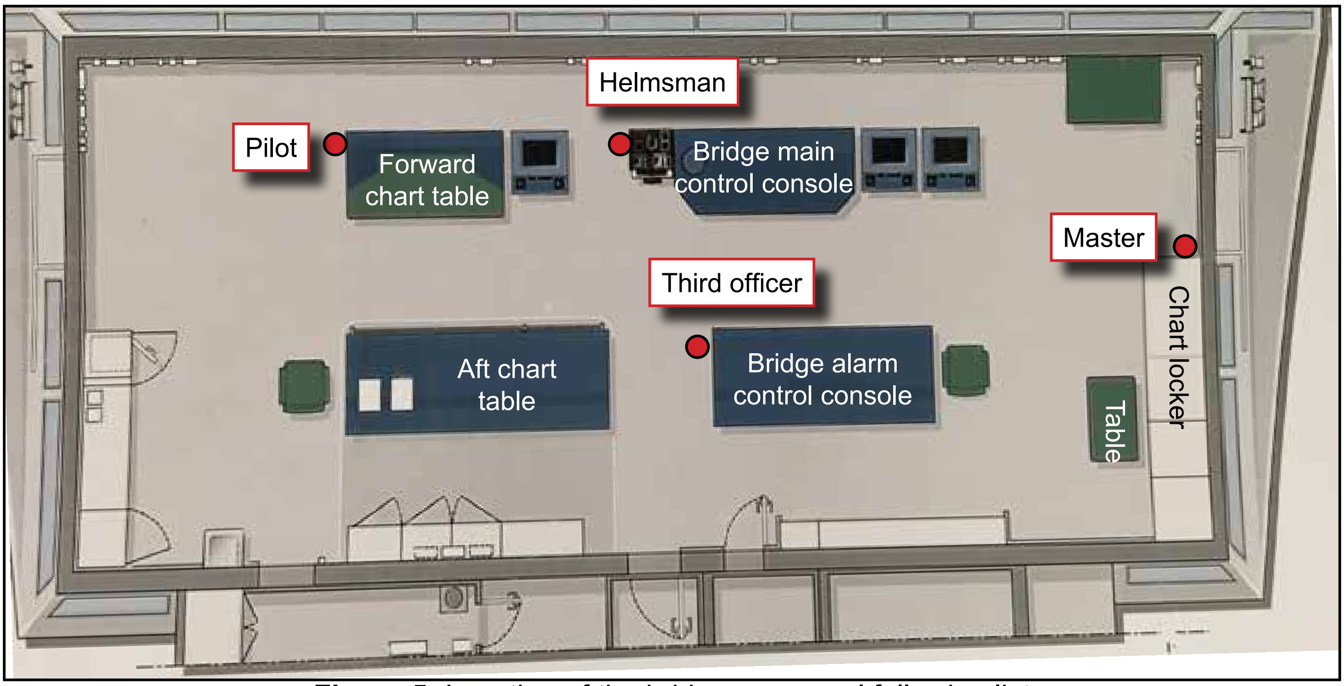


Figure 5: Location of the bridge personnel following list

There was no organised muster but crew gathered towards the high side of the open deck, particularly around decks 13 and 14, aft of the bridge on the port side. Most of the crew removed their shoes to try to get purchase on the sloping decks.

The deck cadet and second officer managed to reach the ship's control centre and assisted the chief officer in passing out immersion suits and lifejackets.

An off-duty crewman had been resting in his cabin on the port side of deck 13 when the vessel began to list. He got out of bed and fell over as the list increased. He then stood up and left his cabin. As the vessel continued to list, he slipped, and fell approximately 18 metres along the forward cross-alleyway on deck 13, hitting the door on the starboard side. The crewman broke both his arm and his leg in the fall and was in significant pain such that he could not move.

Several of the ship's crew suffered minor cuts and bruises as items fell during the ship's sudden listing.

The crew in the engine room used the emergency escape and climbed from the engine room up to the open deck.

1.3.6 Evacuation

The ship's electrician, who found himself pinned against the railings on the starboard side of the ship on deck 13, jumped into the water as he saw an RNLI lifeboat approach. He was recovered from the water. The bosun, who was stranded on the forward mooring deck, also jumped into the water. He was rescued from the water by the Calshot ILB and transferred to the all-weather lifeboat.

At 2209, the first six casualties were winched from *Hoegh Osaka'*s open deck onto R104 and transferred to Daedalus airfield. The helicopter winchman remained on board the ship to assist with casualty evacuation.

The pilot on board an inbound car carrier, *Tegula*, was advised by VTS of the developing situation and instructed to anchor the vessel. Once the vessel was anchored, *Tegula*'s pilot transferred onto SP to assist with communication and emergency co-ordination.

At 2221, there was a report from one of the rescued crew that *Hoegh Osaka'*s engine room was flooding, and not all of the crew had been evacuated.

By this time, one tug was pushing aft and two were pushing on *Hoegh Osaka*'s port side forward **(Figure 6)**, ensuring that the ship remained aground on the bank. The crew of *RFA Lyme Bay,* which was in the vicinity, monitored the stricken ship and reported to VTS that *Hoegh Osaka* appeared to be stationary. The pilot co-ordinated the tug movements and communicated with SP and the harbourmaster throughout.

Image courtesy of Police ASU

Figure 6: Aerial view of ship with tugs in attendance

Tegula's pilot transferred onto *Hoegh Osaka's* aft mooring deck to look for signs of flooding or crew in need of assistance.

Owing to the difficulty in evacuating the crew from the ship, an RNLI crewman on the Yarmouth lifeboat (a tree surgeon with rope skills), was winched on board *Hoegh Osaka* to assist with rigging ropes to aid the crew evacuation.

Royal Air Force (RAF) helicopter R169 was tasked from RAF Chivenor. A National Police Air Service helicopter also attended and used night imaging equipment to monitor the waters around *Hoegh Osaka*.

By 0015 on 4 January, all persons on board *Hoegh Osaka* had been accounted for and evacuated with the exception of the pilot, master and chief officer, who remained on the bridge with the intention of assisting with any imminent salvage.

As the tide fell *Hoegh Osaka's* angle of list slowly increased and, following discussion with the Southampton harbourmaster, the Coastguard gave the order for the ship to be abandoned. At 0209, the pilot and remaining crew were evacuated from the ship by helicopter. The master pressed the download button on the ship's voyage data recorder (VDR) prior to evacuation. The three tugs that were pushing *Hoegh Osaka* were released on the harbourmaster's authority as the ship was hard aground on an ebb tide.

The tug *Lomax* and SP remained on scene through the remainder of the night **(Figure 7)**.

Figure 7: *Hoegh Osaka* aground on Bramble Bank

1.3.7 Salvage

On 4 January, Svitzer Salvage was awarded a salvage contract under Lloyd's Open Form (LOF)[6]. The salvage master and his team made an initial assessment without boarding the ship, and calculated its list to be 52°.

The Secretary of State's Representative for Maritime Salvage and Intervention (SOSREP)[7] set up a Salvage Control Unit (SCU) in Southampton to co-ordinate the salvage operation.

Salvors gained access to *Hoegh Osaka* on 5 January. The ship's VDR USB[8] flash drive was recovered and passed to the MAIB. The salvors applied a temporary patch to the hull breach on deck 6 that was allowing water to enter the ship.

The complex salvage operation involved three key phases:

- Refloating the ship and moving it a short distance to a secure anchorage.
- Bringing the ship to an upright condition, discharging flood water and securing cargo.
- Towing the ship into Southampton.

Hoegh Osaka refloated at high water on the afternoon of 7 January and was towed from its initial grounding position on Bramble Bank to Alpha anchorage. It was then anchored, with tugs remaining fast to hold the ship in position. The decision was made to leave the flood water on board the ship as it had a positive effect on stability while several weather fronts passed through. The salvage team continued to work, although their progress was hampered by the poor weather.

As the weather improved, the flood water was gradually pumped out and ballast was transferred internally, allowing the ship to be brought to a near upright condition.

On 22 January, *Hoegh Osaka* was towed into Southampton where its cargo was discharged. The ship sailed from Southampton on 10 February and proceeded to A&P Shipyard, Falmouth, where repairs were undertaken prior to it returning to service.

1.3.8 Damage to the ship

As *Hoegh Osaka* listed, cargo shifted to starboard on deck 6. The shell plating in the vicinity of the starboard side gangway access void was punctured by the caterpillar tracks of a JCB excavator **(Figure 8)**. A hole of approximately 25cm x 4cm allowed flood water to enter the ship. This hole was temporarily patched by the salvors at the beginning of the salvage operation **(Figure 9)**.

---

[6] Formally the Lloyd's Standard Form of Salvage agreement, the LOF is a standard legal document for a proposed marine salvage operation. The form is open, as no amount of money is stipulated initially with the amount of money to be paid decided by arbitration at a later date.

[7] On behalf of the Secretary of State for Transport, SOSREP is tasked to oversee, control and if necessary intervene and exercise 'ultimate command and control', acting in the overriding interest of the United Kingdom in salvage operations within UK waters.

[8] Universal Serial Bus

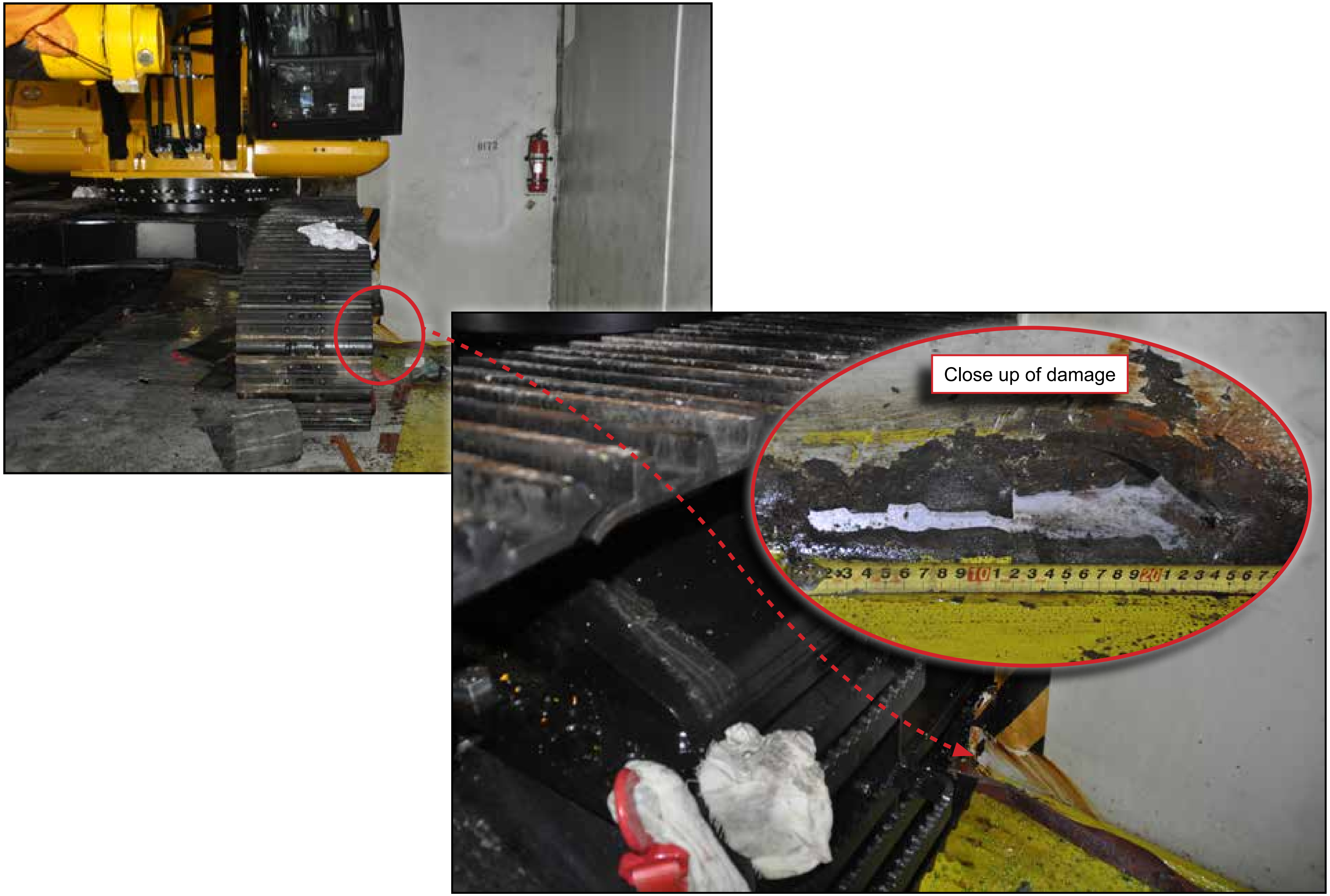


Figure 8: Damage to shell plating caused by JCB tracks

Figure 9: Temporary patch applied to shell damage by salvors

A major component of a stone crusher that had shifted on deck 6, fell onto the watertight deck, puncturing it **(Figure 10)**. This allowed flood water on deck 6 to enter the cargo decks below. Approximately 2700t of sea water came on board and formed a wedge of water on the lower decks.

Several areas of the ship's internal car deck structure were damaged to varying extent by moving cargo **(Figure 11)**.

1.3.9 Damage to the cargo

Although the vast majority of cargo remained in position, 27% of the cargo sustained damage **(Figures 12, 13** and **14)**, varying from repairable scratches and dents to severe damage resulting in total loss **(Table 1)**.

An initial cargo shift occurred as *Hoegh Osaka* heeled; other cargo shifted later. Cars that were damaged were in localised pockets, in general caused by one vehicle breaking its lashings, resulting in a domino effect as the loose vehicle moved into adjacent vehicles. As the majority of the cars were tightly stowed, the build-up of momentum was relatively small, limiting the extent of the damage. However, not all of the high and heavy cargo was tightly stowed. As such, when their lashings released or broke, the size and momentum of the high and heavy cargo caused significant damage to adjacent vehicles **(Figures 15, 16** and **17)**.

Cargo Category	Total number on board	Undamaged units	Damaged units (not total loss)	Total loss units
Cars	1450	1075	323	52
High and heavy	183	122	33	28
Totals	1633	1197	356	80

Table 1: Cargo damage summary

The ship carried two deck lifter machines, self-propelled units used to raise and lower the deck panels. One of these units, stowed on the starboard side of deck 8, was damaged as it shifted **(Figure 18)**, and also caused damage to cargo stowed adjacent to it.

The ship's forklift truck and deck sweeper, both stowed near the centreline of deck 6, shifted and were damaged. The ship's own equipment had been secured by the ship's crew prior to departure.

Figure 10: Component from stone crusher that fell onto deck 6

Figure 11: Damage to starboard side of deck 6 caused by moving cargo

Figure 12: Deck 6 starboard side cargo damage

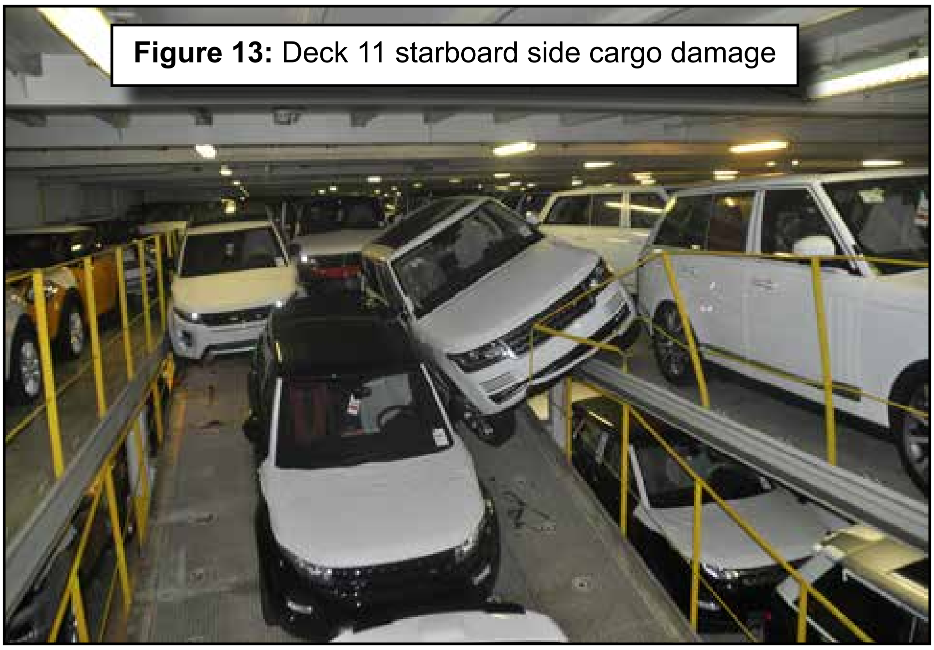


Figure 13: Deck 11 starboard side cargo damage

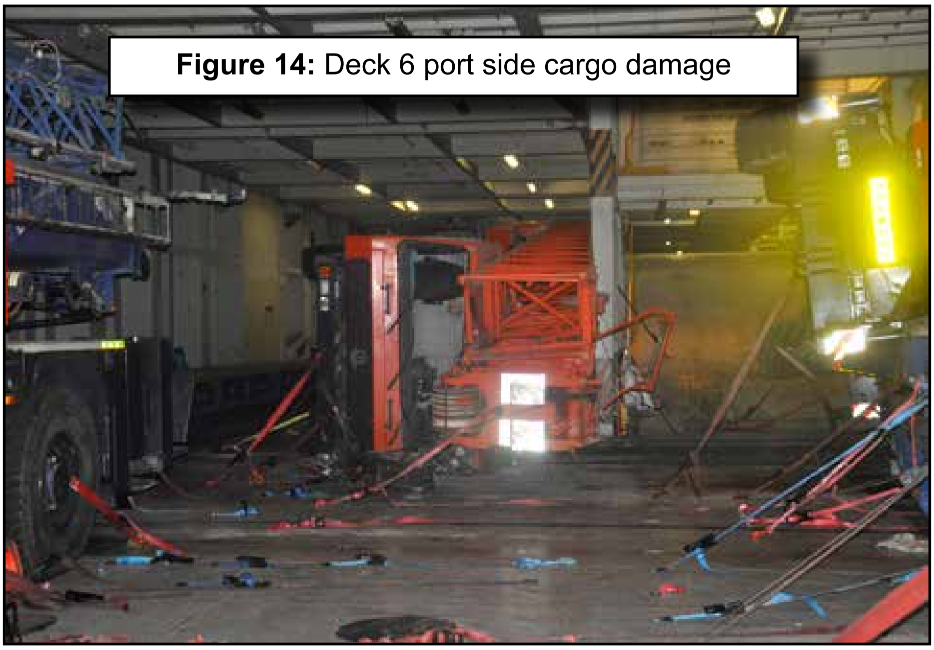


Figure 14: Deck 6 port side cargo damage

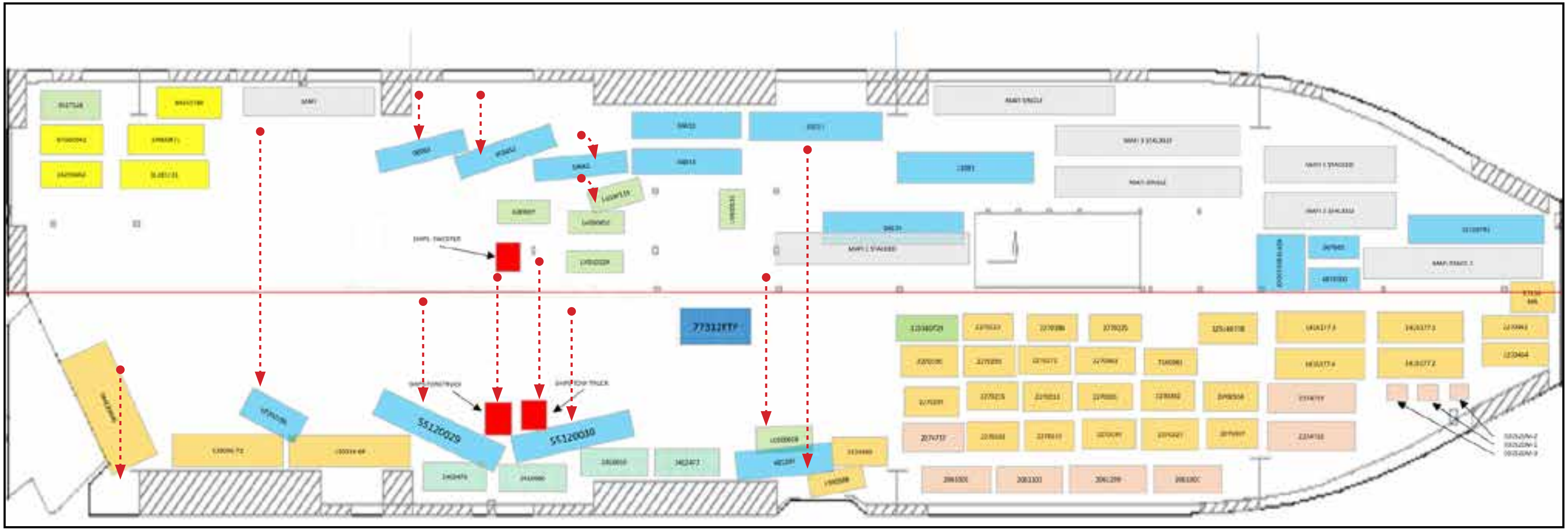


Figure 15: Deck 6 - original stowage and direction of shift of displaced cargo

Figure 16: Track-type bulldozer, original stowage position on port side and final resting position to starboard

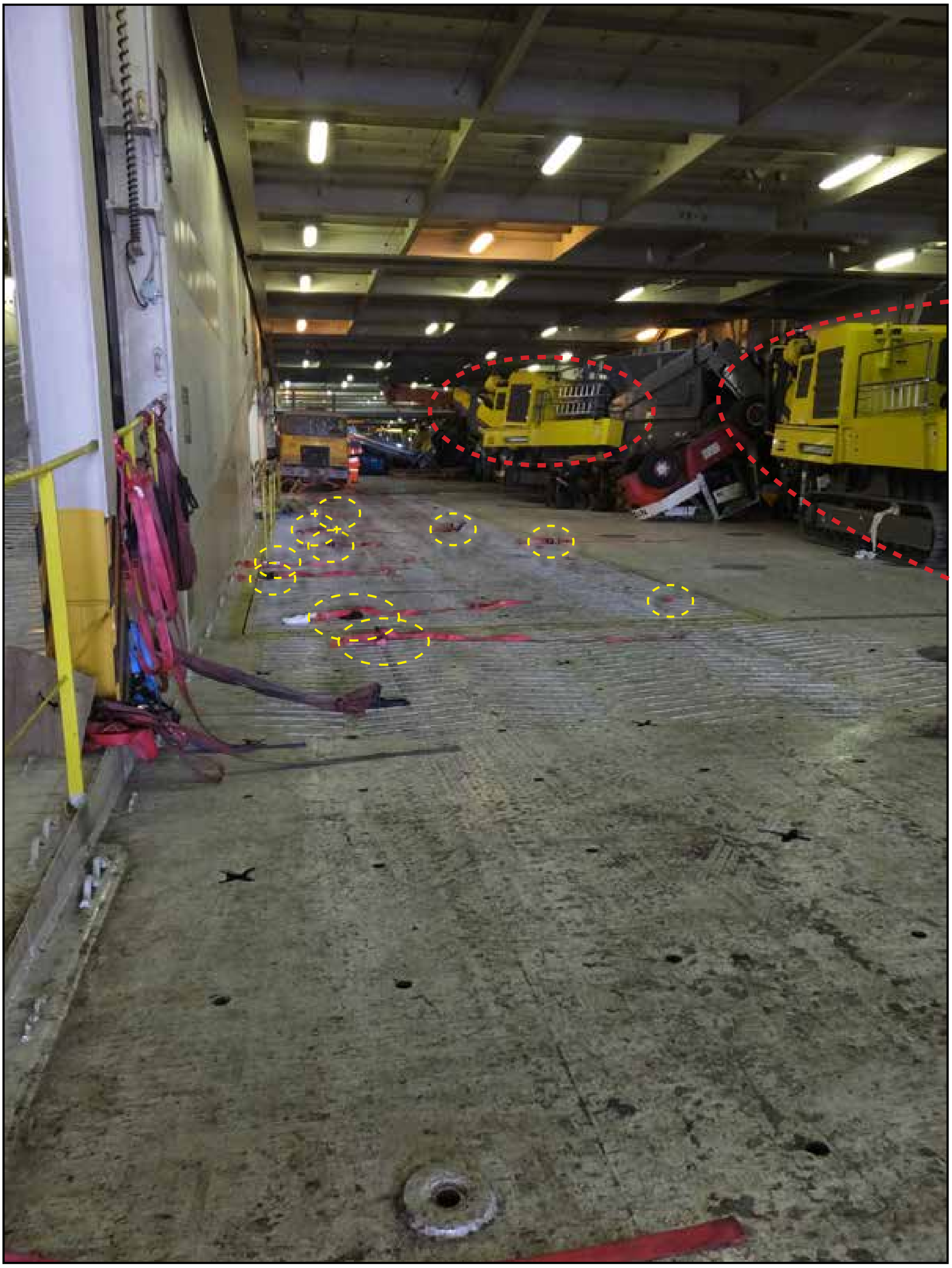


Figure 17: Original stowage position of two powercrushers, broken lashings visible on deck. Post-shift positions to starboard

1.3.10 Environmental conditions

It was dark at the time of the accident, and the visibility was good. The wind was south-westerly force 3 to 4, and the sea conditions were calm.

High water at Southampton on 3 January was at 2208 with a height of 4.2m.

Figure 18: Ship's deck lifter machine

1.4 *HOEGH OSAKA*

1.4.1 Background

Hoegh Osaka was a 51770 gross tonnage, 179.9m long pure car and truck carrier (PCTC). The ship was built in Japan in 2000 as *Maersk Wind* and renamed *Hoegh Osaka* in 2009. The ship had been operated on various routes worldwide by Hoegh Autoliners Shipping Pte (Hoegh Autoliners) and Maersk, the ship's previous owner, and had visited Southampton on many previous occasions.

Hoegh Osaka was classed by Lloyd's Register (LR), was propelled by a single slow-speed diesel engine, and had a service speed of 19.2kt.

1.4.2 Cargo deck specifics

Hoegh Osaka had a total of 12 enclosed vehicle decks **(Figure 19)** connected by moveable and fixed ramps. Most vehicles were driven on and off under their own power.

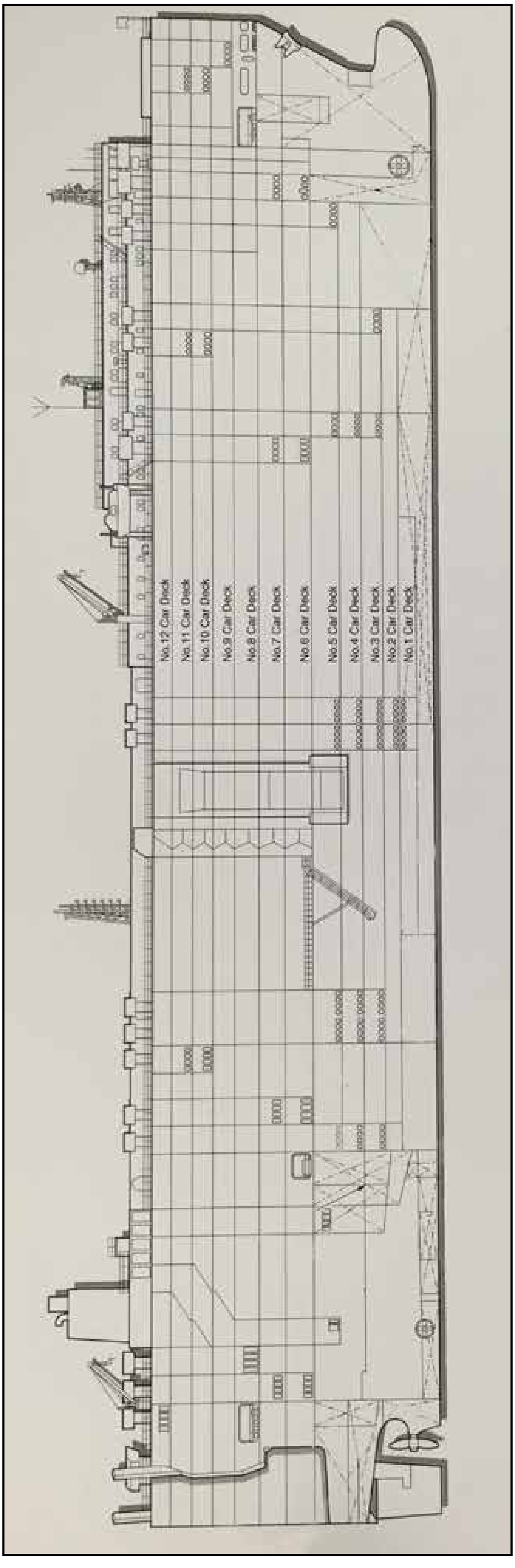


Figure 19: Ship's profile plan

The ship was fitted with a stern ramp on its starboard aft quarter, and a midships ramp on its starboard side. Only the stern ramp was used for cargo operations in Southampton. The stern ramp opened from deck 6, which was designated as the main deck. Cargo was loaded onto deck 6 and was then driven either up or down to its final loading position using a series of internal ramps.

Of the ship's 12 cargo decks, nine were fixed and three, decks 5, 7 and 9, were moveable; they could be raised or lowered as necessary to facilitate cargo stowage requirements. The moveable decks could be raised or lowered in sections to maximise capacity using the ship's own deck lifter machines.

Decks 4, 6 and 8 were strengthened and designated for the carriage of high and heavy cargo. These decks also had greater height clearance than the other vehicle decks. The stern ramp had a safe working load of 100t.

1.4.3 Ownership and management

Hoegh Autoliners, which had a head office in Oslo, Norway, operated a fleet of 60 PCTCs on a global network.

Hoegh Osaka was managed by Wallem Shipmanagement Pte Ltd, Singapore (Wallem). Wallem took over the technical management of the ship from Maersk in July 2014. Wallem managed a fleet in excess of 400 vessels, of various types, and provided both the technical management and crewing for *Hoegh Osaka.*

The manager's International Safety Management Code (ISM Code) Document of Compliance (DoC) had been issued by DNV and was valid until April 2017. *Hoegh Osaka*'s ISM Code Safety Management Certificate (SMC) was issued by LR and was valid until November 2019.

1.4.4 Wallem safety management system

The requirement for management companies to establish a safety management system (SMS) is laid out in the ISM Code. The Code is contained in Chapter IX of the International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS).

Wallem provided a generic SMS for use by its managed vessels. The SMS included the following three volumes:

- Shipboard Management Manual Part 1
- Shipboard Management Manual Part 2
- PCC[9]/PCTC Operations Manual.

Shipboard Management Manual Part 1 set out the company policy for safety, quality and environmental protection. It contained detailed instructions on documentation management, administration, job role and accountability, review and verification, personnel matters, training, deck and engine room procedures, cargo operations and maintenance schedules.

[9] Pure car carrier

Shipboard Management Manual Part 2 contained detailed instructions on communications, audits, critical equipment, risk assessment, inspections and survey, bunkers, security, stowaways and insurance. The manual also contained completed generic risk assessments.

The PCC/PCTC Operations Manual contained additional information on the specific operation of vehicle carriers. In particular it: defined the roles of individual ship's crew involved in cargo operations; detailed the procedures to be taken while loading and discharging cargo; and provided checklists and instructions to the crew. The purpose of the manual was described in its introduction as:

> '*To provide guidance to the master, officers and appropriate ratings on the procedures to be followed on a PCC / PCTC in order to attain safe and efficient operation.*'

The checklists from the PCC/PCTC Operations Manual that were completed by the chief officer in Southampton were:

1. Checklist No.1 Prior loading / during loading
2. Checklist No.2 Prior discharging / during discharging
3. Checklist No.3 Prior departure port
4. Checklist No.4 Loaded passage
5. Checklist No.5 During loading / discharging

The checklists combined contained a total of 213 tick boxes. All had been ticked as affirmative. All five checklists had been signed by the chief officer. None had been signed as having been verified by the master **(Annex A)**.

On the introduction page of the PCC/PCTC Operations Manual, a note stipulated that:

> '*Instructions in the cargo manual from the operator is to be strictly complied with.*' [sic]

In the case of *Hoegh Osaka*, the cargo manual from the operator was interpreted to be the Hoegh Autoliners Cargo Quality Manual.

1.4.5 Hoegh Autoliners Cargo Quality Manual

The Hoegh Autoliners Cargo Quality Manual **(Figure 20)** was carried on board *Hoegh Osaka*. The manual was developed based on the following rules and regulations for the cargo stowage and securing on board ship:

- SOLAS chapters VI and VII
- Code of Safe Practice for Cargo Stowage and Securing (CSS Code)
- 2010 amendments to the CSS Code (Annex 13)

The manual defined all areas of responsibility for the cargo, from it being received at a load port to its delivery at a discharge port.

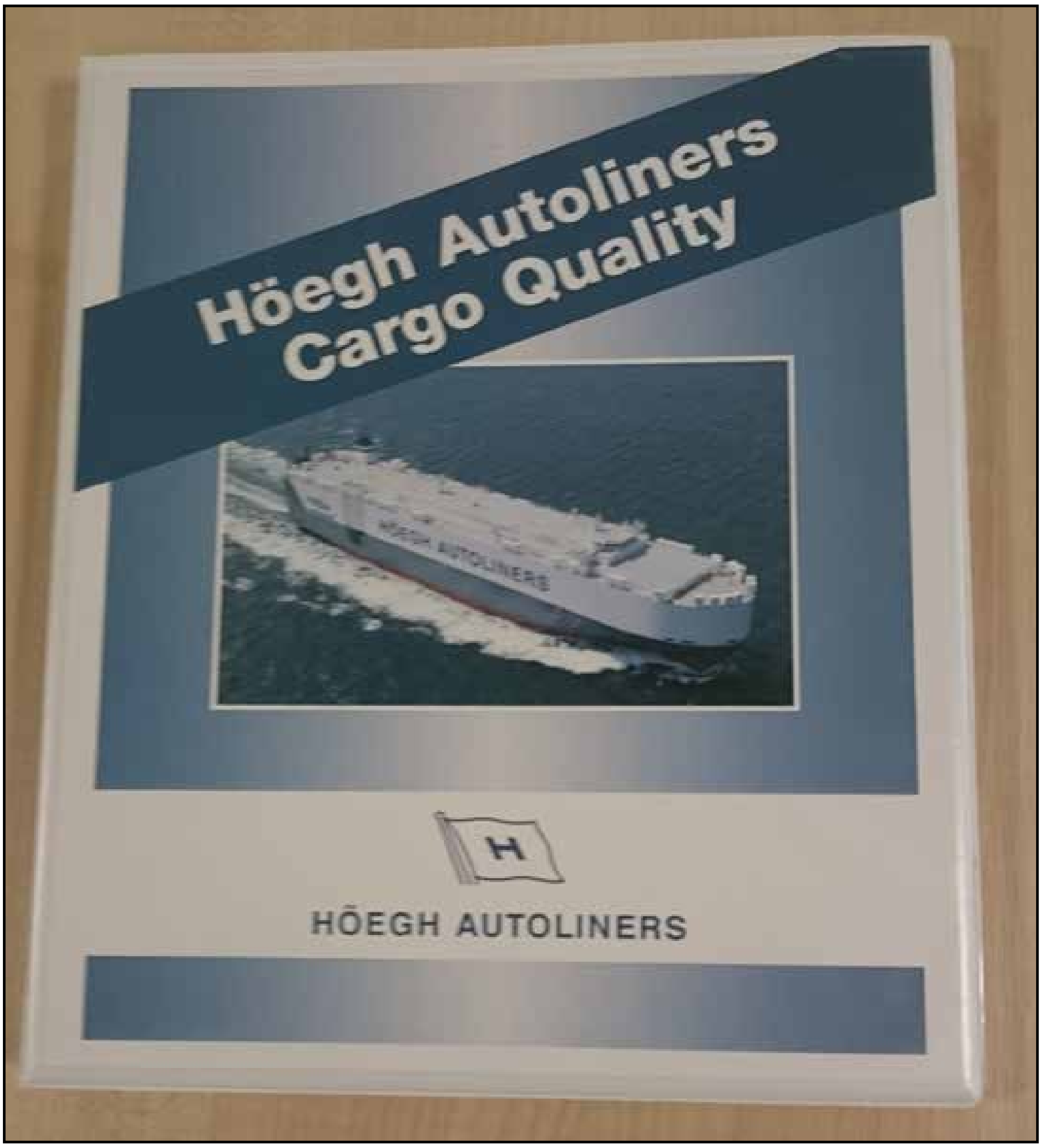


Figure 20: Hoegh Autoliners Cargo Quality Manual

1.4.6 Manning

Hoegh Osaka had a crew of 24, made up of 22 Indian nationals, one Sri Lankan and one Ukrainian. All officers and crew were employed on behalf of the owners by Wallem.

At the time of the accident, the bridge was manned by a pilot, the master, the third officer and a helmsman, who was steering the ship to the pilot's instructions.

The master was a 50 year old Indian national and had been on board for 3 weeks. It was his first trip on *Hoegh Osaka* and his first contract with Wallem. He had been at sea for 32 years and had sailed on car carriers for the previous 10 years, the last 8 years as master. He held an STCW[10] II/2 Master unlimited certificate of competency (CoC).

[10] International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended (STCW Convention)

The third officer was a 25 year old Indian national and had been on board for over 5 months; he kept the 8 to 12 watch while at sea. He had been employed by Wallem as third officer since 2011, serving on various car carriers. He held an STCW II/1 CoC.

The helmsman had been at sea since 2006 and been on board *Hoegh Osaka* for over 5 months; he kept the 8 to 12 watch with the third officer. He had steered the ship in and out of Southampton on several previous occasions.

The chief officer was in the ship's control centre at the time of the accident. He was a 45 year old Indian national and held an STCW II/2 Chief Mate CoC. He had joined *Hoegh Osaka* for the first time as chief officer in July 2014. This was his second contract as chief officer, and his second contract with Wallem. The chief officer had considerable experience on car carriers, having served as an officer on them exclusively since 2009.

1.4.7 Wallem PCTC crew training course

Wallem provided a 2-day training course for senior officers assigned to ships in its PCC/PCTC fleet. This course covered specific topics concerning PCC/PCTC operation in addition to familiarisation with the Wallem SMS.

The master had not attended this course prior to joining *Hoegh Osaka*. The chief officer had attended the course in June 2014.

1.5 CARGO OPERATIONS

1.5.1 Role of the crew

1.5.1.1 The Wallem PCC/PCTC Operations Manual defined the role of the crew during cargo operations, viz:

<u>Master</u>

'The master shall hold overall responsibility for the vessel and her safety at all times.'

<u>Chief officer</u>

'The chief officer is directly responsible to the master for the safety of cargo operations.

Personnel delegated for the duty watchkeeping during cargo operations are directly responsible to the chief officer and shall discharge such orders as instructed by the chief officer.

Chief officer to prepare his port orders each port and is to have same available at ship's office and ensure understanding by duty officers and same to be complied with by duty officers.' [sic]

The chief officer made occasional walks around the cargo loading areas but spent the majority of his time in the ship's control centre, ensuring that the ship remained within the acceptable parameters of heel and trim; both critical during loading with a stern ramp on the quay, particularly in a port with a large tidal range.

The chief officer maintained contact with the master, the duty deck officer and the duty crewman throughout the loading operation utilising a portable radio. The chief officer provided standing orders for the duty deck officer to follow during cargo operations; these instructions were posted on the bulkhead in the ship's control centre and had been signed by the second and third officers.

Duty deck officer

The duty deck officer remained on the vehicle decks throughout loading. The third officer was on cargo watch from 0600-1200. The second officer was on watch from 1200-1800.

The Wallem PCC/PCTC Operations Manual stated:

> *'The duty officer holds responsibility for his watch and shall carry out all instructions as directed by the chief officer. Any irregularities, shortcomings, defects and similar occurrences shall be brought to the immediate attention of the chief officer.'*

This instruction was reflected in the chief officer's standing orders. During loading in Southampton, the chief officer became aware of additional cargo being loaded to that specified in the pre-stowage plan, but he did not receive this information from the duty deck officer.

1.5.1.2 Shipboard Management Manual Part 1 further defined the role of the chief officer during cargo operations:

Section 4, Page 18*:*

> *'The chief officer is responsible to the master for the safe stowage, loading, carriage and discharge of cargo and compliance with owners/charterers instructions regarding the cargo. He shall make a positive report to the master prior to each and every departure, and shall confirm the ship meets all the requirements of the stability booklet and will continue to do so throughout the forthcoming voyage*.' [sic]

The master was advised by the chief officer that the GM for departure was 1.46m and met the requirements of the stability information manual.

1.5.1.3 The Hoegh Autoliners Cargo Quality Manual also specified crew duties.

- *'The master is the ultimate responsible for the cargo and seaworthiness of the vessel'.* [sic]
- *'Officers and crew must be aware of Hoegh Autoliners cargo quality standards and see these rules are followed during cargo operation*
- *Have an updated loading plan.*

- *Officers and crew to be placed on decks in order to actively supervise the cargo operation, this to prevent cargo damage.*

- *Officers and crew must be aware of discharge port segregation and should apply separation band as needed with utmost care to avoid any damage to cargo.*

- *Officer must fill in damage report when/if damage occurs and have it signed by a representative from the stevedore company.*

- *Plan ahead to avoid delays*

- *One crew member to inspect moorings and external ramps*

- *Maintain a watchman as per ISPS rules.'*

1.5.2 Port captain

The use of a port captain was common in the deep sea ro-ro shipping industry.

In this case, the port captain was a Norwegian national who had been employed in his present role since 1999. He had sailed as a deck officer on chemical tankers prior to his employment as a port captain, and held an STCW II/2 Chief Mate CoC. He was based at Hoegh Autoliners' head office.

The role of the port captain was primarily to form a link between the ship's crew and the voyage planning manager, the local agents and stevedores.

The role of port captain was defined by Hoegh Autoliners in its internal cargo operations manual as:

- *'Pre-plan loading and stowage of cargo*

- *Plan loading and stowage of cargo*

- *Supervise the cargo operation according to plan*

- *Ensure loading of vessel in accordance with regulations and standards*

- *Make, distribute afterload report*

- *Report on vessel performance.'*

Hoegh Autoliners further defined the port captain's role as to ensure that booked cargo was loaded, stowed and secured safely and efficiently without any damage to crew, stevedore, vessel and cargo. To attain this, six specific areas of responsibility were defined:

- *'Prepare and send pre load plan*

- *Conduct pre load meeting*

- *Conduct ramp meeting*

- *Load cargo in accordance with pre load plan*

- *Stow cargo in accordance with Hoegh Autoliners Cargo Quality Manual*

- *Lash cargo in accordance with Hoegh Autoliners Cargo Quality Manual'.*

Once assigned to a particular vessel the port captain began compiling a loading list for each of the load ports. The load lists were used to enable a pre-stowage cargo plan to be compiled. Work on a particular port load commenced several weeks prior to the vessel's arrival.

The port captain planned the cargo loading for the north-west European ports. He liaised directly with booking office personnel, the stevedoring companies and the ship. He generated the pre-stowage plan and attended the loading for each of the three loading ports on the EUME service.

Depending on the ship's itinerary, the port captain either flew between ports or, on occasion, travelled on board the ship.

There was no definition of the role or responsibility of the port captain within the Wallem SMS Manual.

1.5.3 Cargo plan

The port captain received booked cargo figures from the booking offices. This information was used to generate a pre-stowage plan that was supplied to the ship prior to its arrival at a load port. The pre-stowage plan contained a graphical representation of the ship's decks, indicating the intended stowage position of the individual cargo units on the ship. The Hoegh Autoliners Cargo Quality Manual, page 27, stated:

> *'Vessel and agent will receive stowplan from Hoegh Autoliners Port Captain. If Agent/Stevedore/Chief officer see's any potential problems they should respond to PC on mail as soon as possible.'* [sic]

The pre-stowage plan for *Hoegh Osaka*'s call at Southampton was provided to the agent, stevedores and the ship on 2 January. The plan was passed to the chief officer by the master on the morning of 3 January as cargo operations commenced.

The port captain did not receive any e-mails from the agents, stevedores or the ship identifying any potential problems with the planned load.

The Hoegh Autoliners Cargo Quality Manual stated:

> *'All cargo operations shall be according to the agreed stow plan. Alterations, if any may only be made if cleared by the Hoegh Autoliners Port Captain or Vessel's Master'.* [sic]

During the loading operations in Southampton, the master of *Hoegh Osaka* was not advised of any alterations or additions to the pre-stowage plan.

On completion of a load, it was the responsibility of the chief officer to merge a plan of the cargo loaded with a plan of the cargo that was on board prior to loading, to produce a combined stowage plan.

At the time of this accident no combined stowage plan existed that showed the total cargo on board. There was a plan showing the cargo on board on arrival Southampton and there was a plan indicating the cargo that was loaded in Southampton. The two plans had not been merged to create a single cargo plan.

1.5.4 Stevedoring

SCH carried out all stevedoring operations on *Hoegh Osaka.* SCH had a long running contract with Hoegh Autoliners in Southampton and had provided stevedoring services for many years.

A team of 88 personnel attended the ship and, in addition to mooring and letting the ship go, provided personnel to drive all cargo on board and teams of lashers to secure all cargo on the ship using the ship's securing equipment. Lashing supervisors monitored the securing of cargo.

SCH provided a final cargo tally and stowage plan to the ship prior to its departure from Southampton. The stowage plan, which indicated the weight of cargo loaded on each deck and its location, was sent by e-mail to the agent and the port captain.

SCH used an electronic system to scan and log all vehicles as they were loaded onto the ship. This scanning system read a bar code on each vehicle being loaded. The bar code provided details of the make, model, weight and destination of each vehicle.

Before loading used high and heavy cargo, SCH attached a loading sticker to each unit that detailed its discharge port and declared weight **(Figure 21)**. The declared weight was obtained from the cargo manifest.

Figure 21: Vehicle loading bar code sticker

1.5.5 Cargo particulars

Hoegh Osaka arrived in Southampton on 2 January 2015 with the following cargo on board:

- 200 Hyundai cars on decks 1 and 2.

- 21 units of high and heavy cargo, primarily construction equipment, on deck 6.

Two cargo units were discharged in Southampton: a small boat and a wind turbine blade. This left 932.6t of cargo on board at the start of loading.

The pre-stowage plan supplied to the master on 2 January indicated the ship was to load:

1306 cargo units weighing a total of 4008.9t.

The final cargo tally provided to the chief officer on completion of cargo loading operations indicated that the ship had loaded:

1418 cargo units weighing a total of 4625.6t.

The additional 112 cargo units that were loaded, weighing a total of 616.7t, comprised 50 cars and 62 high and heavy cargo units.

SOLAS Chapter VI, Regulation 2, Paragraph 1 states:

'The shipper shall provide the master or his representative with appropriate information on the cargo sufficiently in advance of loading to enable the precautions which may be necessary for proper stowage and safe carriage to be put into effect…..'

Paragraph 3 states:

'Prior to loading cargo units on board ships, the shipper shall ensure that the gross mass of such units is in accordance with the gross mass declared on the shipping documents.'

1.5.6 Cargo weight discrepancies

The final cargo tally provided to the ship did not reflect the actual weight of cargo loaded. New cars were given estimated weights instead of the actual weights of the individual vehicles.

All Land Rover cars were assigned an estimated weight of 2t on the cargo tally.

The majority of the Land Rover cars loaded on board *Hoegh Osaka* were petrol variant Range Rovers.

Weights and numbers of the Land Rover cars on board are listed in **Table 2**:

Model	Weight (t)	Number on board	Total weight assuming 2t per item	Total using actual weights
Range Rover	2.513	564	1128	1417.332
Range Rover Sport	2.357	183	366	431.331
Land Rover Discovery 4	2.590	68	136	176.12
Land Rover Defender	2.098	19	38	39.862
Range Rover Evoque	1.802	260	520	468.52
Land Rover Discovery Sport	2.042	5	10	10.21
TOTAL WEIGHT	-	-	2198	2543.375

Table 2: Land Rover car weights and number of each model

With the exception of the Evoque, all of the Land Rover car weights were in excess of the tally estimated 2t, equating to a discrepancy of about 345.4t.

All new cars loaded had a bar code. This bar code was recorded electronically by the tally as the vehicle came on board the ship. The bar code contained specific information on the vehicle including its actual weight. All of the vehicle actual weights were recorded electronically by the tally, although these figures were not used in compiling the final cargo tally that was supplied to the ship.

All high and heavy cargo carried was provided with a shipping note. The shipping note contained the declared weight of the cargo unit. New high and heavy cargo had shipping notes provided by the manufacturer; the declared weights of the new units corresponded with those on the weight plates attached to each particular unit.

A selection of used high and heavy cargo that had been loaded in Southampton was selected by the MAIB for weighing. The units were weighed on a certified weighbridge.

Description	Declared weight (t)	Actual weight (t)	Variance (%)	Variance weight (t)
Volvo truck	7.000	7.360	+5	+0.360
Scania truck	9.270	9.820	+6	+0.550
Volvo truck	7.000	8.640	+23	+1.640
Mercedes truck	7.000	7.280	+4	+0.280
Volvo truck	7.600	7.280	-4	-0.320
Volvo truck	7.000	7.400	+6	+0.400
Mercedes truck	7.000	7.400	+6	+0.400
Volvo truck	7.000	10.420	+49	+3.420
Volvo truck	7.000	12.120	+73	+5.120
Volvo truck	7.000	7.420	+6	+0.420
Scania truck	9.380	9.420	+1	+0.040
Volvo truck	7.000	7.260	+4	+0.260

Description	Declared weight (t)	Actual weight (t)	Variance (%)	Variance weight (t)
Scania truck	10.200	10.240	+1	+0.040
Scania truck	12.200	12.360	+1	+0.160
Scania truck	8.500	10.940	+29	+2.440
Volvo truck	14.000	7.400	-47	-6.600
Volvo truck	6.790	7.100	+5	+0.310
Scania truck	11.240	11.300	+1	+0.060
Scania refuse truck	8.500	14.160	+67	+5.660
Volvo truck	7.000	7.460	+7	+0.460
Volvo truck	7.040	7.500	+7	+0.460
Scania truck	11.160	11.240	+1	+0.080
Volvo truck	7.000	7.460	+7	+0.460
Total in excess of booked weight for 23 vehicles				+16.100

Table 3: Used high and heavy cargo weighed by the MAIB following accident

1.5.7 Cargo disposition on departure Southampton

The following cargo was loaded in Southampton:

- 1250 cars
- 164 units of high and heavy cargo
- 4 units of static cargo.

Decks 10, 11 and 12 were filled with cars. Cars had also been loaded on deck 9. High and heavy cargo had been loaded on decks 4, 6 and 8.

Hoegh Osaka sailed from Southampton with 1450 cars on board and 183 units of high and heavy cargo. There were also some ship's own machinery on the vehicle decks and some stacked cargo trailers.

Table 4 shows the cargo that was on board *Hoegh Osaka* at the time of the accident and its distribution by deck. Following analysis by the MAIB, Table 4 shows the weight that was provided to the ship in the final cargo tally and the actual weight of cargo that was on each individual deck **(Figure 22)**.

Deck	Cargo summary	Weight as per stowage plan / final cargo tally (t)	Actual weight (t)
12	327 Land Rover cars / 9 Mini cars / 1 Honda car/ 24 Jaguar cars / 36 Peugeot cars	758	840
11	358 Land Rover cars/ 34 Mini cars/ 2 Peugeot cars/ 1 Rolls Royce car	759	910
10	358 Land Rover cars / 11 Mini cars / 2 Jaguar cars / 1 Citroen car / 1 Peugeot car	735	857
9	45 Land Rover cars / 8 Mini cars / 18 Jaguar cars	130	124
8	73 JCB units / 10 buses / 2 trucks / 1 armoured vehicle / 4 hoists / 6 Land Rover cars/ 3 Mini cars / 2 ship's deck lifters	1033	1047
6	33 JCB units / cranes / trucks / fair-ground trailers / 3 stone crushers / 4 airport service trucks / hoists / compressors / 5 Land Rover cars / ship's equipment	1587	1571
4	3 forklift trucks / 18 lorries / trucks / 1 digger	261	273
2	80 Hyundai cars	114	77
1	120 Hyundai cars	172	115
	Total	5549	5814

Table 4: Cargo on each deck and weight on departure

1.5.8 Pre-loading meeting requirements

The Hoegh Autoliners Cargo Quality Manual stated that a pre-loading meeting should take place ashore prior to the ship arriving and cargo operations commencing. Personnel required to attend the meeting were the port captain, agent, terminal operator, stevedore supervisor and the tally. A checklist was recommended to be completed at this meeting. No checklist was completed on this occasion.

The manual also stipulated that a pre-loading meeting should take place on board the ship prior to cargo operations. At this meeting, the updated pre-stowage plan was to be distributed to the deck officers and crew. This meeting did not take place.

The manual also stated that a ramp meeting was to take place 30 minutes before loading commenced. The meeting was to be attended by the chief officer, port captain and stevedore representative. The purpose of the meeting was to ensure an up-to-date pre-stowage plan had been received by all parties. This meeting took place without the chief officer being present, though the chief officer had met with the stevedore supervisor separately.

The Wallem PCC/PCTC Operations Manual also required a pre-loading meeting to be held.

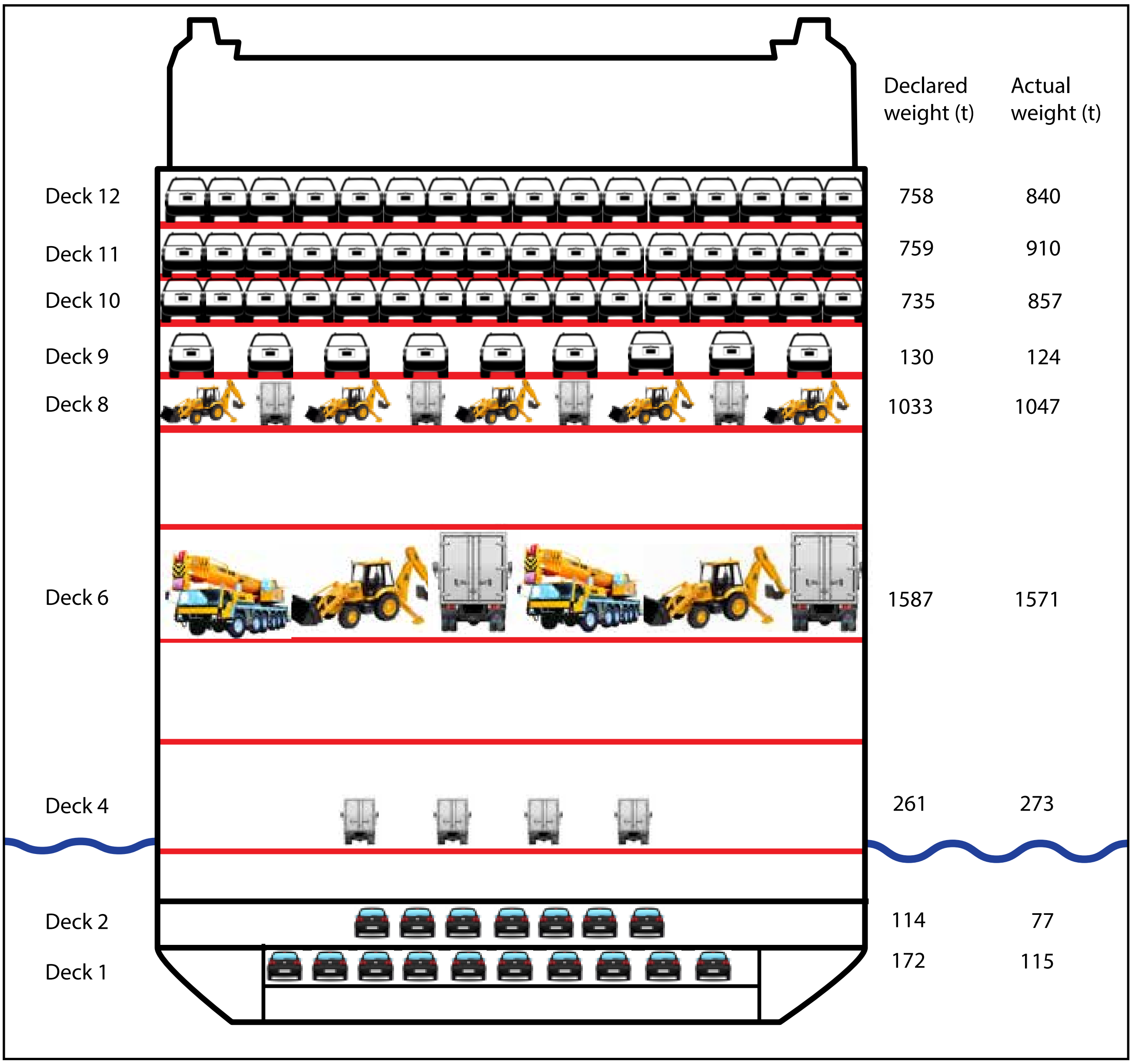


Figure 22: Indicative deck plan - including weights

1.6 BALLAST OPERATIONS

1.6.1 Ballast system

Hoegh Osaka had 15 dedicated ballast tanks on a ring main system **(Figure 23)**. All ballast operations were controlled remotely from the panel in the ship's control centre. Each tank could be ballasted or deballasted using the dedicated ballast pump or the fire, bilge and ballast pump. A ballast eductor was fitted within the system, enabling tanks to be stripped dry on completion of deballasting.

The fore deep tank had been re-categorized as a grey water tank, and was reported as being isolated and blanked from the ballast system. Although this tank was no longer utilised as a dedicated ballast tank, following the accident the tank was found to contain 139t of fresh water.

The ballast tank capacity and reported tank status at the time of the accident were as listed in **Table 5**.

Tank	**Capacity (t)**	**Reported tank status (t) (%full)**
Fore peak	965	180 (19%)
Fore deep	363	0
1 port	724	Full
1 starboard	724	Full
2 port	846	Full
2 starboard	868	Full
3 port	384	300 (78%)
3 starboard	384	100 (26%)
4 port	180	Full
4 starboard	192	Full
5 port	237	Full
5 starboard	237	Full
Aft peak port	738	340 (46%)
Aft peak centre	389	300 (77%)
Aft peak starboard	476	100 (21%)
Total	7707	5328

Table 5: Ballast tank capacity and reported tank status

A ballast water management plan was on board. This plan detailed the procedure for carrying out a ballast water exchange. A complete ballast water exchange had not been carried out since *Hoegh Osaka* was taken under Wallem's management in July 2014.

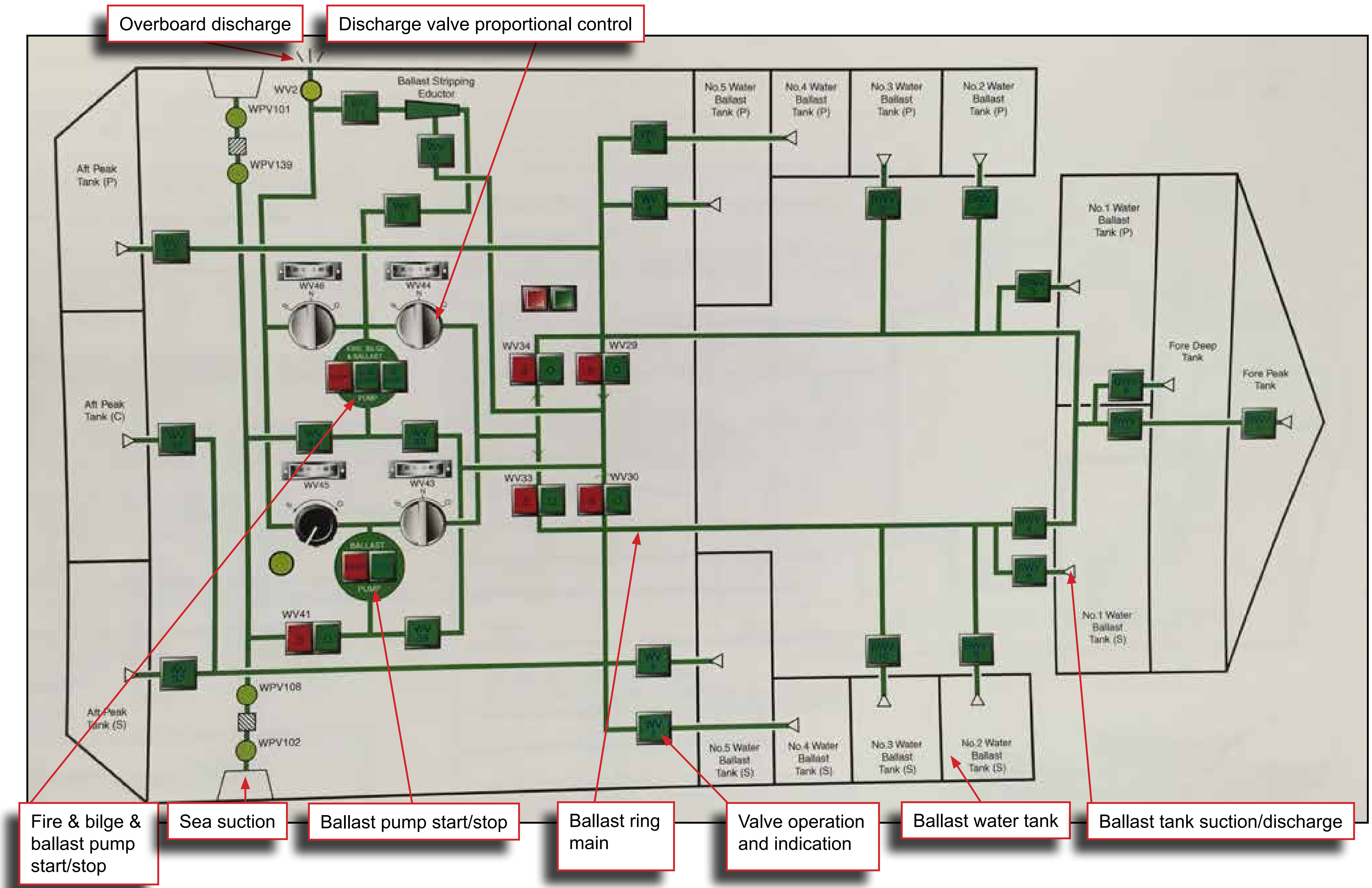


Figure 23: Ballast system diagram

1.6.2 Ballast during cargo operations

*Hoegh Osaka'*s list could be controlled using its ballast heeling tanks. The heeling system could operate automatically but the chief officer preferred to operate it in the manual mode, transferring ballast water internally from tank 3 port to 3 starboard or vice versa.

Trim was adjusted by transferring ballast water internally between the fore peak and aft peak ballast tanks.

The Wallem PCC/PCTC Operations Manual contained the following guidance on ballast operations:

Appendix 1.9:

'Chief Officer to ensure ballasting / deballasting operations are carried out as per plan and logged in ballast log. Duty officer to assist Chief Officer as required. Avoid ballasting and deballasting during bunkering.

Double bottom tanks to be ballasted by gravity only.

These vessels are very tender and susceptible to listing with lowering and stowing of ramps, as well as a small difference in ballast water weights on port and starboard sides. Hence, all ballasting and deballasting operations must be carefully monitored to ensure proper stability of the vessel and avoid listing.

Normally DB tanks are kept as full as far as practicable and trim adjusted with Aft peak tank and side tanks. List is corrected by Heel tanks.' [sic]

Further guidance on how to use the specific ballast system on *Hoegh Osaka* was contained within the *Maersk Wind* operation manual.

1.6.3 Tank gauges

Hoegh Osaka was designed so that the tank level of each ballast tank could be remotely measured and indicated on gauges in the ship's control centre ballast console **(Figure 24)**.

The chief officer's standing orders stated:

'When ballasting or de-ballasting is carried out always monitor the progress by checking the sounding gauges of the respective tank at regular intervals.'

The only gauge that was operating at the time of the accident was that of the fore peak tank. All of the other gauges had been inoperative since *Hoegh Osaka* was taken under Wallem's management in July 2014. The gauges were recorded as defective in the ship's handover survey and also noted as defective during Wallem's technical superintendent's visit to the ship in November 2014. Repair of the defective gauges had not been deemed a priority by Wallem as the ballast tank soundings could be taken manually.

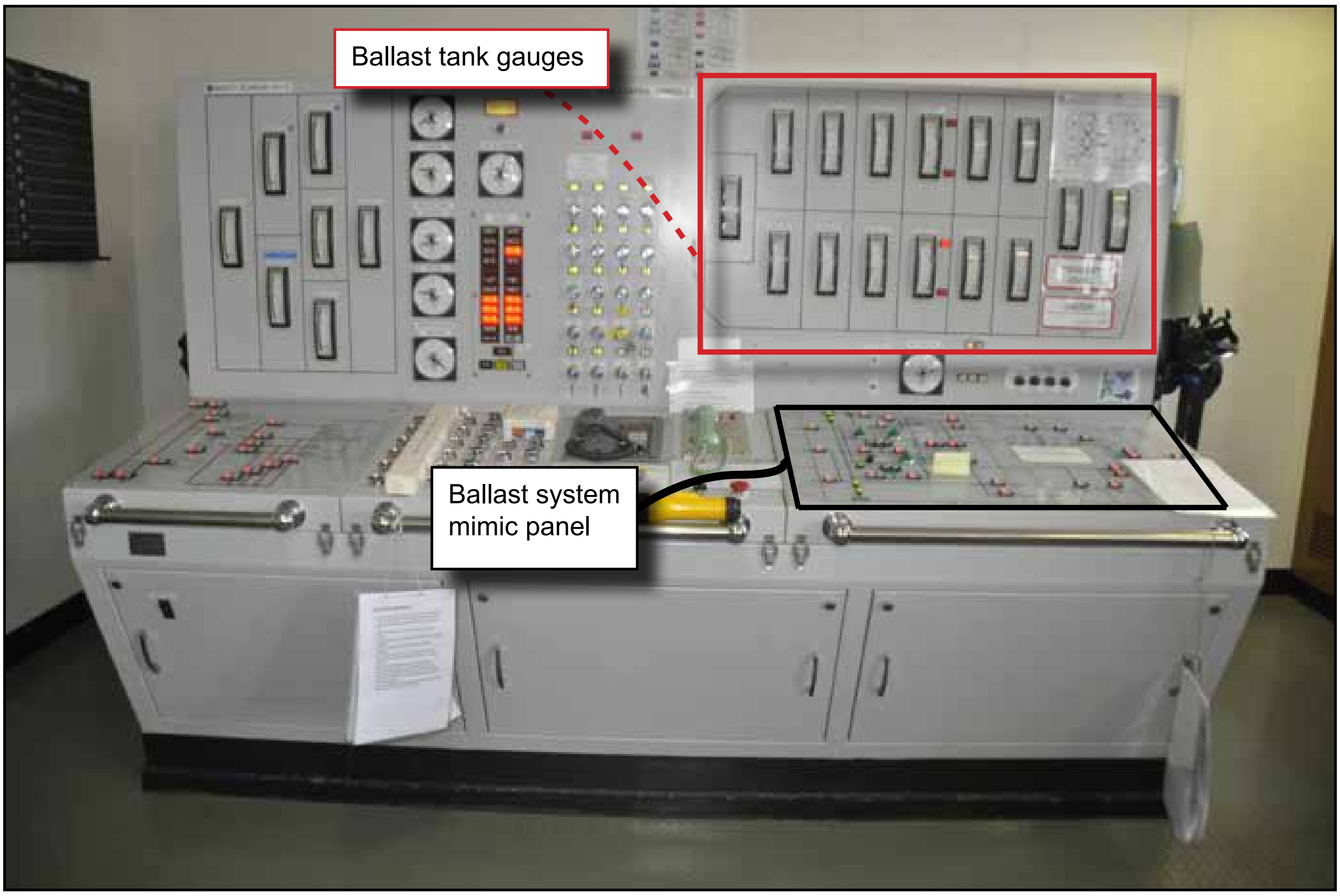


Figure 24: Ballast system control panel and tank gauges

1.6.4 Tank soundings

Each ballast tank was fitted with a manual sounding pipe. A notation was made in the deck logbook narrative, daily, stating that soundings had been taken.

The Wallem SMS directed that ballast tank soundings were to be taken daily and recorded in a ballast recording log. The ballast log was maintained on the chief officer's computer.

Ballast tank level records were produced, but the ballast tanks were not regularly sounded. The last recorded complete entry in the chief officer's ballast log signified all tanks had been sounded during a port call on 17 December 2014, and indicated a total of 5079.6t of ballast on board. For the same date, a recorded departure stability condition indicated a total of 4137t of ballast on board.

For a port call on 16 December, the chief officer's ballast log indicated a total of 4683.2t of ballast on board. For the same date, a recorded departure stability condition indicated a total of 4127t of ballast on board.

It was a regular practice of the chief officer to adjust ballast tank quantity records to compensate for the difference between calculated draughts and draught readings taken before sailing.

1.6.5 Ballast movement recording

Due to the faulty remote gauges, the chief officer estimated the amount of water in each ballast tank on the basis of the time spent transferring ballast to/from each tank. He knew that the pumping capacity of the pump was 7t per minute, and multiplied that pumping rate by the number of minutes that the pump was running to calculate the quantity of ballast transferred. This figure was then added to or subtracted from the figure that he believed was in the relevant tank at the start of the operation.

The ship's ballast management log indicated that ballast water had been loaded or discharged from *Hoegh Osaka* on 11 separate occasions since the ship had been under Wallem's management. The last recorded ballast movement of this type was on 8 December 2014, when an additional 130.8t of ballast was loaded.

The chief officer's ballast log for 8 and 9 December indicated a total of 4314.6t and 4459.5t of ballast on board respectively, a difference of 144.9t. During a port call on 10 December, the ballast figure on board was recorded as 4067t.

1.7 STABILITY REQUIREMENTS AND ONBOARD ASSESSMENT

1.7.1 Loading and stability information manual

Hoegh Osaka was provided with a loading and stability information manual approved by Det Norske Veritas, the appointed classification society at build, that fulfilled the requirements of SOLAS (as amended in 1990) Chapter II-1, Part B-1 Regulation 25-8. This regulation stated:

> *'The master of the ship shall be supplied with such reliable information as is necessary to enable him by rapid and simple means to obtain accurate guidance as to the stability of the ship under varying conditions of service.'*

The manual contained instructions to the master concerning stability and, in Section 1. Paragraph 3 of Part 3 stated:

> *'The master must ensure, prior to departure, that the required minimum stability criteria shall be maintained throughout the voyage after making due allowance for free surface effect as may be appropriate.'*

The manual explained three International Maritime Organization (IMO) stability requirements that the ship had to satisfy:

- The general intact stability criteria (as defined in IMO resolution A.749(18) Chapter 3.1), which included minimum metacentric height (GM) and other areas under the intact righting lever (GZ) curve.

- Severe wind and rolling criterion (weather criterion) (as defined in IMO Resolution A.749(18) Chapter 3.2), which ensured a vessel had the ability to withstand the combined effects of beam wind and rolling when in the intact condition.

- Subdivision and damage stability requirements (as defined in SOLAS (as amended in 1990) Chapter II-1, Part B-1 Regulation 25-1 to 25-6).

To enable the easy assessment of *Hoegh Osaka*'s stability in accordance with SOLAS, the manual included a minimum permissible GM curve **(Figure 25)**. This curve allowed the draught and corresponding GM, which could be manually calculated from the ship's loaded condition, to be plotted against each other to check that the ship's stability satisfied all of the IMO stability requirements.

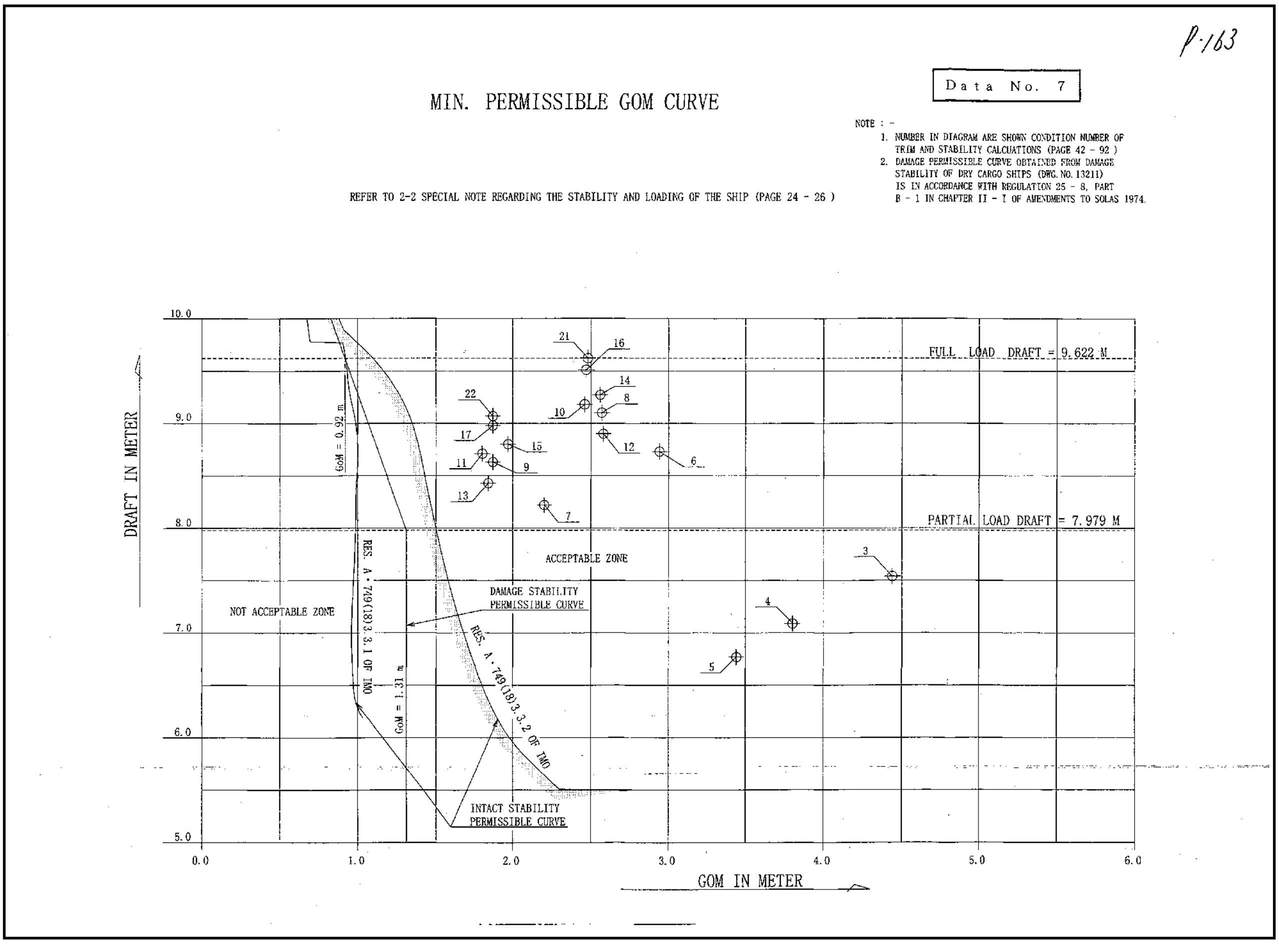


Figure 25: Minimum permissible GM curve

SOLAS, Chapter V, Regulation 34, Paragraph 1 states:

> '*Prior to proceeding to sea, the master shall ensure that the intended voyage has been planned using the appropriate charts and nautical publications for the area concerned, taking into account the guidelines and recommendations developed by the Organization'.*

The paragraph refers to the guidelines for voyage planning adopted by the Organization by Resolution A.893(21). The Annex to A.893(21) states:

> '*2.1 All information relevant to the contemplated voyage or passage should be considered. The following items should be taken into account in voyage and passage planning:*
>
> *.1 the condition and state of the vessel, its stability and its equipment….'*

Though not applicable to *Hoegh Osaka,* SOLAS Chapter II-1, Regulation 20, which relates to the loading of passenger ships, Paragraph 1 states:

'On completion of loading of the ship and prior to its departure, the master shall determine the ship's trim and stability and also ascertain and record that the ship is in compliance with stability criteria in relevant regulations. The determination of the ship's stability shall always be made by calculation. The Administration may accept the use of an electronic loading and stability computer or equivalent means for this purpose.'

1.7.2 Loading computer

To aid *Hoegh Osaka*'s crew's assessment of the stability, an LR approved loading computer program, Loadstar, was provided in the ship's control centre. The Loadstar manual contained an instruction to test the loading computer with standard conditions every 3 months. The last test file saved on board was for 31 December 2013.

The computer required the quantities of fuel oil, lubricating oil, ballast, fresh water and stores to be entered. Vehicle deck cargo details were then entered in terms of weight and location on the relevant cargo deck. The computer then calculated the longitudinal centre of gravity (LCG) and transverse centre of gravity (TCG) from the location entered. The vertical centre of gravity (VCG) defaulted to deck level unless a height above the deck was manually entered **(Figure 26)**. The loading and stability information manual included the average size, weight and VCG for various vehicle types.

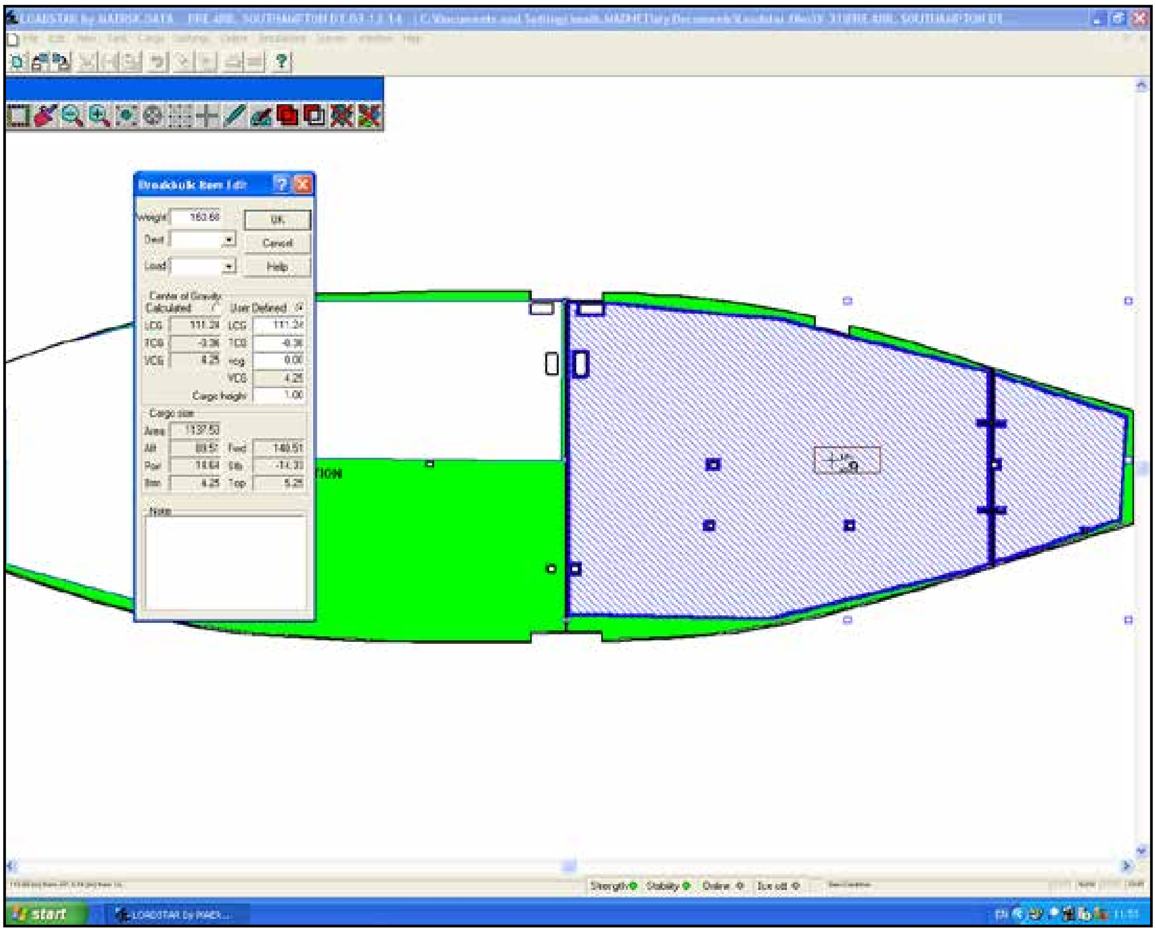


Figure 26: Screenshot from loading computer

The last condition saved on the Loadstar computer related to *Hoegh Osaka*'s arrival in Southampton on 2 January. Examination of a selection of the previous arrival and departure conditions established that the VCG of the cargo was always left to default to deck level.

There is no requirement for ro-ro cargo vessels to have a loading computer provided on board, although this is a requirement for ro-ro passenger ships.

1.7.3 Draught adjustment

As the pre-departure draught readings were taken while the stern door was still on the quay a correction of plus 15cm was applied to the aft draught to allow for the door being open. This was normal procedure as the ramp was generally on the quay when the draughts were recorded.

1.7.4 Wallem safety management system requirements

The Wallem PCC/PCTC Operations Manual contained no specific instructions as to when stability calculations were to be completed.

The Wallem SMS stated under the chief officer's responsibility:

> *'He shall make a positive report to the master prior to each and every departure, and shall confirm that the condition of the ship meets the requirement of the stability booklet and will continue to do so throughout the forthcoming voyage'*.

There was a reference to assessing the ship's stability on page 2 of checklist No.4, item 8 and checklist No.5, item 2. Both had been ticked and signed by the chief officer on 3 January **(Annex A)**.

There was no box to be ticked on checklist No.3 (Prior departure port) to indicate that the ship's condition met the stability requirements and would continue to do so throughout the voyage.

1.8 PILOTAGE

1.8.1 Port of Southampton

Southampton is a major port on the south coast of England. Its business is diverse, with a wide variety of vessel sizes and types using it, including cruise ships, container vessels and oil tankers.

Ro-ro cargo is an important segment of the port's business with both new and used vehicles imported and exported. Southampton handles around 820,000 vehicles each year. In 2014, 1087 ro-ro vessels called at the port.

Pilotage is compulsory in the port of Southampton for all vessels over 61m length overall.

1.8.2 Pilot

The pilot on board *Hoegh Osaka* at the time of the accident was a 65 year old British national. He was a career pilot, having commenced a pilotage apprenticeship in the port of Liverpool at the age of 16. He had been a Southampton Class 1 pilot since 1990, and had previously piloted *Hoegh Osaka*.

1.8.3 Port passage plan

Having embarked *Hoegh Osaka*, the pilot discussed the port passage plan with the master in conjunction with completing the port pilot card.

The port passage plan was in two parts, completed by the pilot and discussed with the master. Once the plan had been agreed, both the master and the pilot signed the forms.

The port passage plan included local tidal and weather conditions in addition to the intended route **(Figure 2)**. The pilot card for *Hoegh Osaka*'s departure indicated draughts of 8.4m forward and 9m aft.

All ships leaving Southampton via Thorn Channel started their turn to port as soon as West Bramble buoy had been cleared in order that, on steadying up, their final heading passed north of Prince Consort buoy and directly towards the main channel south of Ryde Middle bank **(Figure 2)**.

1.9 CARGO SECURING

Cargo is required to be secured according to recognised principles, taking into account the dynamic forces that may occur during sea transport and the most severe weather conditions expected.

1.9.1 Code of Safe Practice for Cargo Stowage and Securing

SOLAS Chapter VI Regulation 5.4 states:

> *'Appropriate precautions shall be taken during loading and transport of cargo units and cargo transport units on board ro-ro ships, especially with regards to the securing arrangements on board such ships and on the cargo units and cargo transport units and with regard to the strength of the securing points and lashings.'*

Regulation 5.6 of the same chapter states:

> *'All cargoes, other than solid and liquid bulk cargoes, cargo units and cargo transport units shall be loaded, stowed and secured throughout the voyage in accordance with the Cargo Securing Manual approved by the administration.'*

The IMO's CSS Code provides generic guidelines on how to meet the SOLAS requirements. The CSS Code was written in 1990 and adopted by the IMO in 1991. Its purpose was to provide an international standard for the safe stowage and securing of cargoes.

Annex 4 of the current edition of the CSS Code (2011) details recommendations for the safe stowage and securing of wheel-based (rolling) cargoes. The following are extracts:

'1. Wheel-based cargoes, in the context of these guidelines, are all cargoes which are provided with wheels or tracks, including those which are used for the stowage and transport of other cargoes, except trailers and road-trains…, but including buses, military vehicles with or without tracks, tractors, earth-moving equipment, roll-trailers, etc.

2.2 Wheel-based cargoes should be provided with adequate and clearly marked securing points or other equivalent means of sufficient strength to which lashings may be applied.

2.3 Wheel-based cargoes which are not provided with securing points should have those places, where lashings may be applied, clearly marked.

2.4 Wheel-based cargoes, which are not provided with rubber wheels or tracks with friction-increasing lower surface, should always be stowed on wooden dunnage or other friction-increasing material such as soft boards, rubber mats, etc.

2.6 Wheel-based cargoes should be secured by lashings made of material having strength and elongation characteristics at least equivalent to steel chain or wire.

2.7 Where possible, wheel-based cargoes, carried as part cargo, should be stowed close to the ship's side or in stowage positions which are provided with sufficient securing points of sufficient strength, or be block-stowed from side to side of the cargo space.

2.8 To prevent lateral shifting of wheel-based cargoes not provided with adequate securing points, such cargoes should, where practicable, be stowed close to the ship's side and close to each other, or be blocked off by other suitable cargo units such as loaded containers, etc.'

Annex 13 of the CSS Code provides guidance on methods to assess the efficiency of securing arrangements for non-standardised cargo. The guidance includes the maximum securing load (MSL[11]) that should be used for different securing devices. For a web lashing, the MSL should be taken to be 50% of its breaking strength. It also recommends that the total of the MSL values of the securing devices on each side of a unit of cargo (port as well as starboard) should equal the weight of the unit.

Included as an appendix to the CSS Code is IMO Resolution A.489(XII) - Safe stowage and securing of cargo units and other entities in ships other than cellular containerships. Paragraph 5 of the Annex to this resolution states:

'When reasonable, cargo units and other entities should be provided with means for safe application of portable securing gear. Such means should be of sufficient strength to withstand the forces which may be encountered on board ships in a seaway.'

[11] Maximum securing load (MSL) is a term used to define the allowable load capacity for a device used to secure cargo to a ship

Paragraph 9 of the Annex states:

> *'Where there is reason to suspect that cargo within any unit is packed or stowed in an unsatisfactory way, or that a vehicle is in a bad state of repair, or where the unit itself cannot be safely stowed and secured on the ship, and may therefore be a source of danger to ship or crew, such unit or vehicle should not be accepted for shipment.'*

Also included as appendices to the CSS Code are IMO Resolutions:

- A.533(13) – Elements to be taken into account when considering the safe stowage and securing of cargo units and vehicles in ships, and

- A.581(14) – Guidelines for securing arrangements for the transport of road vehicles on ro-ro ships.

A.533(13) includes guidance addressed to all parties who are in some way associated with either the design or operation of the ship, or with the design, presentation or loading of cargo units including vehicles. A.581(14) details guidelines for the provision of securing points on ships' decks and road vehicles, except buses. It also includes guidelines on securing equipment and vehicle stowage.

1.9.2 UK regulation and guidance

The relevant cargo securing and stowage requirements laid down in SOLAS are enabled in the UK by The Merchant Shipping (Carriage of Cargoes) Regulations 1999. The regulations apply to seagoing UK ships wherever they may be, and seagoing ships that are not UK ships but are within UK waters, when loaded or intended to be loaded with any cargo. The regulations place a number of requirements on shippers, including the need to inform the ship owner or master in advance of loading that the cargo is suitable for the ship and can be safely stowed and secured on board the ship under all expected conditions during the intended voyage.

There is no requirement under UK legislation to weigh individual cargo units to be loaded onto a ro-ro vessel, although the above regulations stipulate that the shipper must provide the master with the gross weight of the cargo. For *Hoegh Osaka'*s cargo, this information was included on the shipping notes provided to the stevedoring company, SCH.

Further relevant guidance is provided in the MCA publication Roll-on/Roll-off Ships – Stowage and Securing of Vehicles – Code of Practice. This code is addressed to all parties associated with either the design or the operation of the ship, or with the design of freight vehicles, or with the presentation of vehicles for loading.

1.9.3 Cargo securing manual

SOLAS Chapters VI and VII require a cargo securing manual (CSM), approved by the Administration, to be provided on all types of ships engaged in the carriage of cargoes other than solid and liquid bulk cargoes.

Hoegh Osaka carried a CSM that had been supplied to *Maersk Wind* at build. The CSM had initially been approved by DNV in 2000 and signed as accepted by LR in 2014 on the basis of the previous approval.

Many of the annexes and appendices contained in the current edition of the CSS Code (2011) were included either fully or as edited extracts in *Hoegh Osaka*'s CSM. In particular, Annex 4 of the CSS Code was reproduced in full. Although reference was made in the CSM to Annex 13 of the CSS Code and IMO Resolution A.581(14), the extracts provided did not reflect later amendments that were made to those documents. Consequently, the CSM stated that, for a web lashing, the MSL should be taken to be 70% of its breaking strength. It also stated, without further qualification, that the MSL of lashings should not be less than 100kN[12], and that they should be made of material having suitable elongation characteristics.

The CSM also included Lashcon[13] calculations for a number of cargo unit examples, indicating the required number and arrangement of lashings for each.

Neither the port captain nor the SCH lashers and lashing supervisors had access to or knowledge of *Hoegh Osaka*'s CSM.

1.9.4 Hoegh Autoliners Cargo Quality Manual

Hoegh Autoliners Cargo Quality Manual was intended to complement the requirements of SOLAS Chapters VI and VII and the CSS Code.

Although not required to be approved by the relevant Administration, the manual described how each type of cargo was to be loaded and secured on board the company's ships. It also detailed the securing equipment to be used for different types of cargo:

- *'Cars, p/ups and light cargo units 0 – 3000 kg shall be secured by car lashings with a break load of minimum 2000 kg and MSL minimum 1000 kg.*

- *High and Heavy units with weights between 3000 – 10000 kg shall be preferabley secured by Rollash with a break load of minimum 5000 kg and MSL minimum 2500 kg.* [sic]

- *High and Heavy units with weights above 10000 kg shall be secured by Heavy Duty Webb Lash with a break load of minimum 10000 kg and MSL minimum 5000 kg. Rollash can be used as an alternative provided total MSL is sufficient. NB do not mix heavy duty and Rollash on the same unit.'* [sic]

For cars, the required minimum number of lashings varied depending on the mode of stowage. For high and heavy cargo, the sum of the MSL values of the securing devices on each side of a cargo unit was to at least equal the weight of the unit. The manual mirrored the 'rule-of-thumb' method included in the CSM, and then categorized the required number of lashings against a range of cargo unit weights. All tracked cargo was to be secured on rubber mats or wooden dunnage.

---

[12] Throughout the report, MSL is expressed in kN, kg or t. E.g. A 100kN lashing is also referred to as a 10,000kg or 10t lashing.

[13] Lashcon was a DNV Excel program developed to enable ships' officers to easily calculate the lashing requirements for any cargo unit by calculating the acceleration forces in accordance with Annex 13 of the CSS Code.

Following the accident, it was not possible to determine exactly the number and arrangement of lashings that had been applied to the cargo units that had shifted as the salvors had applied additional lashings to cargo during the salvage operation. However, it was noted that the majority of lashings applied to the cargo on board *Hoegh Osaka* had remained intact, and that rubber mats had been used appropriately.

The manual also included the following relevant extracts:

> *'Hoegh Autoliners will accept only cargo that comply to all international treaties related to sea transportation established by IMO and countries/areas related and that can be safely handled, loaded, stowed, transported and discharged from the vessels under our control without endanger the safety of shore personnel, crew, environment or vessel, and is complying with Hoegh Autoliners "Cargo Acceptance Policy".'* [sic]

> *'All cargo must be equipped with adequate lashing points easily accessible. All movable parts must be secured mechanically.'* [sic]

> *'The master is the ultimate responsible for the cargo and seaworthiness of the vessel. As a consequence of this, lashing of cargo must always be done to the satisfaction of the ship's command.'* [sic]

With regard to registering 'static' cargo, the manual required the cargo to have the following clearly marked:

- *'Gross weight*
- *Centre of gravity*
- *Forklift points (Cargo or package design is to be suitable for safe forklift handling without risking damage.)*
- *Dedicated lashing points to ensure safe stowage.'*

A similar requirement in respect of non-static cargo was not included.

1.9.5 Cargo securing equipment

Paragraph 7 of the Annex to IMO Resolution A.489(XII) states:

> *'Ships should be provided with fixed cargo securing arrangements and with portable securing gear. Information regarding technical properties and practical application of the various items of securing equipment on board should be provided.'*

Paragraph 6.1 of the Annex to IMO Resolution A.581(14), as amended by MSC.1/Circ.1355, states:

> *'The maximum securing load (MSL) of lashings should not be less than 100 kN and they should be made of material having suitable elongation characteristics. However, for vehicles not exceeding 15 tonnes (GVM), lashings with lower MSL values may be used. The required number and MSL of lashings may*

be calculated according to annex 13 to the Code of Safe Practice for Cargo Stowage and Securing (CSS Code), taking into consideration the criteria mentioned in paragraph 1.5.1 of the Code.'

The following are extracts from the current edition of the MCA publication Roll-on/Roll-off Ships -Stowage and Securing of Vehicles – Code of Practice:

'5.3.2 Steel chains are commonly used for lashing freight vehicles of more than 3.5 tonnes gross vehicle mass (GVM). Webbing straps or other novel securing systems may be used instead of steel chain, provided that they have an equivalent strength and suitable elongation characteristics (see IMO MSC/Circ 812[14] for further details).

5.3.3 Chains/straps and associated elements (eg hooks, shackles, elephants' feet and tensioning devices) should have an MSL of 100kN.'

Hoegh Osaka carried the following cargo securing equipment:

Hoegh Autoliners Ro-Ro Lash
Breaking load 2000kg, MSL 1000kg (10kN), yellow in colour.

Hoegh Autoliners Rollash
Breaking load 5000kg, MSL 2500kg (25kN), blue in colour.

Hoegh Autoliners Heavy Duty Webb Lash
Breaking load 10000kg, MSL 5000kg (50kN), red in colour.

Approval certificates for the web lash securing straps and cargo securing equipment inspection details were included in the CSM.

Wheel chocks of various sizes and rubber mats to be placed under the tracks of tracked vehicles were carried on board.

All high and heavy cargo on Hoegh vessels were secured using web lash; no cargo securing chains were used. Lashing chains originally supplied to *Hoegh Osaka* had been removed in 2011 and replaced with web lashings.

The heavy duty web lashings used to secure high and heavy cargo on board *Hoegh Osaka* had an MSL of 5000kg (50kN). This was half the required strength recommended by the IMO for road vehicles exceeding 15t in weight.

1.9.6 Cargo securing equipment inspection and maintenance

Hoegh Osaka's CSM stated that all portable securing equipment should be visually inspected and greased as necessary at intervals not exceeding 3 months. The manual also stated that the equipment should be visually inspected at each use.

Since July 2014, the record of cargo securing device inspection and maintenance indicated that inspections had taken place monthly until 8 November 2014, with satisfactory results.

[14] MSC/Circ.812 , dated 16 June 1997, advised of amendments to IMO Resolution A.581(14) and the CSS Code, aimed at extending the guidance for securing arrangements for transport of road vehicles on ro-ro ships, to cover the use of web lashings that were widely accepted on such ships.

1.9.7 Securing points on cargo

The following is an extract from the Annex to IMO Resolution A.533(13):

'2.1 It is of the utmost importance to ensure that:

.1 cargo units including vehicles intended for the carriage of cargo in sea transport are in sound structural condition and have an adequate number of securing points of sufficient strength so that they can be satisfactorily secured to the ship…'

All of the cars carried on board *Hoegh Osaka* were fitted with dedicated securing eyes before they were loaded. Although some of the high and heavy cargo had clearly marked securing points, some did not. In those cases, it was left to the stevedores to select appropriate strong points to which to secure lashings **(Figures 27, 28** and **29)**.

The ten buses loaded on deck 8 were stowed side by side in a block stow and secured by means of lashings connected to their wheels. All of the buses shifted and were damaged as a result of the accident. IMO Resolution A.581(14) does not apply to buses. However, Annex 4 of the CSS Code and IMO Resolution A.533(13) do apply.

Figure 27: JCB cargo indicating various securing points

Figure 28: Lorry secured using web lash to wheels

Figure 29: A 30t trailer with no securing points, secured by wheels

1.9.8 Responsibility for cargo securing

The Wallem PCC/PCTC Operations Manual required strict compliance with the Hoegh Autoliners Cargo Quality Manual, which placed the ultimate responsibility for the securing of cargo on the master. The requirement was reinforced in the chief officer's standing orders to the duty deck officers.

The Wallem PCC/PCTC Operations Manual also indicated that the number of lashings required for a cargo unit should be decided following discussion between the port captain and ship's master or chief officer.

SCH, which provided stevedoring and cargo securing services to several ro-ro company customers in Southampton, required its staff to secure cargo in accordance with its own procedures.

The Wallem PCC/PCTC Operations Manual required the ship's crew to check the cargo securing arrangements with the lashing supervisor on completion of each deck area. Checklist No.1, additional note 6, checklist No.3, item 7, and checklist No.4, items 2 and 3 referred to the inspection of cargo lashings.

1.10 TECHNICAL INVESTIGATIONS

1.10.1 Web lashing testing

The MAIB commissioned an independent test house to comment on the mode of failure, or to carry out destructive tensile testing, on the web lashings removed from *Hoegh Osaka* following the accident.

Samples of each of the three types of web lashing on board the ship at the time of the accident were selected. The comments and test results are at **Annex B**.

All seven of the web lashings tested failed at loads significantly above their respective MSL.

1.10.2 Analysis of water from fore deep tank

The fore deep tank had been designated as a grey water holding tank, with LR approval, and was reported as being empty and isolated from the ballast system.

Following the accident, the tank was found to contain a quantity of water. To ascertain if this water was in the tank prior to or as a consequence of the accident, a sample of water was removed from the tank for testing.

The sample removed from the tank and a sample of sea water taken from The Solent in the vicinity of Bramble Bank were tested and compared. The commissioned laboratory concluded that the samples were not of the same composition; the fore deep tank sample being from a fresh water source.

On inspection following the accident, it was found that the fore deep tank was not isolated from the ship's ballast system, and so it was concluded that the water found in the tank was present prior to the accident **(Annex C)**.

1.10.3 Cargo securing investigation

Brookes Bell Safety at Sea was commissioned to determine the cargo securing arrangement that should have been applied to four identified high and heavy cargo units on board *Hoegh Osaka* to meet the requirements of the CSS Code. The four identified units included the track-type bulldozer and the two powercrushers featured in **Figures 16** and **17** respectively.

It was also tasked to compare the results of its determination with both the requirements of the CSM and the Hoegh Autoliners Cargo Quality Manual. It concluded that the contents of both documents satisfied the MSL requirements at Annex 13 of the CSS Code. However, the maximum MSL of the web lashings on board *Hoegh Osaka* was 50kN and therefore did not comply with the CSM requirements **(Annex D)**.

1.10.4 *Hoegh Osaka* stability modelling

To enable the stability of *Hoegh Osaka* to be assessed independently, the MAIB commissioned the construction of a stability model using the Wolfson HST software. This included validation of the model against the data contained within the ship's loading and stability information manual.

Using a plausible departure condition calculated by the MAIB and data derived from *Hoegh Osaka*'s VDR, Brookes Bell Safety at Sea was tasked to predict the time and corresponding angle of heel during the ship's turn in the vicinity of Bramble Bank **(Annex D)**.

1.11 PREVIOUS ACCIDENTS

1.11.1 *Cougar Ace*

The Singapore registered car carrier *Cougar Ace* took on a significant list while en route from Japan to Vancouver, Canada on 23 July 2006. The ship was carrying a cargo of 4812 new Mazda and Isuzu vehicles. While undergoing a ballast water exchange, the ship lost stability and listed to an angle of 60°. All of the crew were successfully evacuated following the listing. The ship remained afloat, was towed closer to shore and was eventually righted.

Safety issues included:

- There was improper planning and execution of ballast water exchange operations.
- The officer in charge did not ensure stability was maintained throughout the operations.
- The shipboard procedures concerning ballast water operations were inadequate.

1.11.2 *Riverdance*

The Bahamas registered ro-ro cargo vessel *Riverdance* grounded on Shell Flats, off Cleveleys Beach, Lancashire, UK on 31 January 2008. The prevailing severe weather prevented the ship from being refloated, and subsequent efforts to salvage it failed.

Safety issues included:

- The true weights and disposition of the ship's cargo were not known.
- The ship's stability was not calculated before departure.
- Ballast was never adjusted regardless of cargo or weather.

1.11.3 *Stena Voyager*

An articulated lorry crashed through the stern door of the UK registered high-speed passenger ferry *Stena Voyager* shortly after the vessel had commenced a scheduled crossing from Stranraer, Scotland to Belfast, Northern Ireland on 28 January 2009.

Safety issues included:

- The lorry had not been effectively secured. There was a lack of lashing points on both the vehicle and the ferry's deck such that the lorry could not be secured in accordance with the requirements of the vessel's CSM.
- The lashings used had an MBL of 2.5t as opposed to 10t as recommended in IMO guidance.

1.11.4 *Annabella*

The UK registered container vessel *Annabella* encountered heavy seas in the Baltic Sea, resulting in the collapse of a stack of cargo containers on 26 February 2007.

Safety issues included:

- There were shortcomings in the flow of information between the shipper, planners, loading terminal and vessel.
- Ship's staff were given insufficient time to verify/approve proposed cargo plans.

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 FATIGUE

The possibility of fatigue was examined. There is no evidence to suggest that the pilot or any of the crew were suffering from fatigue and, therefore, it is not considered a contributing factor to this accident.

2.3 OVERVIEW

The results from the analysis conducted following this accident show that *Hoegh Osaka* heeled heavily to starboard while rounding West Bramble buoy as a result of having inadequate stability.

Cargo distribution was such that the upper vehicle decks were full while the lower vehicle decks were lightly loaded. *Hoegh Osaka* was low on bunker fuel oil, which was stored low down in the ship, and the cargo's overall VCG was relatively high, with no additional ballast having been loaded prior to the ship's departure from Southampton. The ship's inadequate stability had not been identified as no accurate stability calculation had been carried out before the ship sailed.

As *Hoegh Osaka* heeled, several large cargo units broke free of their lashings and shifted to starboard. This shift resulted in the ship's hull being breached, allowing sea water to flood onto deck 6 and subsequently onto its lower decks.

As the heel increased, the rate of turn increased and *Hoegh Osaka* turned rapidly to port in an uncontrolled manner, leading to the ship grounding on Bramble Bank.

2.4 STABILITY

2.4.1 Stability modelling

Establishing *Hoegh Osaka*'s departure stability condition was vital to understanding why the ship heeled to such a large angle. Having commissioned the construction and validation of a stability model, the MAIB was able to calculate a plausible condition for the ship at the time of the accident. To facilitate this, an accurate assessment of weight distribution throughout the ship was required.

Following the salvage operation, quantities of fuel oil, lubricating oil, fresh water and stores, etc on board at the time of the accident could be readily confirmed or reasonably estimated. However, the same was not true in respect of the weight and location of cargo and ballast on board.

Investigation of the actual cargo weight and stowage highlighted significant discrepancies from the final cargo tally supplied to the ship, and that the chief officer had not allowed for cargo unit VCGs in his calculated stability condition. The ship's loading and stability information manual included average VCGs for various vehicle types. These, together with the actual cargo weights derived from shipping notes and test weighings following the accident, were used by the MAIB in its stability calculations.

The status of *Hoegh Osaka*'s ballast tanks on board following the salvage operation was determined by means of manual soundings, however the figures obtained differed significantly from those reported prior to the accident. It was concluded that the differences were due to one or more of the following:

- The ballast tank contents might have changed when the ship listed due to movement between tanks or vent pipes allowing water discharge or entry.

- The contents of most ballast tanks were altered by an unconfirmed amount during the salvage operation.

- Previous ballast tank levels had been inconsistently recorded and so the recorded levels extant when the vessel sailed could not be relied on.

Without confirmation of the actual ballast distribution on board *Hoegh Osaka* at the time of the accident, the MAIB was unable to determine the ship's GM on departure. However, it was clear from the unusual list that the ship adopted on initially raising the stern ramp that the ship's GM was less than normal. An iterative process, therefore, was employed to determine a plausible GM for *Hoegh Osaka*.

Using a GM of 0.7m, it was possible for Brookes Bell Safety at Sea to model *Hoegh Osaka*'s behaviour as it turned in the vicinity of Bramble Bank. It concluded that *Hoegh Osaka* would have lost stability once it had heeled to an angle of around 12º at 2109:11, causing it to roll rapidly to a large angle (possibly as high as 60º) before settling at around 40º **(Annex D)**.

To achieve a GM of 0.7m in the stability model, it was necessary to adjust ballast tank levels by 635t to maximise free surface effect, and to maximise the overall ballast VCG. The final estimated condition was a slightly reduced mean draught from that determined by the chief officer, while maintaining a bow trim of approximately 0.6m **(Annex E)**.

While *Hoegh Osaka* left its berth with positive stability (GM>0), its estimated condition did not comply with IMO stability requirements. The estimated righting lever curve (GZ) is reproduced in **Figure 30**. The very low area under the GZ curve (blue line) is indicative of the righting moment that was available to resist the heeling moment of *Hoegh Osaka* when turning to port in the vicinity of Bramble Bank (red line). However, there was sufficient righting moment to resist the heeling moment at the Calshot turn (green line). The angle at which the shell plating damage in the vicinity of the starboard gangway void was submerged was estimated at 30°, although at what heel angle this damage occurred is unknown. However, at some stage beyond 30° heel, flood water would have entered the ship. As the ship heeled further to starboard, the available righting moment would have increased as the hull side became immersed.

Hoegh Osaka had inadequate residual stability to survive the Bramble Bank turn at 12kt, but had sufficient residual stability to survive the Calshot turn at 10kt. This was because the heeling moment when turning is proportional to the square of the speed (44% greater heeling moment).

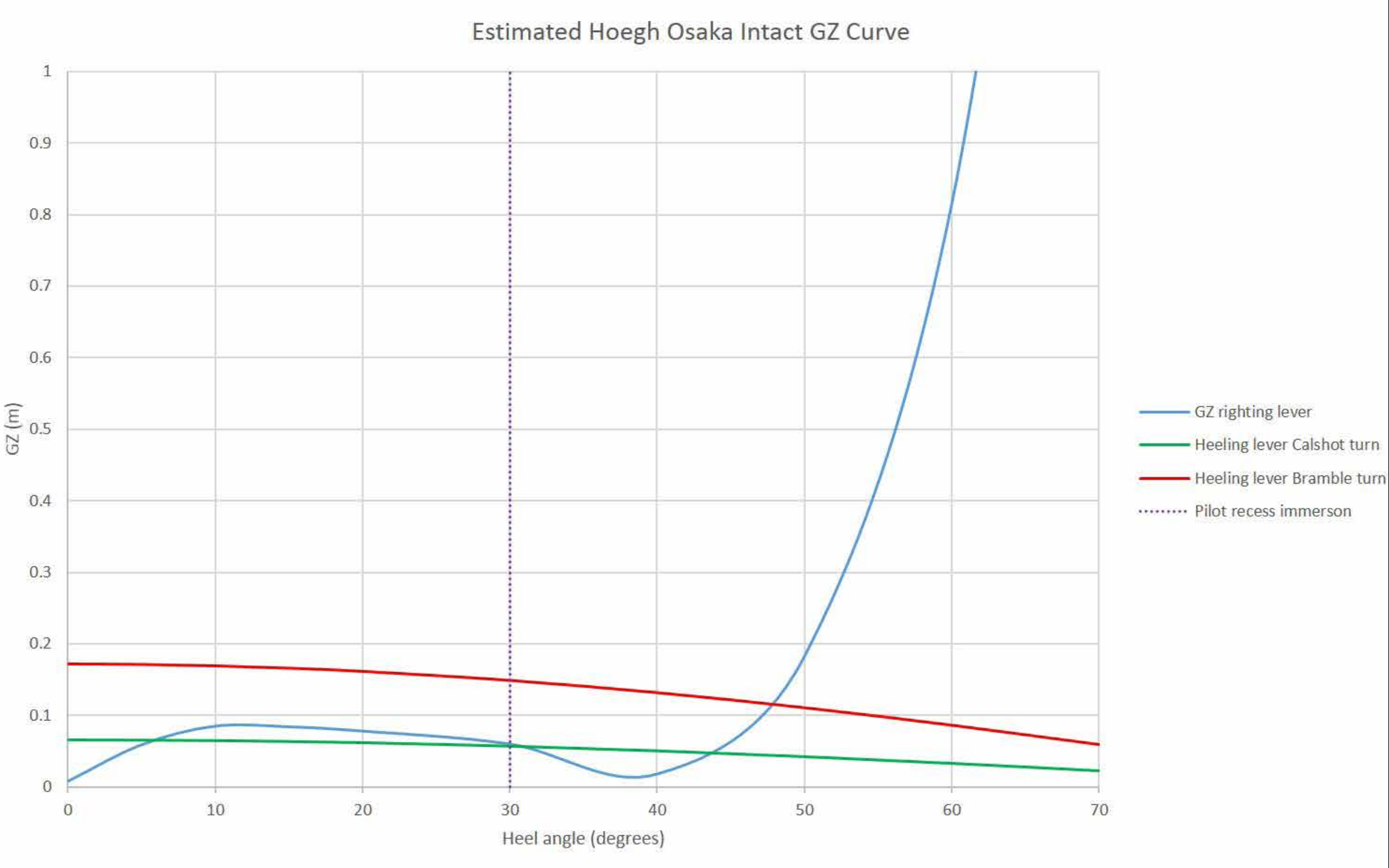


Figure 30: Estimated *Hoegh Osaka* intact GZ curve

In conjunction with the low level of stability, *Hoegh Osaka*'s 0.6m bow trim would not have helped the situation. Although a slight bow trim improved fuel efficiency once on passage at sea, it would have been detrimental to manoeuvring, and probably contributed to the high rate of turn as the ship negotiated the turn in the vicinity of Bramble Bank.

2.4.2 Use of loading computer

The loading computer was removed from *Hoegh Osaka* during the salvage operation and examined by the MAIB. It was tested with standard conditions in accordance with the Loadstar manual, thereby confirming the validity of the loading computer and Loadstar program for *Hoegh Osaka*.

The loading computer enabled the chief officer to readily assess the ship's stability and structural strength to ensure the ship was safe to sail and complete the intended voyage. Once the chief officer had received the pre-stowage cargo plan from the master on the day of loading, it is reported that he entered the figures into the loading computer and assessed the stability to be acceptable. Unfortunately, the calculated condition was not stored on the loading computer when it was examined by the MAIB.

To recreate the information that was likely to have been presented to the chief officer when calculating the ship's stability condition following departure, the cargo figures in the final cargo tally were added to the last saved condition relating to *Hoegh Osaka*'s arrival in Southampton on 2 January. Additionally, ballast tank quantities were adjusted to reflect those reported at the time of the accident. In the estimated condition created by the MAIB, the GM achieved was 1.29m against a minimum GM requirement of 1.34m, therefore marginally failing the stability standard. However, due to the unverified ballast condition, disparities between cargo weights and the lack of cargo VCG data, the reality of the situation was significantly worse.

Firstly, the ballast tank quantities were estimates and appear to have borne no resemblance to actual tank levels (a ballast total difference of 635t). Secondly, most of the cargo weights supplied by SCH were estimated rather than actual values (a cargo total difference of 265t). Thirdly, while the Loadstar software provided the ability to enter the VCG of cargo above the deck, this function was never used in any of the conditions examined in *Hoegh Osaka*'s stability file. The cumulative effect of the difference between the assumed and actual cargo figures is shown in Table 6:

Deck		Actual cargo figures		Reported cargo figures		Reported cargo compared with actual cargo	
	Weight (t)	VCG (m)	Weight (t)	VCG (m)	Wt diff (t)	Wt diff (%)	>VCG (m)
Deck 12	840.5	33.01	758	32.25	+82	+11	+0.76
Deck 11	910.1	30.51	759	29.73	+151.1	+20	+0.78
Deck 10	857.0	27.99	735	27.20	+122	+17	+0.79
Deck 9	124.3	25.65	130	24.82	-5.7	-4	+0.83
Deck 8	1047.0	23.53	1033	21.61	+14.3	+1	+1.92
Deck 6	1571.0	17.10	1587	15.09	-16.0	-1	+2.01
Deck 4	273.1	12.69	261	8.95	+12.1	+5	+3.74
Deck 2	76.6	4.80	114	4.25	-37.4	-33	+0.55
Deck 1	114.8	2.82	172	2.19	-57.2	-33	+0.63
Total	5814.5	23.79	5549	21.57	+265.5	+5	+2.22

Table 6: Comparison of reported cargo figures with actual cargo figures

While not a regulatory requirement for *Hoegh Osaka*, a loading computer is an effective and useful tool in the safe running of a ship. However, the results will only be as good as the information that is entered into it. The chief officer's practice of not entering details of additional cargo during loading, not allowing for cargo unit VCGs, and adjusting ballast tank quantities on the loading computer to compensate for draught readings demonstrated that he underestimated the importance of accurately calculating the ship's stability condition.

2.4.3 Stability assessment

Although the chief officer advised the master that *Hoegh Osaka*'s GM for departure was 1.46m and met the requirements of the loading and stability information manual, this advice was based on preliminary and, as it transpires, inaccurate figures. Given that the chief officer was re-entering the cargo figures into the loading computer as *Hoegh Osaka* was proceeding along Southampton Water, a thorough assessment of the ship's stability had not been conducted prior to leaving the berth. Witness and anecdotal evidence suggests that this was a common practice and that final cargo figures were sometimes not received on board until after the ship had sailed.

Assessing a ship has adequate stability to sail and complete its intended voyage safely should be a fundamental element of ship operation that professional seafarers fully understand and implement. To enable this to be done properly and ensure the master is able to discharge his ultimate responsibility for the safety of his/her vessel, accurate updated cargo figures must be supplied to the ship with sufficient time made available for the ship's crew to finalise a departure stability calculation before the ship sails.

The MAIB's *Riverdance* investigation[15] highlighted the danger of making an assumption of adequate stability, without assessing the vessel's actual stability condition prior to departure.

While a ship is alongside, cargo can be unloaded or redistributed. Once at sea, ballast adjustment is the only option available to improve stability. The task of ballasting could endanger the vessel unless properly assessed, as demonstrated by *Cougar Ace*'s accident. An accurate knowledge of a ship's stability at all times is not optional; it is vital in ensuring a ship remains safe with adequate stability reserves.

The remaining analysis seeks to determine what factors contributed to the chief officer underestimating the value of accurately calculating *Hoegh Osaka*'s stability condition. It also aims to identify why, despite indications of poor stability prior to and following the ship's departure, insufficient action was taken to remedy the situation prior to the accident.

2.5 CARGO OPERATIONS

2.5.1 Itinerary change

Southampton was originally to be *Hoegh Osaka*'s final north-west European port. The ship was to load cargo in Hamburg and Bremerhaven before proceeding to Southampton. The port captain had already compiled pre-stowage cargo plans for these ports assuming this itinerary.

When the itinerary changed, the pre-stowage plans were not altered. The cargo loaded in Southampton was loaded in the same location as it would have been had Southampton been the final loading port, not the first.

Bremerhaven was the principal port in Europe for loading high and heavy cargo. 3172t of cargo was to be loaded on decks 1, 2, 3, 4, 6 and 8. In addition to loading cargo in Hamburg, 1950t of bunker fuel oil had been ordered. When the ship was loading in Southampton, space was left on the lower decks to load cargo in Germany and the upper decks were filled. This resulted in the ship leaving Southampton with a VCG that was too high.

Had *Hoegh Osaka* maintained its original itinerary, it would have sailed from Southampton with significantly more bunker fuel oil on board and, with cargo filling its lower decks, its stability would have been greatly improved.

2.5.2 Relationship between port captain and chief officer

The port captain saw planning the load and supervising the loading operation as his responsibilities. He had created the pre-stowage plans and was loading the ship in the next two ports. As such, he saw little value in involving the chief officer in any decision-making processes.

The port captain's view was effectively supported by the instructions provided in both the Hoegh Autoliners Cargo Quality Manual and its internal cargo operations manual. Although the chief officer was instructed to respond to the port captain if he envisaged any potential problems with the completed pre-stowage plan, the port captain was not instructed to involve the chief officer in the preparation of the plan.

[15] MAIB Report No 18/2009

The instructions also required the port captain and chief officer to attend a ramp meeting before the start of the loading operation. However, that meeting was intended to ensure that an updated pre-stowage plan had been received by all parties rather than to question the plan itself. The little value the port captain placed on involving the ship's crew was demonstrated by the fact that the ramp meeting involving the port captain went ahead without the chief officer in attendance.

Furthermore, the instructions required the port captain or master to authorise any subsequent alterations to the pre-stowage plan. However, it was the port captain, without informing either the master or the chief officer, who approved the loading of additional cargo after the loading operation had started.

The Wallem PCC/PCTC Operations Manual provided no guidance on the role of the port captain, nor how the chief officer and port captain should co-operate to best effect. The chief officer saw the port captain as the owner's representative and, given the chief officer's nationality[16], he was likely to have been particularly respectful of the port captain's perceived status.

The Hoegh Autoliners Cargo Quality Manual reiterated that the master was ultimately responsible for the cargo and seaworthiness of the vessel. However, in view of the above factors and his familiarity with similar previous pre-stowage plans for Southampton that had been executed without incident, the chief officer neither felt that he had the authority nor had the need to question the pre-stowage plan presented on this occasion.

The chief officer also did not hold a pre-load meeting on board with deck officers and crew, a requirement included in both the Hoegh Autoliners Cargo Quality Manual and the Wallem PCC/PCTC Operations Manual. His omission might well have been influenced by the lack of importance that the master seems to have placed on planning, given that he did not pass the pre-stowage plan to the chief officer as soon as he received it.

2.5.3 Additional cargo

Hoegh Osaka's final cargo tally indicated that an additional 112 cargo units had been loaded. This additional cargo weighed 616.7t and was an increase of around 15% compared with the original pre-stowage plan figures supplied to the ship by the port captain.

The SOLAS requirement for shippers to provide the master or their representative with appropriate cargo information sufficiently in advance of loading should allow a ship's master to verify before shipment that the ship will still have adequate reserves of stability.

In both Hamburg and Bremerhaven, the policy is to have all booked cargo in the port 24 hours prior to a vessel loading. Additional cargo is not accepted during loading. Southampton, which does not have a similar policy, was the last north-west European port of call on the EUME itinerary. It was also the final European port on several other ro-ro trades. As such, there was an encouragement to fill the ships,

[16] In his study of a multinational corporation, Hofstede (1980, 1991) found differences on several dimensions of behaviour, including 'power distance', which refers to the extent to which people perceive difference in status or power between themselves and their subordinates or superiors.

and to not leave empty cargo spaces. On this occasion, despite the fact that with the changed itinerary *Hoegh Osaka* had two more European load ports to visit, additional cargo was still loaded.

In this case, through no omission of the shipper, neither the master nor the chief officer was informed of the additional cargo before it was loaded. However, if there is a desire to load additional cargo after the loading operation has started, procedures need to be in place to ensure that the master, and not just the master's representative, is informed in sufficient time to enable an accurate stability assessment to be conducted prior to accepting the additional cargo on board.

In commenting on the absence of cargo information provided to the master, the MAIB's *Annabella* investigation[17] noted:

> *'Notwithstanding any cargo planning carried out ashore, the master has the ultimate responsibility for the safety of his vessel. He must therefore be given the tools and the time to satisfy himself of the safety of the planned cargo.'*

2.5.4 Estimated cargo weights

The final cargo tally provided to the ship prior to departure was an estimation of the weight of cargo on board. This allowed the final tally and the cargo mapping to be completed faster than would otherwise be the case.

There is no requirement to weigh cargo for shipment on board ro-ro vessels but SOLAS Chapter VI requires the master to be provided with an accurate weight by the shipper.

Weights of new cars were known to SCH, yet the cargo weight provided to the ship was an estimation. When the estimated cargo tally weights were compared with the actual weights following the accident, the most significant differences were on decks 10, 11 and 12, all of which had a higher weight of cargo than expected. Conversely, decks 1 and 2 had a lower weight of cargo than anticipated. To reduce the scope for misleading stability assessments, a cargo tally should use estimated weights only when actual weights are not available.

Significant differences between the actual weight and the shipper's declared weight were noted with regard to several cargo units that were weighed by the MAIB after the accident.

While a shipper is responsible for providing an accurate weight for any cargo unit being shipped, ships' officers charged with loading ro-ro ships need to be aware that an actual weight of cargo may be unavailable. As such, the importance of an accurate draught survey must be understood. A comparison of the calculated draughts and actual draught readings is imperative, and any significant difference must be investigated and corrected, with any residual difference appropriately allowed for.

---

[17] MAIB Report No 21/2007

2.5.5 Cargo securing

The lashing requirements for each of the four identified high and heavy cargo units were investigated by Brookes Bell Safety at Sea. It was not possible to determine exactly the number and arrangement of lashings that had originally been applied to each unit owing to salvor intervention. However, the number of lashings found following the salvage operation suggests that the units might not have been secured in accordance with the requirements of the Hoegh Autoliners Cargo Quality Manual.

The port captain, master, chief officer and SCH lashing supervisors all shared a responsibility for ensuring that the cargo was properly secured. The Flag State required the cargo to be secured in accordance with *Hoegh Osaka*'s CSM. However, Wallem required the master and chief officer to liaise with the port captain in complying with different requirements set out in the Hoegh Autoliners Cargo Quality Manual, and SCH required its staff to follow its own procedures, regardless of the requirements of the Hoegh Autoliners Cargo Quality Manual and without reference to the ship's CSM. Without a mutual understanding of the cargo securing standard required, attempts to implement and enforce an appropriate standard will inevitably be flawed. Given the port captain's and chief officer's familiarity with, and previous acceptance of, SCH's cargo securing procedures, seemingly with no adverse consequences, neither saw reason to challenge those procedures on this occasion.

All of the web lashings tested by the MAIB following the accident failed at loads significantly above their respective MSL. Assuming that the cargo that shifted had been secured in accordance with the requirements of the ship's CSM and Hoegh Autoliners Cargo Quality Manual, Brookes Bell Safety at Sea concluded that the MSL requirements of the CSS Code would have been satisfied. It also concluded that it was most likely that the cargo shifted during *Hoegh Osaka*'s loss of stability event and was not causal to the accident **(Annex D)**.

Notwithstanding that cargo shift was considered not to be causal to the loss of stability, the maximum MSL of the web lashings on board *Hoegh Osaka* was 50kN and therefore did not comply with the CSS Code when used to secure road vehicles that weighed in excess of 15t. Furthermore, a number of buses that were found to have shifted did not have securing points or clearly marked lashing points, contrary to the requirements of the CSS Code and Hoegh Autoliners Cargo Quality Manual.

Hoegh Osaka's CSM was approved by DNV in 2000 and accepted by LR in 2014 to provide instructions on cargo securing. Although the Wallem PCC/PCTC Operations Manual required the Hoegh Autoliners Cargo Quality Manual to be strictly complied with, the CSM remained the approved cargo securing document in accordance with SOLAS Chapters VI and VII.

The CSM did not reflect later amendments to Annex 13 of the CSS Code and IMO Resolution A.581(14), extracts of which were provided in the manual. Furthermore, neither the Hoegh Autoliners Cargo Quality Manual nor the current edition of the MCA publication Roll-on/Roll-off Ships – Stowage and Securing of Vehicles – Code of Practice reflected the amended version of IMO Resolution A.581(14). Consequently, neither document reflected the recommendation for the MSL of lashings used to secure road vehicles to be not less than 100kN (unless the vehicle's GVM does not exceed 15t, when lashings with lower MSL values may be used).

Unlike *Hoegh Osaka*'s CSM, the Hoegh Autoliners Cargo Quality Manual contained no reference to the recommendations contained in Annex 4 of the CSS Code. It therefore omitted to highlight the importance of ensuring that part cargo was either block-stowed, or stowed close to the ship's side or in a position provided with sufficient securing points. Although requiring all cargo received for shipment to be equipped with adequate and easily accessible lashing points, the manual did not include clearly marked dedicated lashing points as a condition for registering non-static cargo in the same way as it did for registering static cargo.

A lack of vehicle lashing points and the use of lashings with a lower MBL than that recommended in IMO guidance were safety issues that were identified in the MAIB's *Stena Voyager* investigation[18].

2.6 BALLAST MANAGEMENT

Unlike the listing and capsize of *Cougar Ace* in 2006, no ballast transfer operations were taking place on board *Hoegh Osaka* at the time of the accident. Ballast tank contents were fixed prior to and following the ship leaving the berth. However, previous ballast tank levels had been inconsistently recorded, and so their recorded status at the time of the accident could not be relied on.

The Wallem PCC/PCTC Operations Manual required the chief officer to carefully monitor ballasting and deballasting operations, and the chief officer's own standing orders required ballast tank gauges, which were located in the ship's control centre, to be regularly monitored at such times. The Wallem SMS also required ballast tank soundings to be taken and recorded daily. These instructions could be readily complied with when the ballast tank gauges were operational. However, the task was made more difficult as all but the fore peak tank gauge were inoperative.

Wallem shore-based managers were aware that the ballast gauges were defective but had made no arrangements to have them repaired as manual soundings could still be taken and recorded. Given the low priority given by Wallem to repairing the gauges, a similar level of priority was assumed by the chief officer. With no readily available means for monitoring the transfer of ballast during cargo operations, the chief officer resorted to estimating the amount of ballast transferred using a 'time elapsed' pumping rate calculation. He had done so with no adverse consequences since joining *Hoegh Osaka* 5 months previously, and therefore believed he knew with sufficient accuracy the quantity of ballast water in each tank. To comply with the Wallem SMS requirement for ballast tank soundings to be recorded daily, the chief officer falsified the sounding records.

It is not possible to maintain an accurate understanding of ballast tank quantities without taking frequent soundings. Ballast water was transferred regularly during cargo operations to adjust the ship's trim and heel. The process of applying estimated figures to previously estimated figures, and to then adjust those figures to compensate for draught readings compounded to cause the chief officer to assume a ballast condition for *Hoegh Osaka*'s departure that bore no resemblance to reality.

[18] MAIB Report No 21/2009

2.7 SAFETY CULTURE

2.7.1 Hoegh Osaka

The chief officer held an STCW II/2 chief mate CoC that would have required him to demonstrate a knowledge, understanding and proficiency in using stability, trim and stress tables, diagrams and stress-calculating equipment. Using such, he would also have been required to demonstrate that his intended stowage and securing of cargoes and distribution of ballast would ensure that a ship's stability and stress conditions would remain within safe limits at all times during the voyage.

However, the value the chief officer placed on following the above fundamental principles of seamanship and, particularly, in accurately calculating a ship's stability condition, had diminished over time. Since 2009, he had served exclusively as an officer on car carriers, and this was both his second contract as chief officer and his second contract with Wallem, having joined *Hoegh Osaka* 5 months prior to the accident. During that period, he had become familiar with car carrier operations and, given that stability had not previously given him cause for concern, he was content to follow what had become a routine practice for a ship to sail before its departure stability condition had been accurately calculated.

This investigation has identified that, at least since joining *Hoegh Osaka*, the chief officer's regard for the above principles had diminished to the extent that he considered it unnecessary to maintain an accurate record of ballast water distribution, to actively pursue and update his knowledge of the cargo to be loaded, and to use the loading computer to best effect by entering the VCG of cargo above the deck. This last point might have been addressed had the chief officer been instructed in the use of the loading computer as part of his familiarisation on joining the ship.

In recognising the particular operational requirements of its PCC/PCTC fleet, Wallem provided a 2-day training course for senior officers. Although the chief officer had attended the course before joining *Hoegh Osaka*, the need to accurately calculate a ship's stability condition for departure and the forthcoming voyage did not feature in the topics covered. *Hoegh Osaka*'s master had not attended the course.

The Hoegh Autoliners Cargo Quality Manual and Wallem's SMS both provided comprehensive instructions and guidance. However, the investigation has identified areas where they need to be modified or enhanced, and where current requirements are in need of reinforcement, particularly with regard to cargo reception and securing, ballast management, stability assessment, and communications between the port captain and ship's staff.

One area of Wallem's SMS that is in need of modification is its use of extensive checklists. The five checklists contained within the PCC/PCTC Operations Manual that were completed by the chief officer during *Hoegh Osaka*'s call at Southampton contained a total of 213 check items, all of which had been ticked, and none of which had been signed as having been verified by the master.

Checklist No.4 was intended for completion during a loaded passage; the fact that it was completed before departure demonstrates that the chief officer underestimated its value and it provides no confidence as to what checks were actually completed. Although checklist No.1 referred to the inspection of cargo lashings during loading, it was not clear when the check item was to be completed. Checklist No.5 indicated that the ship's stability had been assessed during loading, but a similar check item was not included in checklist No.3 (prior departure port), and no instructions were provided in the SMS as to how the stability should be assessed. Although the master was advised by the chief officer before departure that the ship's GM met the requirements of the loading and stability information manual, he was unaware of how it had been calculated or on what information the calculation was based.

Important checklist items, such as ensuring cargo was properly secured and that stability was properly assessed, were lost among a large number of minor tasks. Consequently, the value of the checklists as important safety tools was diminished.

2.7.2 Wider PCC/PCTC industry

Witness and anecdotal evidence suggests that the practice of not calculating a departure stability condition on completion of cargo operations and before a ship sails extends beyond the chief officer, *Hoegh Osaka*, Wallem and Hoegh Autoliners, to the PCC/PCTC sector in general. The chief officer placing little value on the importance of conducting accurate stability calculations appears to be widespread such that for reasons of efficiency, as highlighted in the MAIB's *Riverdance* investigation, ships are sailing under the assumption that their stability condition is safe. What is a fundamental principle of seamanship appears to have been allowed to drift, giving rise to potential unsafe practices.

So strong was the drift on *Hoegh Osaka* that despite indications of poor stability, notably the chief officer's calculated GM being lower than he had expected, the list caused by raising the stern ramp being well in excess of that normally experienced, and the master's interpretation that the ship did *'not feel right'*, no action was taken to delay *Hoegh Osaka*'s departure until an accurate stability condition had been calculated.

In commenting on ro-ro safety, the MAIB's *Riverdance* investigation noted:

> *'…it becomes clear that there has been a widespread acceptance of unsafe practices with relation to stability within ro-ro vessels. Fundamental requirements, from accurate knowledge of the weight and distribution of cargo to allow stability calculations to be made, through to the ability to properly chock and lash a trailer, and the securing of cargoes within trailers have become eroded with time.'*

The IMO recognised a need to introduce a SOLAS requirement for masters of passenger ships and passenger / ro-ro ships to always determine the ship's stability condition by calculation on completion of loading and prior to departure. There appears to be an emerging need to introduce a similar requirement for ships in the PCC/PCTC sector. However, there is insufficient evidence from this investigation to warrant a recommendation to that effect.

SECTION 3 - CONCLUSIONS

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

1. *Hoegh Osaka* had inadequate residual stability to survive the Bramble Bank turn at 12kt. [2.4.1]

2. The ship's bow trim would have been detrimental to manoeuvring, and probably contributed to the high rate of turn. [2.4.1]

3. While the ship had positive stability on departure, it is estimated that its condition did not comply with IMO stability requirements. [2.4.1]

4. *Hoegh Osaka*'s actual cargo weight and stowage were significantly different to the final cargo tally supplied to the ship. [2.4.1]

5. The chief officer did not allow for cargo unit VCGs when calculating the stability condition. [2.4.1, 2.4.2]

6. *Hoegh Osaka*'s ballast tank quantities were estimated by the chief officer and differed significantly from actual tank levels. [2.4.1, 2.4.2]

7. Most of the cargo weights supplied by SCH were estimated rather than actual values. [2.4.2]

8. *Hoegh Osaka*'s chief officer underestimated the importance of accurately calculating the ship's stability condition. [2.4.2]

9. Witness and anecdotal evidence suggests that it was common practice for a thorough assessment of *Hoegh Osaka*'s stability to not be conducted until after the ship had sailed. [2.4.3]

10. *Hoegh Osaka*'s changed itinerary resulted in the ship leaving Southampton with a VCG that was too high. [2.5.1]

11. The pre-stowage cargo plans for the three north-west European ports were compiled by the port captain assuming the original itinerary, and remained unaltered after the itinerary had changed. [2.5.1]

12. The port captain saw little value in involving the chief officer or the master in any decision-making processes. [2.5.2]

13. Neither the Hoegh Autoliners Cargo Quality Manual nor its internal cargo operations manual instructed the port captain to involve the chief officer in the preparation of the pre-stowage cargo plan. [2.5.2]

14. *Hoegh Osaka*'s chief officer neither felt that he had the authority nor had the need to question the pre-stowage plan presented on this occasion. [2.5.2]

15. The Wallem PCC/PCTC Operations Manual provided no guidance on the role of the port captain, nor how the chief officer and port captain should co-operate to best effect. [2.5.2]

16. There were significant differences between the actual weight and the shipper's declared weight with regard to several cargo units that had been loaded on board *Hoegh Osaka*. [2.5.4]

17. The Wallem SMS requirement for ballast tank soundings to be taken and recorded daily was made more difficult because all but the fore peak tank gauge were inoperative. [2.6]

18. In light of the low priority given by Wallem to repairing the gauges, a similar low priority was assumed by *Hoegh Osaka*'s chief officer, who resorted to estimating ballast tank quantities. [2.6]

19. *Hoegh Osaka*'s chief officer believed he knew with sufficient accuracy the quantity of ballast water in each tank. To comply with the Wallem SMS requirement for ballast tank soundings to be recorded daily, the chief officer falsified the sounding records. [2.6]

20. The chief officer's process of applying estimated figures to previously estimated figures, and to adjust those figures to compensate for draught readings compounded to cause him to assume a ballast condition for *Hoegh Osaka*'s departure that bore no resemblance to reality. [2.6]

21. Given that stability had not previously given him cause for concern, *Hoegh Osaka*'s chief officer was content to follow what had become a routine practice for a ship to sail before its departure stability condition had been accurately calculated. [2.7]

22. Instruction on the use of the loading computer had not formed part of the chief officer's familiarisation on joining *Hoegh Osaka*, and the need to accurately calculate a ship's stability condition for departure and the forthcoming voyage did not feature in Wallem's 2-day training course for newly assigned senior officers to its PCC/PCTC fleet. [2.7]

23. A number of areas in both Hoegh Autliners Cargo Quality Manual and Wallem's SMS are in need of modification or enhancement, and a number of current requirements are in need of reinforcement. [2.7]

24. Although *Hoegh Osaka*'s master was advised of the ship's stability condition before departure, he was unaware of how it had been calculated or on what information the calculation was based. [2.7.1]

3.2 OTHER SAFETY ISSUES RELATING TO THE ACCIDENT[19]

1. Witness and anecdotal evidence suggests that the practice of not calculating the actual stability condition on completion of cargo operations but before the ship sails extends to the PCC/PCTC sector in general. For reasons of efficiency, what is a fundamental principle of seamanship appears to have been allowed to drift, giving rise to potential unsafe practices. [2.7.2]

[19] These safety issues identify lessons to be learned. They do not merit a safety recommendation based on this investigation alone. However, they may be used for analysing trends in marine accidents or in support of a future safety recommendation.

3.3 OTHER SAFETY ISSUES THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. Anecdotal evidence suggests that final cargo figures were sometimes not received on board *Hoegh Osaka* until after the ship had sailed. [2.4.3]

2. Although required, *Hoegh Osaka*'s chief officer, possibly influenced by the lack of importance that the master seemingly placed on planning, felt it was unnecessary to hold a pre-load meeting with deck officers and crew. [2.5.2]

3. The number of lashings found following the salvage operation suggests that some high and heavy cargo units might not have been secured in accordance with the requirements of the Hoegh Autoliners Cargo Quality Manual. [2.5.5]

4. Given their familiarity with, and previous acceptance of SCH's cargo securing procedures, neither the port captain nor *Hoegh Osaka*'s chief officer had reason to challenge those procedures on this occasion. [2.5.5]

5. The maximum MSL of the web lashings on board *Hoegh Osaka* when used to secure road vehicles weighing in excess of 15t, and the lack of securing points or clearly marked lashing points on some cargo units, were contrary to the requirements of the CSS Code. [2.5.5]

6. Neither *Hoegh Osaka*'s CSM nor the current edition of the MCA publication Roll-on/Roll-off Ships – Stowage and Securing of Vehicles – Code of Practice reflected the amended version of IMO Resolution A.581(14) in respect of the minimum MSL of lashings to be used when securing road vehicles. [2.5.5]

7. The Hoegh Autoliners Cargo Quality Manual omitted to highlight the importance of ensuring that part cargo was either block-stowed, or stowed close to the ship's side or in a position provided with sufficient securing points. It also did not include clearly marked dedicated lashing points as a condition for registering non-static cargo. [2.5.5]

SECTION 4 - ACTION TAKEN

The **MAIB** has**:**

- Issued a safety flyer highlighting particular lessons to be learned from this accident for distribution to shipowners and shippers of vehicles **(Annex F)**.

The **Maritime and Coastguard Agency** has:

- Drafted a Marine Guidance Note, providing guidance on the safe stowage and securing of specialised vehicles.

Hoegh Autoliners Shipping Pte has:

- Issued a fleet circular letter to all Hoegh-operated vessels reinforcing the importance of adherence to procedures already contained within its operation manuals.

- Commenced an internal investigation of the accident to establish the contributing factors and identify measures that may need to be considered / implemented to avoid a recurrence.

- Introduced a procedure whereby the master and chief officer of Hoegh-operated vessels are required to confirm receipt and approval of the pre-stowage cargo plan.

- Updated its 'ramp meeting' instruction to highlight the importance of continual communication and updates between the port captain and chief officer throughout the cargo operation.

- Conducted a review and audit of Wallem's SMS.

- Introduced a vetting inspection campaign of the senior management on board Hoegh-operated vessels with a focus on matters relating to ship stability and management of cargo operations.

- Enhanced its mandatory seminar / meetings with the masters and chief officers of Hoegh-operated vessels to include sessions on stability and cargo management.

- Standardised and upgraded the stability program provided on all Hoegh-operated vessels.

- Amended its trim poster taking into consideration the effect forward trim may have on stability.

Wallem Shipmanagement Pte Ltd, Singapore has:

- As part of the repairs to *Hoegh Osaka,* ensured that the ballast tank gauges were repaired and tested prior to the vessel entering service.

- Issued an advisory notice to all of its PCC/PCTC masters and crews, including the following: '*Thus all PCC/PCTC Master's and crew are reminded to most diligently follow and ensure full compliance with:*

    1. *Arrival Check lists and cargo loading discharging Checklists.*

    2. *Departure Check lists. (not just use as tick boxes)*.

    3. *Make sure that Ballast and other tanks soundings are taken when ballast operations take place so that exact quantities and percentage filling are known at all times. Avoid Slack tanks and free surface so far as possible. Do not carry out ballast operations assuming that tanks are full or partly empty or only based on pump capacity and time of running.*

    4. *Ensure cargo data is properly entered into Lodicator along with all other weights and all stability (Fluid GM) requirements are full complied with and vessel is not "tender".*

    5. *Cargo must be properly lashed before departure from port.*

    6. *Do not come under any "perceived commercial pressure". Ensure vessel is well secured and stable in every respect for the entire voyage before agreeing to sail out.'* [sic]

- Issued a follow-up advisory notice to all of its PCC/PCTC masters and crews, including the following:

    'We thank you for having taken action to check your own vessels procedures and ensure that sufficient stability is maintained at all times. Proper soundings of tanks must be done during and after ballast operations, (avoiding slack tanks), besides ensuring that gauges are operational and any error is known and accounted for.'

- Sent a briefing pack, consisting of a questionnaire, guidelines and presentation on stability, to all of its PCC/PCTC masters, marine superintendents and training centre. Marine superintendents then visited the ships to discuss the briefing pack content, complete the questionnaire and take steps to improve operations on board.

- Increased the length of its PCC/PCTC training course from 2 to 3 days to include greater focus on operations and stability aspects.

- Prepared an action plan following a review and audit of its SMS by Hoegh Autoliners Shipping Pte.

- Conducted its own internal investigation of the accident to identify its causes and to implement an action plan with target dates to avoid a similar accident in the future.

- Revised and enhanced its PCC/PCTC Operations Manual in a number of areas, including the following:

  1. Shipboard pre-arrival meetings.
  2. Ship-shore pre-cargo operation meetings.
  3. Cargo securing.
  4. Loading computer familiarisation.
  5. Liaison with port captain.
  6. Pre-stowage and final stowage cargo plan acceptance procedures.
  7. Ballast system operation and monitoring procedures.
  8. Stability guidelines and procedures.
  9. Checklists in respect of the above.

  In particular, its enhanced stability guidelines and procedures includes the following:

  > *'The master and Chief officer…must confirm…before sailing for the next port, that calculation results…provide the ship with sufficient stability… Early confirmation is preferred…therefore as soon as pre-loading plans are received on board, the Chief officer must input the loadable weights after ascertaining the quantities of ballast, bunkers and water into the loading computer and produce results of the condition of stability for the Master's approval before loading is allowed to commence. Further, upon completion of loading, the actual quantities of cargo loaded must be input and the actual departure stability condition must be verified and signed off by Chief Officer and Master before casting off from port.'* [sic]

Associated British Ports, Southampton has:

Instructed pilots to ask the master to confirm his stability and that the vessel is in all respects ready to proceed to sea prior to sailing from the berth.

SECTION 5 - RECOMMENDATIONS

Hoegh Autoliners Shipping Pte is recommended to:

2016/107 Enhance its internal procedures and instructions to ensure that the stability of its vessels is maintained throughout the operating cycle by, inter alia:

- Involvement of the master and chief officer as early as practicable in the preparation of a pre-stowage cargo plan, and in the approval of any proposed updates as a result of itinerary changes or before additional cargo is accepted for shipment.
- A requirement that cargo handlers use actual weights of cargo units rather than estimated weights (when available) in preparing a ship's final cargo tally, and that due diligence is given to establishing the actual weight of used high and heavy cargo when presented for shipment.
- Ensuring *Hoegh Osaka*'s CSM is appropriately updated in respect of web lashing MSL rating and the required MSL of web lashing used to secure road vehicles, and that the ship is appropriately equipped.
- Ensuring the Hoegh Autoliners Cargo Quality Manual reflects or refers to the ship's CSM, particularly with regard to the provision of clearly marked lashing points as a condition of acceptance for shipment and the importance of block stowage or secure positioning of part cargo.
- Reinforcement of the method of cargo securing required by the Hoegh Autoliners Cargo Quality Manual.

Wallem Shipmanagement Pte Ltd, Singapore is recommended to:

2016/108 Noting the actions it has already taken, further review its procedures and instructions to ensure that:

- Clear guidance is given to its masters and chief officers as to what actions should be taken prior to the ship's departure if, after checking, there remains a significant difference between a ship's calculated displacement and that obtained from actual draught readings.
- Checklists are revised and rationalised so that they can be used effectively, and that safety critical items are not lost among a large number of minor tasks.
- Its revised and enhanced PCC/PCTC Operations Manual is promulgated and fully implemented throughout its PCC/PCTC fleet.

Southampton Cargo Handlers is recommended to:

2016/109 When available, use actual weights of cargo units rather than estimated weights in preparing a ship's final cargo tally, and give due diligence to establishing the actual weight of used high and heavy cargo when presented for shipment.

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

2016/110 Promulgate the amended version of IMO Resolution A.581(14) in respect of the minimum MSL of lashings to be used when securing road vehicles:

- Through its forthcoming Marine Guidance Note, providing guidance on the safe stowage and securing of specialised vehicles; and
- Within the next edition of its publication Roll-on/Roll-off Ships - Stowage and Securing of Vehicles – Code of Practice.

The **Association of European Vehicle Logistics** is recommended to:

2016/111 Promulgate to its members the findings of this investigation and, in particular, the MAIB safety flyer.

The **International Chamber of Shipping** is recommended to:

2016/112 Bring the safety lessons of this accident to the attention of its members by circulating to them the MAIB safety flyer, and providing emphasis to the essential requirement that an accurate calculation of stability should be conducted once loading is complete but before a vessel sails to ensure its stability is adequate for its intended voyage.

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

Marine Accident Report

INVESTORS IN PEOPLE