Report on the investigation of the

grounding of the UK ro-ro vessel

Finnreel

off Rauma, Finland

on 14 March 2001

Marine Accident Investigation Branch
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Extract from

The Merchant Shipping

(Accident Reporting and Investigation)

Regulations 1999

The fundamental purpose of investigating an accident under these Regulations is to determine its circumstances and the cause with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

CONTENTS

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AB	-	able seaman
ARPA	-	Automatic Radar Plotting Aid
Bar	-	Measure of pressure
C	-	degrees Celsius
CCTV	-	Closed Circuit Television
CPP	-	Controllable pitch propeller
d.c.	-	direct current
DNV	-	Det Norske Veritas
ECDIS	-	Electronic Chart Display and Information System
ECR	-	Engine Control Room
g	-	gravitational force
GPS	-	Global Positioning System
HF	-	High frequency
IMO	-	International Maritime Organization
ISM	-	International Safety Management
ITF	-	International Transport Federation
kW	-	Kilowatts
LED	-	Light Emitting Diode
LOF	-	Lloyd’s Open Form
LR	-	Lloyd’s Register
MCA	-	Maritime and Coastguard Agency
MF	-	Medium Frequency
mg	-	milligrams
RH	-	Relative Humidity
Ro-Ro	-	Roll on - Roll off
SOLAS	-	Safety of Life at Sea
UTC	-	Universal Co-ordinated Time
VHF	-	Very high frequency
VTS	-	Vessel Traffic Service

SYNOPSIS

At 2230 on 14 March 2001, the Marine Accident Investigation Branch (MAIB) was informed that the UK-registered ro-ro vessel *Finnreel* had grounded that day, off Rauma, Finland. An investigation began immediately.

Finnreel left the port of Rauma bound for Hull at 1946 on 14 March 2001, with a cargo of paper products. She was under pilotage in the main channel when the main engine oil mist detector alarm activated at 2004. Before any action could be taken, the main engine automatically shut down. The vessel sheered to starboard out of the channel and grounded at 2008.

She was refloated on the evening of 16 March 2001 after some of her cargo had been discharged to lighten her.

The vessel's fore peak, No 1 centre and No 2 port and starboard ballast tanks and the bow thruster space were all holed as a result of the grounding. However, there were no injuries or pollution. Subsequently, the vessel was repaired in dry dock in Gothenburg, Sweden.

The initiating cause of the incident was found to be the alarm activating on the main engine oil mist detector. This, in turn, shut down the main engine. The reason for the alarm activating has not been determined.

The cause of the grounding was found to be the vessel sheering to starboard out of the channel with no means available to remedy the situation.

A further nine contributory factors were identified.

Recommendations have been made which, if implemented, will reduce the risk of a similar accident happening again.

Chart of the region

Figure 1

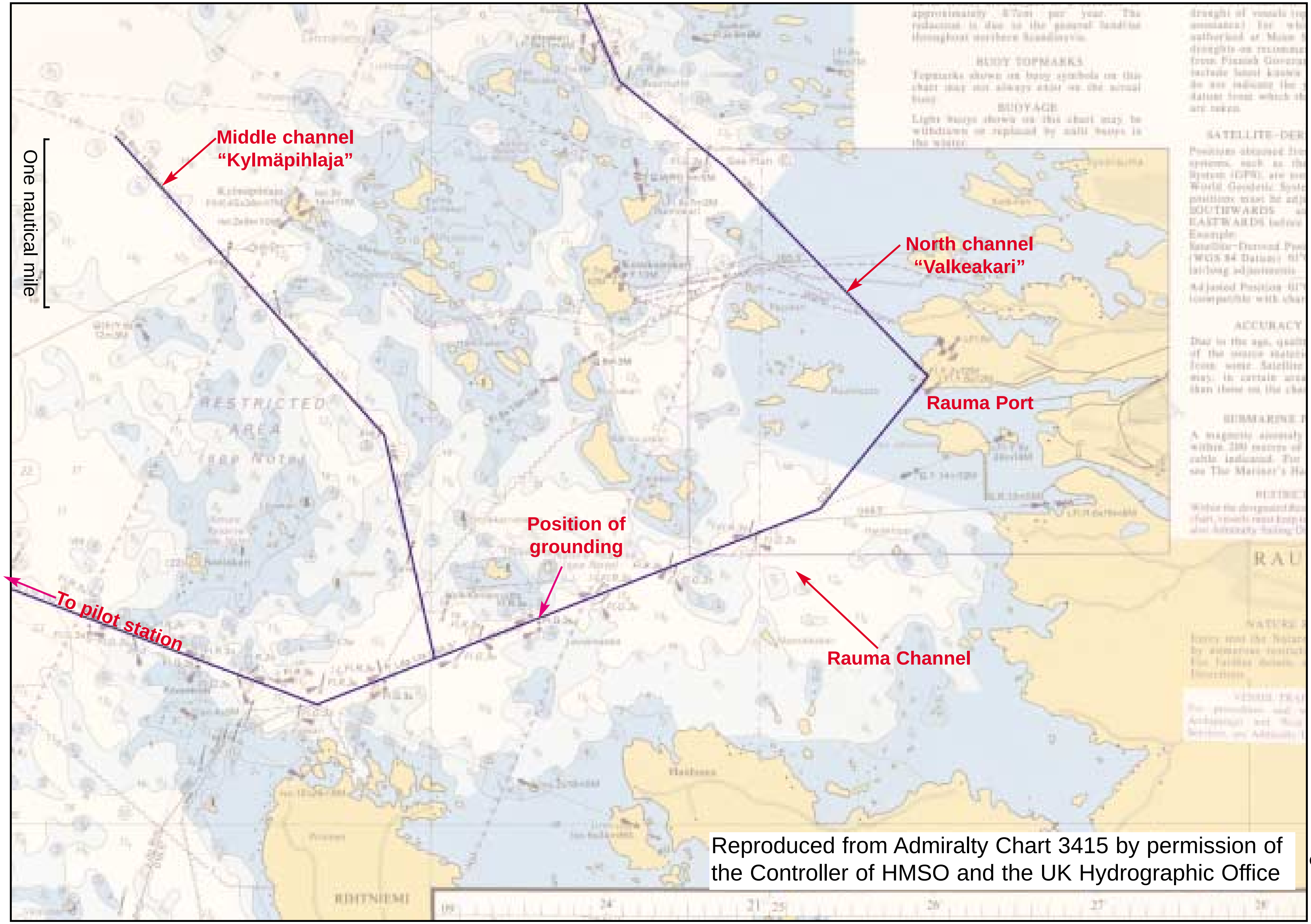


Figure 2

The three access channels to Rauma

One nautical mile

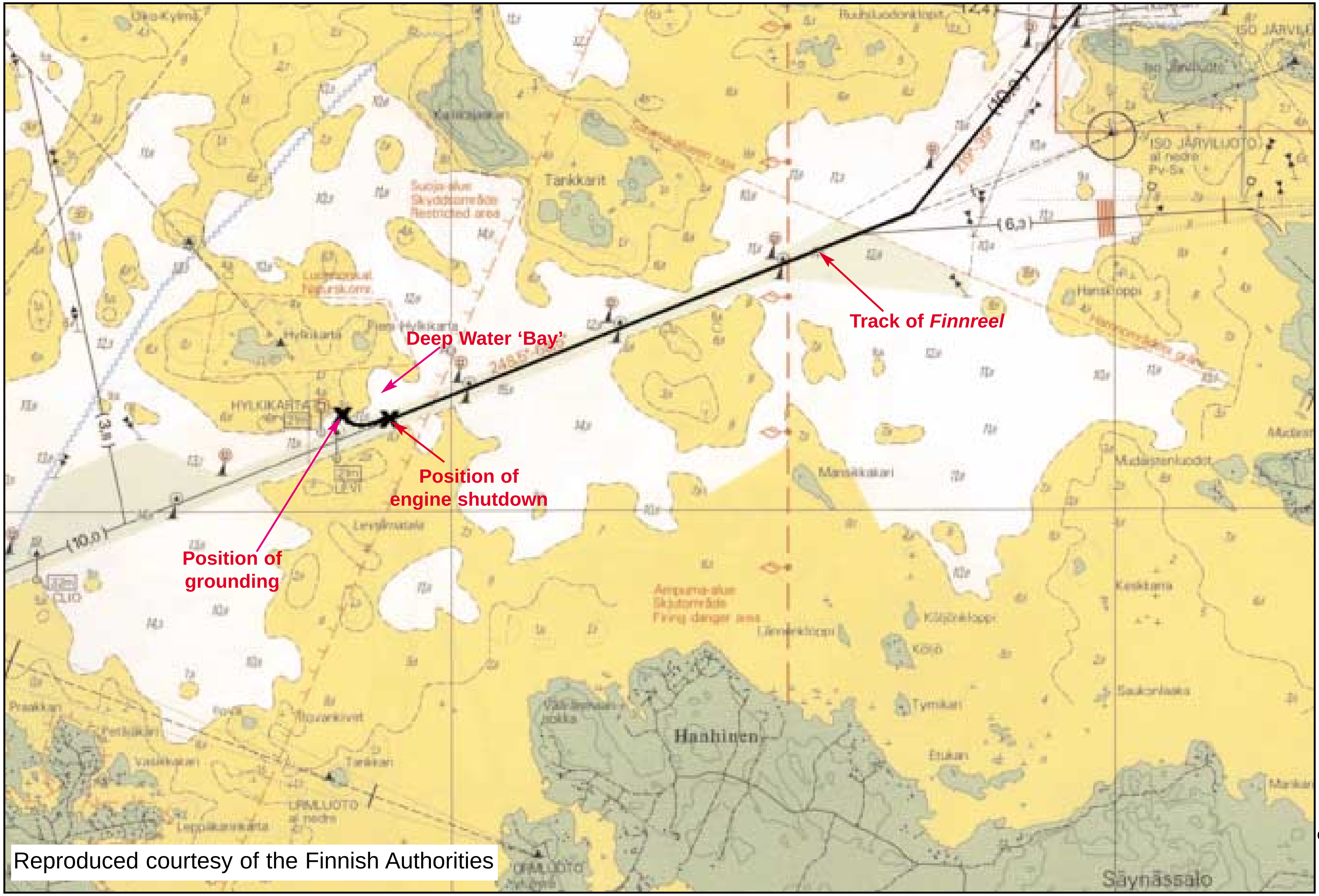


Figure 3

Chart of channel (Finnish Chart 41)

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *FINNREEL* AND ACCIDENT

Vessel details

Registered owner	:	Carnoustie Universal
Manager	:	Norbulk Shipping UK
Port of registry	:	London
Flag	:	United Kingdom
Type	:	Ro-ro cargo vessel
Built	:	Nanjing, China, in 2000
Classification society	:	Lloyd's Register of Shipping
Construction	:	Steel
Length overall	:	162.582 metres
Gross tonnage	:	11530
Engine power and type	:	Diesel direct drive through single reduction gearbox, single CPP 12600kW
Service speed	:	20 knots
Other relevant info	:	Bow and stern thrusters

Accident details

Time and date	:	2008 (UTC+1) 14 March 2001
Location of incident	:	61°06.27′N 21°21.31′E off Rauma, Finland
Persons on board	:	15 (14 crew 1 pilot)
Injuries/fatalities	:	None
Damage	:	Hull and bottom damage. Flooded bow compartments

1.2 BACKGROUND (ALL TIMES UTC+1)

Finnreel **(see Figure 4)** was a ro-ro cargo vessel, owned by Carnoustie Universal and managed by Norbulk Shipping of Glasgow, UK. The vessel was engaged on a regular triangular service between Helsinki, Rauma and Hull, with a mixed general cargo, most of which was usually paper products. She was purpose-built for the carriage of paper products with specifically designed ventilation, drainage and an anti-roll (Intering) system.

The vessel had arrived in Rauma from Helsinki on 7 March 2001 on her scheduled service, but her sailing to Hull had been delayed because of a dispute with the ITF over crew contract details. During this 7-day period, the vessel was alongside No 5 ro-ro berth, waiting for clearance before any cargo could be loaded. On the morning of 14 March, the loading ramps were opened at 0605 and cargo loading started at 0707. The loading operation was completed at 1925 with the ramps closed at 1935.

While alongside in port, the engine room was maintained at an ambient temperature of about 30°C with the main engine cooling water being circulated at about 70°C. With the vessel on stand-by for loading and departure, the only maintenance carried out was adjustments to the main engine inlet and exhaust valve clearances and a crankcase inspection.

Figure 4

Ro-Ro vessel *Finnreel*

1.3 ENVIRONMENTAL CONDITIONS

The conditions were good; there was some broken ice drifting in to the port, with an air temperature of about zero. Visibility was about 6 miles. It was partly cloudy, with no rain or snow and virtually no wind. Two weeks before the grounding the channel had been iced-locked. There was no tide and little current.

1.4 NARRATIVE (ALL COURSES TRUE)

1.4.1 With cargo work nearing completion, *Finnreel* prepared for departure. The pilot, who had been given 2 hours notice at 1600 on 14 March 2001, boarded at about 1830. The chief officer was in the cargo control room finalising the ballast and Intering operations, and completing loading. In the engine room, a second diesel alternator had been started and connected to the main switchboard, the hydraulic pumps for the CPP system had been started, and both steering gears switched on. At about 1920, the master tested the steering gear. The chief officer, having closed the stern door at 1940 and finished a final check of the cargo lashings, made his way up to the bridge, ensuring, as he went, that the crew were standing-by for departure.

The main engine lub oil pump was started and the engine kicked over on air. The indicator cocks were shut and the main engine was started locally at 1940. Engine speed was slowly brought up to 500 rpm, the nominal operating speed, and engine control transferred to the bridge. With the shaft-driven alternator on line and supplying the thrusters, both bow and stern thrusters were started. The master then rang stand-by. During departure, the chief, second, relief second and third engineers, plus the electrician, were in the engine room control room (ECR).

1.4.2 As was the normal practice on *Finnreel,* the master was on the bridge for departure with the chief officer and pilot. The second officer went aft while the third officer went forward. The vessel singled up with the last mooring line coming inboard at 1946. Sailing draughts were 6.25 metres forward, 6.70 metres aft. The master took control of the vessel while she left the berth, handling engine movements and the helm himself. The chief officer recorded movement times. Once clear of the berth and lined up for the channel, the master handed over the conduct of the navigation to the pilot, while the chief officer took the helm. The vessel’s speed in the harbour was between 4 and 6 knots. Communication between the pilot and the master was in Swedish.

The pilot was using the port side radar to confirm the vessel’s position in the channel, as well as using the leading lights astern as a further check. No other traffic was either inbound or outbound. The pilot requested an increase of speed to about 12 to 12.5 knots. About 10 minutes after leaving the berth, the bosun arrived on the bridge from the forecastle, where he had been for departure. He then took over the helm from the chief officer. The pilot was giving orders to the helmsman in English. The bow thrusters were left running ready for use if required.

1.4.3 The bridge team was monitoring VHF radio channels 67 and 13. The chief officer entered vessel positions on the chart at 1959 and 2002.

The third officer arrived on the bridge at about 2000, when the vessel was passing the Hanskloppi buoy. He took over the watch from the chief officer at about 2002, after the ship's position had been plotted on the chart. The chief officer then left the bridge and went down to the mess room.

1.4.4 The vessel was proceeding normally in the buoyed channel with the master on the starboard bridge wing, the pilot by the helmsman, and the third officer in the chart room. The helmsman was applying helm, on a continuous basis, to maintain the vessel's position in the channel. In the ECR, the four engineers and electrician were still present, waiting for the pilot to disembark and for full away to be rung.

At 2004, the main engine crankcase oil mist detector alarm sounded in the ECR, and was acknowledged by the second engineer. Almost immediately the alarm changed to main engine shutdown, followed by further alarms as the engine slowed and the engine-driven auxiliaries responded.

Both second engineers went down to the bottom plates and to check the condition of the main engine crankcase doors and the temperature of the bearing oil returns. Neither hot crankcase doors, nor unusual oil return temperatures, were subsequently found.

1.4.5 On the bridge, the helmsman was steering about 249° and the vessel's speed was 12.5 knots approaching the Levi and Hylkikarta buoys. The pilot then noticed that *Finnreel* was heading about 2° to starboard of the intended track. The helmsman called out “no steering” and the pilot ordered hard to port. As the main engine slowed down, the shaft alternator main breaker tripped off the switchboard with the result that both thruster breakers also tripped off.

The master, who was on the starboard bridge wing, saw and heard the alarm indicating that both thrusters had lost electrical power. He tried to restart the units but could not get a response. As he went to the central console to try from there, the helmsman told him that the vessel was not steering. Despite the rudder having been moved to port, the vessel continued to swing to starboard. The master telephoned the ECR and told the chief engineer that they had a problem with the steering. The chief engineer sent the third engineer and the electrician aft to check the steering gear. Nothing abnormal was subsequently found. The master could hear an alarm sounding, but could see no alarm lights lit on the main engine alarm panel on the bridge. He then moved the propeller pitch control to slow astern and confirmed that the pitch was responding. On hearing the alarm, the third officer had gone to the central console where the pilot was standing, and had seen from the radar and gyro compass that the vessel was moving to starboard, out of the channel, despite the rudder being over to port. The pilot asked for hard to port from the bow thruster, but was told by the master that he could not start the thruster unit. The master placed the propeller pitch control to full astern, and although the pitch moved to the full astern position, the vessel was sufficiently far out of the channel to run aground on the north side close east of the Hylkikarta buoy. The time from the start of the swing to starboard, to the vessel grounding was about 90 seconds. *Finnreel* grounded at 1908, in position 61°06.27′N 21°21.31′E **(see Figures 5 and 6)**.

1.4.6 The speed at impact was about 8.5 knots with the ship's heading 276°. The grounding was accompanied by a loud bang, vibration, a sensation of "sliding upwards" and then rolling, before the vessel came to a halt. The pilot used VHF radio channel 67 to tell the VTS of the grounding and then called the pilot boat on channel 13. Coastguard/VTS subsequently used channel 14 while the pilot boat used channel 8 for contact and discussion. The third officer wrote down the ship's position from the GPS and then continued to log the times of the various actions undertaken by the ship's crew.

Meanwhile, the master had telephoned the ECR and asked the engineers to check the engine room for leaks etc. The chief officer arrived on the bridge and was instructed by the master to check the holds, while the second officer, who had also arrived, was told to muster the crew. The third officer and two ABs were sent to sound round the vessel using a hand lead line.

The master went to the ballast console and saw that water was being lost from the fore peak, which had been full on sailing, and No 1 centre and 2 port and starboard ballast tanks were flooding. An AB was sent to check the bow thruster space and reported back that this was filling with water.

1.4.7 Further flooding checks were carried out, with the chief officer also reporting that the bow thruster space was filling with water. At 2020, the chief engineer was asked to start pumping out the bow thruster space to try to maintain the water level below that of the electric motors.

Contact was made with the head office of Norbulk Shipping in Glasgow at about the same time, and arrangements were made to maintain contact every 30 minutes. The master made no attempt to take the vessel off the rocks because he considered, with the extent of the damage not known precisely, it was safer to remain in position. The pilot boat, which was on the scene about 30 minutes after the grounding, at 2038, noted *Finnreel*'s draughts and passed them to the master.

At 2150 two coastguard officers boarded *Finnreel* to carry out an investigation of the grounding. The coastguard vessel *Tursas* arrived at 2210 and stood-by to assist as required. Two more coastguard officials arrived on board shortly afterwards to assist the investigation.

At about 2300, the master signed Lloyd's Open Form 2000 (LOF 2000) with Alfons Hakans Salvage Ltd.

At 2311, Norbulk Shipping was told that the vessel's current draughts were 4.15 metres forward, 7.35 metres aft, with the fore peak, ballast tanks No 1 centre and No 2 port and starboard, and the bow thruster space breached. The main engine was available for use as required.

Figure 5

Finnreel aground

Figure 6

1.4.8 At 0008 on 15 March, the salvage master arrived on board to discuss the salvage plan. Shortly after this all four coastguard officers left *Finnreel*. At 0245, the tug *Jason* arrived alongside with a dived survey being carried out between 0300 and 0400. The results of the dived survey showed that there was no damage other than that reported earlier. By 0800, the tug *Kalkke* was alongside with preparatory work for the refloating well advanced. The salvage company, Alfons Hakans Salvage Ltd, had discussed and agreed with the master what operations were to be carried out. These included the removal of about 2100 tonnes of cargo from the after part of the main cargo deck on to barges and the restowage of other cargo from forward to aft as required.

Throughout the morning of 15 March 2001, various officials boarded the vessel, and ballast operations and cargo damage inspections were carried out. By 1445, the vessel was considered ready for the cargo lightening operation, with barges and discharge equipment in position. During the next 10 hours, cargo discharge to a barge moored astern continued, until two barges had been loaded **(see Figure 7)**.

Figure 7

Cargo being discharged while aground

Tank ballast operations were carried out as the operation progressed. Damaged tanks were sealed and pressed up with compressed air, it being anticipated that the final draughts would be 4.92 metres forward and 6.80 metres aft. Once afloat it was intended that the vessel would return to Rauma.

A further dived survey, between 1600 and 1645, established that damage was between frames 176 and 218, with the actual grounding point between frames 182 and 205.

1.4.9 At 0310 on 16 March 2001, cargo discharge resumed with completion of discharge and ballasting operation during the early evening of that day. *Finnreel* was refloated at 1900, and was towed back to Rauma where she finally docked at ro-ro berth No 4 at 2034.

Once alongside, the remaining cargo was discharged by 0635 on 17 March. Once berthed alongside at Rauma, a crankcase inspection was carried out together with crankshaft deflections. No defects or misalignment were found. For the subsequent voyage to Gothenburg, the crankcase mist detector was disconnected. The vessel sailed at 1845 on 18 March for Gothenburg for repairs.

1.5 CREW PARTICULARS

1.5.1 The vessel had been issued with a UK safe manning certificate in accordance with the requirements of The Merchant Shipping (Safe Manning, Hours of Work and Watchkeeping) Regulations 1987. This specified a minimum manning of ten persons. At the time of the grounding *Finnreel* had a crew of 14. The managers had opted to carry an extra deck officer to the number required by the safe manning certificate. An additional second engineer was also carried on board for handover purposes.

As the vessel was UK-registered, and the officers did not possess UK certificates of competency, they were required to hold certificates of equivalent competency issued by the Maritime and Coastguard Agency. This they did.

1.5.2 The master was born in Poland, but was Swedish. He had been at sea since 1973 and had obtained his Swedish master’s certificate in 1988/89. Most of his experience had been on ro-ro vessels and reefers, and he had been master for 8 years. He was ashore for 11 months in the year 2000 and joined Norbulk Shipping in January 2001. He had sailed previously on *Finnreel* as master for 4 weeks and rejoined the vessel at the beginning of March 2001. He was in the second week of a new tour of duty when the grounding occurred.

The chief officer was Lithuanian, had been at sea for 15 years and obtained his Lithuanian master’s certificate in October 2000. He had been employed by Norbulk Shipping for 7 years, and had sailed on *Finnreel* previously. He joined the vessel at the beginning of March 2001.

The second officer was Latvian, had been at sea for 2½ years and had obtained his Latvian licence to sail as a deck officer in 1998. He joined *Finnreel* in Kotka, Finland, at the beginning of February 2001.

The helmsman at the time of the grounding was Latvian, had been at sea for 13 years and was sailing as bosun. He had been on *Finnreel* for 6 weeks, during which time he had acted as helmsman when she entered or left harbour.

The pilot was Finnish, and had been at sea for 18 years, four of which were as master. After 3 months as an apprentice, he had qualified as a pilot in January 2001. He had previously piloted *Finnreel* on three or four occasions as an apprentice pilot, and three or four times as a qualified pilot.

1.5.3 The chief engineer was Swedish and had been at sea for 30 years. He obtained his latest Swedish endorsement to sail as chief engineer in an unlimited capacity in 1998. He had sailed on Norwegian ro-ro vessels for three years before joining *Finnreel* in December 2000. Since then he had sailed on the vessel one month on, and one month off. He rejoined the vessel towards the end of February 2001.

The second engineer was Latvian and obtained his second engineer's certificate in 1998.

The third engineer was also Latvian, and obtained his second engineer's certificate in 1999.

The electrician was Latvian and obtained his second class electro-engineer's certificate in September 2000.

1.6 DESCRIPTION OF VESSEL

1.6.1 *Finnreel* was a steel-hulled, ro-ro cargo carrier, built in August 2000 at the Jinling Shipyard, Nanjing, China. She was constructed under Lloyd's Register "ShipRight" SCM, with bridge and accommodation forward, and engine room aft. She had two stern doors with external ramps, the port one 4.5 metres wide, the starboard one 11.3 metres wide. The internal cargo space had a clear height of 5.0 metres with a total lane length of 1891 metres. She was fitted with two thrusters, one 900kW forward, and one 600kW aft. A semi-balanced rudder was fitted with rotary vane hydraulic control.

The main engine was fitted with a bridge control system, and was designed to operate at constant speed. Vessel speed and manoeuvring was controlled by varying propeller pitch, although engine speed could be varied under constant pitch conditions. A full main and auxiliary alarm system was fitted in the engine control room, together with the main and auxiliary switchboards. Monitoring of the ECR alarm panels from the bridge during unmanned operation periods was carried out using CCTV units. Propeller pitch and alarm print-out facilities were fitted in the engine control room.

1.6.2 Main propulsion was by a single four stroke, 12 cylinder Vee type MAN/B&W diesel engine. It operated at a nominal speed of 500rpm with a maximum output of 12,600kW. It drove through a fixed single reduction gearbox and flexible couplings to a single shaft and controllable pitch propeller (CPP). A single direct drive power take-off from the port side of the gearbox drove a 1500kW 400v alternator. Two 500kW diesel alternators provided auxiliary electrical power at 400 volts 50Hz.

The main engine control system was fitted with an alarm print-out, together with auto shutdown facilities linked to the main engine crankcase oil mist detector system, and high temperature-bearing sensors. An emergency main engine override, fitted on the bridge console, allowed continual operation of the engine, despite shutdown signals due to low lubricating oil pressure or high cooling water temperatures. There was also a light and alarm indicating main engine shutdown on the bridge console.

Steam was provided from an oil-fired auxiliary boiler, as well as from an exhaust gas boiler built into the main engine exhaust system. Steam pressure was 8.3 bar.

1.6.3 The bridge was fitted with two GPS sets, two radars, (one 3cm and one 10cm ARPA) an ECDIS, echo sounder, autopilot, and a course recorder. A weather fax and Navtex units were also fitted. The steering position was built-in on the centre line of the bridge console, with the engine and pitch control unit on the starboard side together with the thruster control units. The engine alarm monitor and a telegraph data logger was on the port side of the console. Bridge wing consoles, giving engine and pitch control, as well as control of both thruster units, were fitted. An emergency main engine stop button was fitted on both the main console and bridge wing consoles, together with a main engine revolution override button if emergency engine speed was required **(see Figure 8)**.

Two MF/HF transceivers were fitted, together with Satcom C and Satcom B units. Two VHF radio units with digital selection control plus six portable VHF radio units were carried.

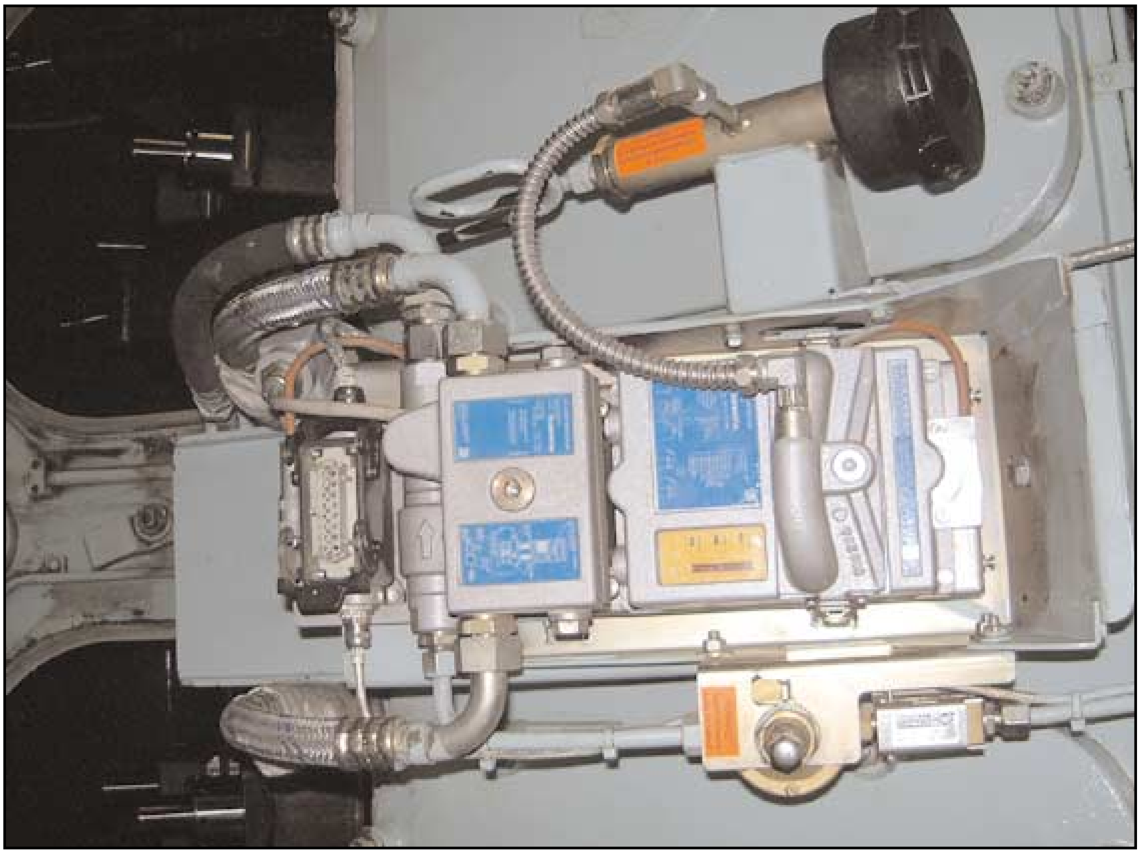
1.6.4 In respect of *Finnreel,* the managing company, Norbulk Shipping, had a certificate of compliance for the ISM Code under SOLAS 1974(as amended), issued by DNV on behalf of the Government of Norway. This was valid until 2004.

At the time of the grounding, *Finnreel* had full valid statutory certification.

Figure 8

Finnreel bridge console

Figure 9



Oil mist detector

1.7 VISATRON OIL MIST DETECTOR (see Figure 9)

1.7.1 The Visatron Oil Mist Detector unit is fitted directly on to, and in, the main engine crankcase. Its function is to sample the atmosphere within the crankcase continuously, and to measure the opacity of that sample compared to that of a representative sample from the engine room. Depending upon the agreed level of sensitivity, an alarm will sound, followed by automatic shutdown of the main engine unless remedial action is taken.

To draw that continuous flow of air from the crankcase up and across the measuring track, a vacuum is created by an air jet pump using low pressure compressed air. The sample flow, consisting of the sucked in atmosphere from the main engine crankcase, is guided through an optical channel for measuring the opacity or turbidity of the sample. The turbidity of the sample is measured by the level of absorption of infrared light.

Percentage opacity is used as the dimensional unit of the turbidity; 100% opacity means total absorption, and 0% opacity means no absorption. Oil mist becomes explosive from a concentration of approximately 50mg of atomised oil in one litre of air and up, which corresponds to an opacity of approximately 40%.

For operation, the unit requires a 24 volt d.c. supply and a driving air supply of between 0.3 and 0.5 bar. It is rated to operate through a temperature range of between 0°C and +70° C, a maximum 90% RH, and a maximum acceleration of 6g.

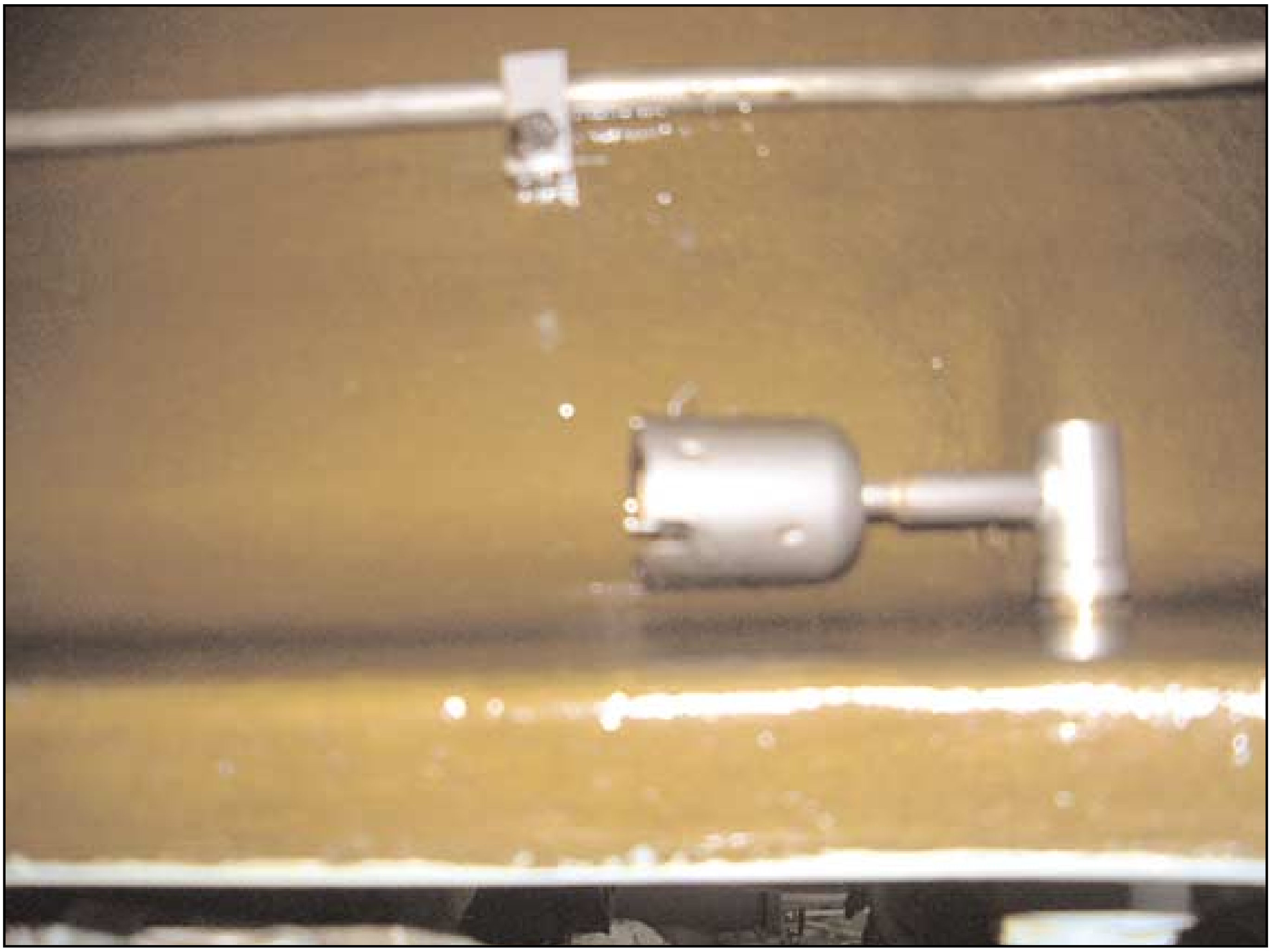
1.7.2 As to the construction of the unit, on the front are two shielded air intake openings, each fitted with a sintered bronze filter. Behind the right-hand filter is a temperature sensor with an inlet flow sensor behind the left filter. The owner chose to fit a Typhoon filter on top of the standard filter inlets to provide an additional level of filtration on the engine room air intake. This additional filter is used in areas where the atmosphere is particularly dusty/dirty or where high humidity is likely to be experienced.

Fitted between the unit and the crankcase, is a 24 volt d.c. heating plate. Its function is to ensure that condensation does not occur in the unit because of wide temperature changes on the unit caused by the engine room temperature variations.

The crankcase sampling pipe system **(see Figure 10)** is installed with a rise of between 2° and 4° to the horizontal leading up to the unit intake. This is to prevent the build-up of oil droplets within the sampling lines causing misleading alarms because of a false impression of opacity.

The air supply to the venturi which creates the vacuum in the measuring chamber is supplied through a pressure regulator and throttle block from a take-off from the usual 2 to 12 bar compressed air ring main in the engine room.

Figure 10



Crankcase sampling head

1.7.3 The control and display window fitted to the unit has five indicator and controls on the front - an alarm LED (Red), a test LED (White), a ready LED (Green), a graded opacity display showing the opacity % on one side and error condition numbers on the other, and an alarm level sensitivity switch. Attached to, but separate from the display panel, is a reset button.

In normal operation (low mist level), the ready LED is on, all others are off. This indicates that electrical power is on, and the air flow sensor confirms that air is flowing across it. If the oil mist increases into an alarm level, the alarm LED “blinks” with the ready LED remaining on. The level of opacity sensed is shown on the opacity display which reads from 0% to 7%, an alarm condition usually set at 2%. The test LED checks only the optical path i.e. that the opacity is acceptable, glasses clean and elements operating.

The alarm sensitivity switch for the four positions marked on the dial (others are available but not marked) are as follows:

1	-	0.5% opacity		
4	-	2.0%	“	(this is the sensitivity set in the factory)
6	-	5.0%	“	
9	-	15.0%	“	

The factory setting of 4 is usually retained by owners, although in engines that are particularly “dirty” in operation a higher setting is selected. In the case of *Finnreel*, the factory setting of 4 was retained.

The re-set button is purely to release the alarm condition. When an alarm condition occurs, the unit remains electrically locked until the reset button is pushed. If an alarm occurs and the reset is immediately pushed before the condition is cleared, the system will clear momentarily, then return back into the locked position.

The reset button does not need to be pressed before the engine is restarted after a normal shutdown - starting the engine will cause the unit to go through its own pre-operation test before automatically moving into the operating mode.

1.7.4 The system as installed complies with the classification requirements of Part 6, Chapter 1, Sections 3.1 and 3.2 of Lloyd’s Register of Shipping. The two sections refer to the control and alarm systems to be fitted to main propulsion engines.

Section 3.1.6 states that oil mist monitoring, or engine bearing temperature monitors for crankcase protection, should be provided with auto shutdown in the case of medium or high-speed engines.

Section 3.2.2(b) states that in the event that an alarm condition is detected due to oil mist or high bearing temperature, automatic shutdown of the main engine is required.

The company fitted both bearing temperature sensors, and an approved oil mist detector system, to the main engine.

1.8 "BANK" AND "SHALLOW WATER" EFFECTS AND SQUAT

"Bank" Effect

"Bank" effect occurs when a vessel is navigating close to a river or channel bank and causes her to behave somewhat erratically, unless controlled by the rudder.

The pressure distribution along the side of the ship is modified because the apparent water flow between the bank and the ship side is severely restricted compared with when navigating away from the bank in a wide river or canal. This problem is compounded when the under-keel clearance is small and the flow under the vessel is restricted causing more water to flow around the sides. The net result of the changed flow conditions is that the fore and after pressure fields increase in intensity while the amidships pressures fall, causing a transverse suction force. Consequently, the suction field pulls the ship bodily towards the bank, but as the forward pressure field is greater than the after pressure field because of the ship's forward motion, the ship's head yaws away from the bank.

To prevent hitting the opposite bank, which may occur at a steep angle where bank effect does not affect the vessel to such an extent, the rudder must be applied to counter the yaw and maintain the vessel's heading.

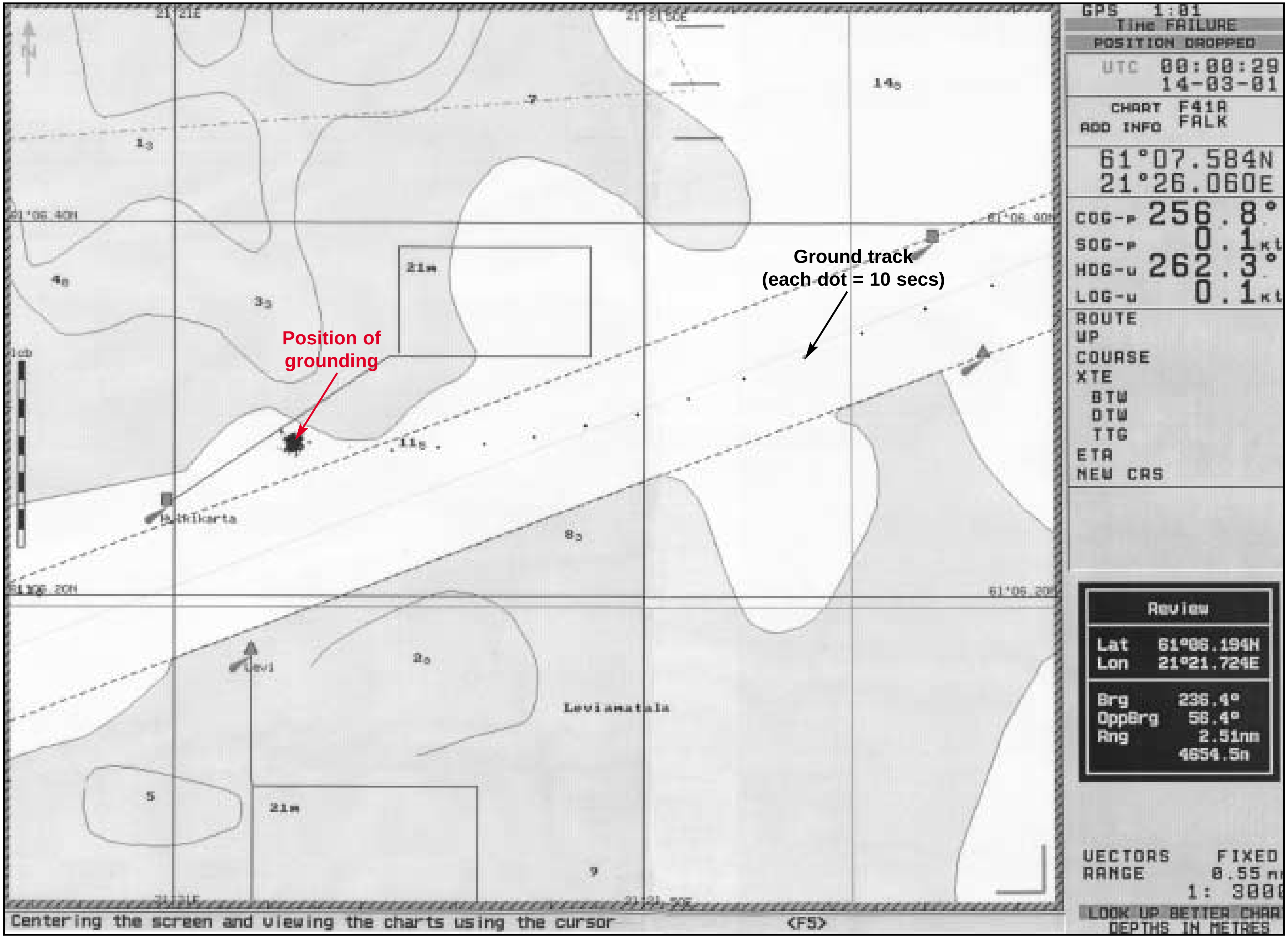
"Shallow Water" Effect

"Shallow water" effect occurs when a vessel is navigating in shallow water and causes her movement to become sluggish. Wave-making and turbulence increase, and there is a drop in vessel speed and an increase in vibration. This effect increases with speed, and is inversely proportional to under-keel clearance.

Squat

The effect of squat, caused when passing through shallow water at speed, can reduce under-keel clearance. Squat is similar to "bank" effect, described above, but in a different plane where the restriction because of water being accelerated through the narrow space between the seabed and the keel causes a pressure decrease and a consequent fall in local water level, making the ship sit deeper in the water. Squat also increases with speed, and is inversely proportional to under-keel clearance.

Marine Guidance Note MGN 18(M), entitled "Dangers of Interaction" and published by the UK Maritime and Coastguard Agency, and the Mariner's Handbook, published by the UK Hydrographic Office, give further information on the above.



Extract from electronic chart used on *Finnreel*

1.9 THE PORT OF RAUMA

Rauma is Finland's principal port for the export of paper, handling nearly one-third of all paper exported from the country. It also exports timber, woodpulp and cellulose. Imports include oil, coal, china clay, animal foodstuffs and grain. Rauma is the third-biggest port in the country. More than 5 million tonnes of exports and imports pass through it, with over 800 vessels using the port every year. During the winter months, ice breakers keep the channel open.

There are three channels to and from the port **(see Figure 2)**. The north channel, Valkeakari, is the shortest route but is not as well marked and is authorised only for vessels with a draught of 7.0m or less. The middle channel, Kylmapihlaja, is for vessels with a draught of 3.8m or less. The south channel, known as the Rauma channel, is used by the majority of vessels calling at the port. It is authorised for use by vessels with a draught of up to 10m. During the winter months the channel is kept open by ice breakers.

From the ro-ro terminals outward bound, a course of 219° is steered for about 1 mile until reaching the main channel, which is covered in an inbound direction by leading lights. A course of 248.5° is then steered for 3 miles. Half-way through this particular leg of the passage the channel passes between Levi buoy to the south and Hylkikarta buoy to the north. Immediately east of the buoys are two small "bays" of deeper water on each side of the channel, the northern "bay" being more pronounced than the southern one. At the buoys the channel is about 170 metres wide between sheer granite banks, with a bottom breadth of 120m, the depth of water being less than 3.5 metres by Hylkikarta buoy, and less than 2 metres close east of Levi buoy **(see Figure 3)**.

After a further 4 miles, on a course of 290.5°, the pilot station is reached and the vessel makes full away on passage after the pilot has disembarked.

Since the channel was dredged in 1996 there have been no reported groundings or significant incidents. There was no speed restriction for vessels using the channel. The Rauma channel is bar-swept to a clearance of 11.50m from chart datum. Prior to the incident, the Finnish Maritime Administration conducted a risk assessment regarding the size of vessels which can use the channel, the traffic flow and navigability of the channel.

The west coast VTS of Finland is divided into two sectors, Pori port and Rauma port. Each sector is dedicated to the entrance and channels leading into the appropriate port, and has radar coverage of the port and its approaches. The pilot station, located on Kylmapihlaja Island, also has radar coverage of the Rauma channel.

1.10 DAMAGE

The vessel's fore peak, and No 1 centre and No 2 port and starboard ballast tanks were all holed along with the forward bow thruster space as a result of the grounding. The vessel was subsequently repaired in dry dock in Gothenburg.

There were no injuries or pollution as a result of the grounding.

1.11 ACTION TAKEN SINCE THE INCIDENT

Following this incident, the owner consulted Lloyd's Register regarding its requirement for automatic shutdown of the main engine when high oil mist is detected in the crankcase even when a bearing temperature monitoring system was fitted. Lloyd's Register responded as follows:

We have considered your request to modify the main engines on the subject vessels so that in the event of high mist being detected in the crankcase, a load reduction can be effected instead of shutting down the main engine.

Since the engines are also fitted with bearing temperature monitoring we will, in this instance, waive the rule requirement for automatic shut down and accept the proposal to modify the engine safety system such that in the event of high oil mist the propeller pitch will be reduced. It is concluded that the oil mist alarm will still be initiated.

Further discussions were held with the engine manufacturer as to any other possible solutions, but ultimately it was felt that the original, Lloyd's approved, pitch reduction system was the best solution. Modifications to *Finnreel* and her three sister vessels have resulted in an immediate pitch reduction of just under 60% when the high oil mist alarm sounds.

These modifications to the operation of the oil mist detector system apply just to *Finnreel* and her three sister vessels. They were approved based on the circumstances of the incident and the dual oil mist and bearing temperature alarm systems fitted on these vessels.

Procedures have been put in place on board all Norbulk managed vessels to ensure that all bridge alarm system indicator lights are checked prior to arrival and departure from each port. In addition, these tests have also been included in the standard daily bridge equipment checks and tests.

The internal wiring of the oil mist detector fitted on board *Finnreel* was checked by the manufacturer's service engineer during the vessel's repair period in Gothenburg in March 2001. No wiring defects were found within the system.

All deck and engine personnel on board *Finnreel* and her three sister vessels are fully aware of the modified alarm and shutdown system fitted on the main engine. Relevant notices have been posted both on the bridge and in the engine room.

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 SHUTDOWN OF MAIN ENGINE

2.2.1 The automatic shutdown device on the main engine was activated as a result of the oil mist detector unit sensing a potentially explosive condition within the crankcase.

Despite an immediate response from the engine room staff, the unit remained in the locked condition. No overheating or high oil return temperatures were found at that time, nor were any defects discovered during a subsequent internal examination of the crankcase.

2.2.2 For the auto shutdown device to operate, an opacity in excess of 2% has to be sensed in the measuring chamber, or a fault has to have occurred within the unit. As no fault was found in the unit, the possibility of false readings was examined. Two conditions which give rise to false readings have been suggested by the manufacturer:

a. A difference of temperature between the crankcase and the engine room ambient could produce condensation in the measuring chamber, and a high opacity reading between the emitter and the receiver;

b. A quantity of oil could build up within the sampling system and eventually become entrained in the sample air and enter the measuring chamber. This would register as a high opacity reading between the emitter and the receiver.

2.2.3 The difficulty with the condensation theory is that the engine room logbook records that at no time were either the electrical power or the air supply to the unit turned off during the period that the vessel was alongside. This means that the plate heater fitted to the unit was on at all times, and that the air supply was maintaining a clean supply through the unit.

With the main engine cooling system being maintained at about 73°C and the fuel valve cooling at about 83°C throughout, the atmospheric temperature within the crankcase remained quite high. The engine room itself was maintained at about 32°C. Although the range of temperatures between the air intake and the crankcase rises during main engine operation, it is considered unlikely that condensation would occur under these conditions and cause a false alarm.

2.2.4 The possibility of an oil carry-over relies on the existence of an oil pocket somewhere in the air sampling system. As mentioned earlier, the crankcase sampling pipe system needs to be installed with a rise of between 2° and 4° to the horizontal leading up to the unit intake. This prevents any accumulation of oil in the line. If, during the outfitting, or as a result of internal maintenance work, the sample pipes are disturbed or kinked, then it is possible for oil to accumulate at that point. Once oil starts to accumulate, there is a very real possibility that under the right conditions, a slug of oil will be carried forward into the measuring chamber. Once that occurs, the opacity reading will rise and an alarm condition will register and could lead to an auto shutdown.

Following the incident, the ship's staff was asked to carry out a detailed inspection of the main engine crankcase paying particular attention to the condition of the sampling pipes. The chief engineer reported that all sampling points were fitted with a suction funnel and oil discharge labyrinth and that he could find no evidence of depressions, kinks or extra bends in the sampling lines.

In his report, the service engineer mentions that he found "a little oil" and cleaned the unit. Whether this oil was sufficient to cause an alarm and shutdown is not known but, so far, it is the only evidence seen that offers a reason for the auto shutdown.

2.2.5 There remained one other remote possibility which could result in an auto shutdown of the main engine. The operating relays fitted at the factory are connected to the following terminals:

Terminals	3, 4, & 5	-	internal fault
"	6, 7, & 8	-	high oil mist

If these relays are connected in series by mistake, it is possible for a shutdown sequence to occur, even though the fault is internal and not an oil mist fault condition.

Normally an internal wiring fault such as this would be picked up and corrected at the factory during the quality control phase, but to eliminate this possibility a check was carried out by a manufacturer's service engineer in Gothenburg during the repair period that followed this incident. No internal wiring defects were found.

2.2.6 The auto shutdown of the main engine also had a significant impact on the pilot and master's ability to control the vessel. At the time of the shutdown, the shaft generator was in operation and supplying electrical power to the forward and aft thrusters. When the shaft generator tripped off the main switchboard because of the slowing down of the main engine, all electrical power to the thrusters was lost. This loss removed the master's and pilot's last chance to avoid the subsequent grounding.

Lloyd's Register approved the modifications carried out on the alarm and safety system of the oil mist detector on board *Finnreel* and her three sister vessels, because bearing high temperature monitoring was also fitted to the main engine. These modifications, resulting in an alarm signal followed by immediate pitch reduction, rather than an automatic engine shutdown, will allow the vessel to manoeuvre clear of immediate danger. Automatic shutdown will still occur if bearing temperatures exceed the operation set point, which may well be high enough to allow the continued generation of oil mist, and hot enough to cause a crankcase explosion.

It follows, therefore, that further engine operation must be limited to the minimum, with constant attention paid to the bearing temperature monitoring system. It is essential, therefore, that in the event that the oil mist detector system is activated, an "open line" communication must be immediately established between the bridge and engine control room. Both master and chief engineer need to establish a clear set of guidelines on the procedure watchkeepers should follow, and establish that all officers are fully aware of the potential dangers involved while the vessel is in this condition.

2.3 ACTIONS OF BRIDGE PERSONNEL

The master, pilot and third officer were caught by surprise by the engine shutdown and didn't realise that the engine had, in fact, stopped until after the grounding. The time from the start of the swing to starboard to the grounding was about 90 seconds.

The master first realised something was wrong when, standing on the starboard bridge wing, he noticed that both thrusters had tripped. This was unusual but, in isolation, was not a serious problem. When he approached the centre console, the helmsman drew his attention to the loss of steering. He could see his vessel was off course to starboard, that the helmsman had applied port helm, and that the vessel was continuing to swing to starboard. He, therefore, quite naturally, turned his attention away from the thruster problem. He informed the chief engineer that there was something wrong with the steering, believing it to be a mechanical fault. His conversation with the chief engineer was short. The chief engineer was unable to tell him of the shutdown and was also busy himself.

The master could hear an alarm sounding on the centre console but assumed it was the thruster alarm, which had a very similar tone to the auto shutdown alarm. He did not see any alarm lit on the main engine alarm panel. Later it was found that the alarm light bulb had failed, a fault not picked up in the pre-sailing tests. However, even if the master had been made aware by the alarm that the engine had shut down, it would have made little difference to the situation and would not have prevented the grounding **(see Figure 11)**.

The master then moved the propeller pitch control to slow astern and confirmed, by visually checking the relevant gauge, that the pitch was responding. The pilot asked for hard-to-port from the bow thruster but was told by the master that he could not start the thruster unit. The master placed the propeller pitch to full astern and, although the propeller pitch moved into the full astern position, the vessel grounded shortly after. The master was aware that the pitch was responding and operating normally but was unaware that the engine had stopped and his actions of operating the pitch would have negligible effect.

The pilot had ordered hard to port and asked for the bow thruster. He had seen the master applying astern pitch, and was also unaware that the engine had stopped. On *Finnreel*'s bridge, unlike on some older vessels, there is little vibration to indicate that the main engine is running.

The actions of those on the bridge were appropriate in the circumstances, and there was little more they could have done, in the short space of time between the engine shutdown and the grounding, to have altered the circumstances.

In not attempting to free the vessel from her grounding position, as he was not aware of the extent of the damage, was a wise decision by the master. If the vessel had been refloated by moving astern, she might have taken on sufficient water to sink her.

Shutdown light
(bulb not working at the time of the incident)

Figure 11

Bridge console engine alarms

2.4 ACTIONS OF ENGINE ROOM PERSONNEL

2.4.1 The response of the engineering staff in the ECR, at the time of the oil mist detector alarm and shutdown, was immediate and followed standard practice. It is not clear whether or not they operated the detector reset button at the engine side (if the alarm condition still existed the lock out would have been automatically re-imposed) but even if they had, the engine would have required restarting. Given the time frame between engine shutdown and the grounding, it is unlikely that there was sufficient time to have prevented the accident.

2.4.2 After the grounding, the chief engineer arranged for the main engine turning gear to be engaged and for the crankcase doors to be removed. A thorough internal inspection of bearings and detector heads was then carried out, using the turning gear as required. No evidence of bearing failure or misalignment was found. This action, in addition to a check on the steering gear and CPP, confirmed that there was no apparent damage to either steering gear, propeller assembly, or main engine. This series of examinations is good engineering practice and what the company would expect of professional engineering sea staff.

2.4.3 With no indication that either the oil mist detector system was malfunctioning, or any suggestion that a bearing was running hot, there was no way that the engineering staff could have foreseen this incident or acted to prevent it.

Immediately after the grounding, the engineering staff, under the master's and chief engineer's direction, followed the emergency procedures stated in the company's Emergency Guidance Manual.

2.5 "BANK" AND "SHALLOW WATER" EFFECTS

Before the engine shutdown, the vessel was having to apply helm, on a continuous basis, to maintain her course in the channel. This indicates that some form of bank effect was taking place. As soon as the main engine had shut down, the water flow to the rudder was disrupted and the rudder's ability to control the ship's heading was reduced severely.

When the main engine shut down, the vessel took a sheer to starboard, which continued despite the rudder being placed hard to port. This eventually forced the vessel out of the channel on the starboard bank at a steep angle, until she ran aground on the granite slopes close east of Hylkikarta buoy.

The vessel had been in the centre of the channel, which was about 120 metres bottom width at the point where the grounding occurred. The vessel has a beam of 20.62m. This gives a distance of around 50m to each bank, a considerable distance in proportion to the vessel's beam, but with about 4.8 metres under-keel clearance and a speed of 12.5 knots, it was quite possible for "bank" effect, of some form, to occur.

The under-keel clearance might have been less than 3m because of the effects of squat, caused when passing through shallow water at speed. This would have been likely to increase the magnitude of the “bank” effect.

The reason the vessel sheered to starboard and not to port is not known for certain, but was probably because of the proximity of a deep water “bay” to the north of the vessel at the position of the shutdown. This created a low pressure to starboard. Together with the high pressure from the port side bank, this would have tended to force the vessel to starboard.

“Shallow water” effect probably also contributed, to a lesser degree, towards the vessel’s sheer out of the channel. It was unfortunate that the engine shutdown occurred in just about the worst navigational position. Had it occurred elsewhere in the channel, the vessel might not have grounded. It was also unfortunate that the incident occurred at the time of year that it did as just two weeks before the accident, the channel had been iced-locked and cleared by an icebreaker each day. The ice on the edge of the channel would have been likely to have kept the vessel within the channel and prevented the grounding, but might also have caused hull damage.

A speed of 12.5 knots was considered quite normal for a vessel of this size in this channel. The master could have instructed the pilot to reduce speed when passing through the areas where the banks were steep but, based on previous experiences entering and leaving Rauma, including pilotage with the same pilot involved on the night in question, he decided it was unnecessary to do so.

The pilot normally proceeded at 12.5 knots in the Rauma channel. He was aware of “bank” effect but had never experienced a sheer out of the channel before. There was no speed restriction for vessels using the channel.

SECTION 3 - CONCLUSIONS

3.1 FINDINGS

1. *Finnreel* ran aground while outbound, under pilotage, in the main channel off Rauma, Finland, at 1908 UTC on 14 March 2001. [1.4.5]

2. At the time of the incident *Finnreel* had full valid statutory certification and was manned in excess of her safe manning certificate. [1.5.1,1.6.4]

3. Weather conditions were good at the time of the grounding; there was some broken ice drifting in to the port, with an air temperature about zero. Visibility was about 6 miles, it was partly cloudy, with no rain or snow and virtually no wind. There was no tide and little current. [1.3]

4. No other traffic was either inbound or outbound at the time of the incident. [1.4.2]

5. The pilot had the conduct of the navigation at the time of the incident. [1.4.2]

6. The vessel was in hand steering, with the third officer and master on the bridge in addition to the pilot and helmsman. [1.4]

7. The master was on the starboard bridge wing when he saw and heard the alarm which indicated that the thrusters had tripped. [1.4.5,2.3]

8. The helmsman reported a problem with the steering as he had applied port helm and the vessel was swinging to starboard. [1.4.5,2.3,2.5]

9. The master adjusted the propeller pitch to slow and then full astern believing the engine to be still running. [1.4.5,2.3]

10. The vessel sheered to starboard out of the channel before grounding close east of Hylkikarta buoy. [1.4.5,2.5]

11. The sheer to starboard was, probably, caused by “bank” effect due to the proximity of shallow water to port and a small “bay” of deeper water to starboard. [2.5]

12. The water flow to the rudder was disrupted by the engine shutdown which severely reduced the rudder’s ability to control the ship’s heading. [2.5]

13. The speed at the time of the engine shutdown was 12.5 knots.[1.4.5,2.5]

14. The indicating light for the main engine shutdown alarm on the bridge console was not working. [2.3]

15. The engine shutdown occurred in just about the worst navigational position. [2.5]

16. The master's action in not attempting to free the vessel from her grounding position, as he was not aware of the extent of the damage, was a wise decision. If the vessel had been refloated by moving astern, she might have taken on sufficient water to sink. [2.3]

17. The actions of those on the bridge and in the engine room were appropriate in the circumstances, and there was little more that could have been done to prevent the grounding. [2.3,2.4.3]

18. The oil mist detector system was an LR approved type and complied with classification requirements that an automatic shutdown device should be installed on the propulsion unit. [1.7.4]

19. No overheating or high oil return temperatures were found at that time nor were any defects discovered during a subsequent internal examination of the crankcase. [2.2.1]

20. Although the range of temperatures between the air intake and the crankcase rises during main engine operation, it is considered unlikely that condensation would occur under these conditions and cause a false alarm. [2.2.3]

21. The service engineer in his report mentions that he found "a little oil" and cleaned the unit. Whether this oil was sufficient to cause an alarm and shutdown is not known but, so far, it is the only evidence seen that offers a reason for the auto shutdown. [2.2.4]

22. The possibility of an internal wiring defect was considered and eliminated during the ship's repair period at Gothenburg, following the incident. [2.2.5]

23. The modifications carried out to *Finnreel* produce an immediate pitch reduction rather than an automatic engine shutdown, and will allow the vessel to manoeuvre clear of immediate danger. [2.2]

24. Automatic shutdown will still occur if bearing temperatures exceed the operation set point, but that set point may well be high enough to allow the continued generation of oil mist, and hot enough to cause a crankcase explosion [2.2.6]

25. Strict monitoring of bearing temperatures is essential to reduce or avoid the danger of a crankcase explosion and serious engine damage. [2.2]

3.2 CAUSE

1. The initiating cause of the incident was the alarm activating on the main engine oil mist detector. The reason for the alarm activating has not been determined. [2.2]

2. The cause of the grounding was the vessel sheering to starboard out of the channel with no means available to remedy the situation. [2.3,2.5]

3.3 CONTRIBUTORY CAUSES

1. The shut down of the main engine due to the operation of the main engine oil mist detector alarm. [2.2]

2. The tripping off of the shaft generator switchboard breaker preventing use of the fore and aft thrusters. [2.2.6]

3. “Bank” effect, which probably caused the vessel to sheer to starboard. [2.5]

4. The relatively high speed of the vessel which enhanced the magnitude of the “bank” effect, “shallow water” effect and squat. [2.5]

5. The relatively small under-keel clearance of the vessel which enhanced the magnitude of the “bank” effect, “shallow water” effect and squat. [2.5]

6. The effect of squat which possibly reduced the under keel clearance and therefore possibly enhanced the magnitude of the “bank” effect and “shallow water” effect. [2.5]

7. The vessel’s position in the channel at the time of the main engine shutdown. [2.5]

8. The reduced effectiveness of the rudder to control the ship’s heading following the loss of propulsion. [2.5]

9. “Shallow water” effect which probably further reduced the effectiveness of the rudder. [2.5]

SECTION 4 - RECOMMENDATIONS

Norbulk Shipping UK is recommended to:

1. Establish procedures that ensure an “open line” communication between the bridge and engine control room, is in place in the event of a high oil mist detector alarm activating.

The Finnish Maritime Administration is recommended to:

2. Review its risk assessment with regard to speed of vessels using Rauma Channel and the consequences of grounding.

3. Circulate this report to its pilots and harbourmasters.

Marine Accident Investigation Branch
May 2002