Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

MARINE INVESTIGATION REPORT

M11W0211

STRIKING OF BERTH

ROLL-ON/ROLL-OFF FERRY *COASTAL INSPIRATION*
DUKE POINT, BRITISH COLUMBIA
20 DECEMBER 2011

Canada

Marine Investigation Report

Striking of Berth

Roll-on/Roll-off Ferry *Coastal Inspiration*
Duke Point, British Columbia
20 December 2011

Report Number M11W0211

Summary

On 20 December 2011, at approximately 1450 Pacific Standard Time, the bow propulsion pitch control on the *Coastal Inspiration* failed to respond while the vessel was approaching the Duke Point ferry terminal in Nanaimo, British Columbia. As a result, the vessel struck the berth at an approximate speed of 5 knots. There was extensive damage to the vessel and ferry terminal, and several passengers and crew sustained minor injuries.

Ce rapport est également disponible en français.

Factual Information

Particulars of the Vessel

Name of vessel	*Coastal Inspiration*
Official number	832381
Port of registry	Victoria, BC
Flag	Canada
Type	Double-ended roll-on/roll-off ferry
Gross tonnage	21 777
Length overall [1]	160 m
Draught	Forward: 5.41 m Aft: 5.64 m
Built	2008, Flensburger, Germany
Propulsion	Electric motor, type VEM DKMUX 1040-10WE, 11 MW, driving 2 controllable-pitch propellers at 140 rpm
Maximum capacity of vessel	1604 passengers and crew, 402 vehicles
On board at the time of occurrence	346 passengers, 31 crew, 129 vehicles
Owner	British Columbia Ferry Services Inc., Victoria, BC

Description of the Vessel

Photo 1: *BCFS Coastal Inspiration* (Source: BC Ferries, with permission)

The *Coastal Inspiration* is a double-ended vessel in service since 16 June 2008 and is 1 of 3 sister vessels operated by the British Columbia Ferry Services (BCFS).

The engine room is located amidships and a bridge, controllable-pitch propeller, and rudder are at each end of the vessel (Appendix A). The 2 ends are identical and, for the purposes of identification, are numbered 1 and 2. The port and starboard sides of the vessel are determined by the direction of travel; in contrast, the numbering system of the machinery in the engine room remains the same regardless of the direction travel.

---

1 Units of measurement in this report conform to International Maritime Organization (IMO) standards or, where there is no such standard, are expressed in the International System of Units (SI).

Figure 1 presents a layout of the propulsion system. The engine room contains 4 engines, each coupled to a synchronous generator (Gen). The generated electrical power is fed to two 6.6 kV propulsion switchboards, 1 at either end of the vessel. Two 600 V main switchboards are then fed from the propulsion switchboards via transformers and supply power to other auxiliaries. The switchboards are arranged in 2 sections with a tie bar that electrically connects both sides of the engine room or isolates one side from the other. The propulsion switchboards drive the electric motors required for propulsion. The vessel is propelled by 2 electric drive motors (DM1 and DM2), 1 at either end of the vessel. Each drive motor has 1 propeller shaft and associated components.

Propeller pitch can be varied while the propeller shafts rotate at a constant speed of 140 rpm. Vessel speed is controlled from either the bridge or the engine control room by altering the propeller pitch via handles; [2] moving a handle transmits data to the pitch control system electronically. The propeller pitch is normally controlled from the bridge and has several back-up features (see the Controllable-pitch Propeller section on page 4).

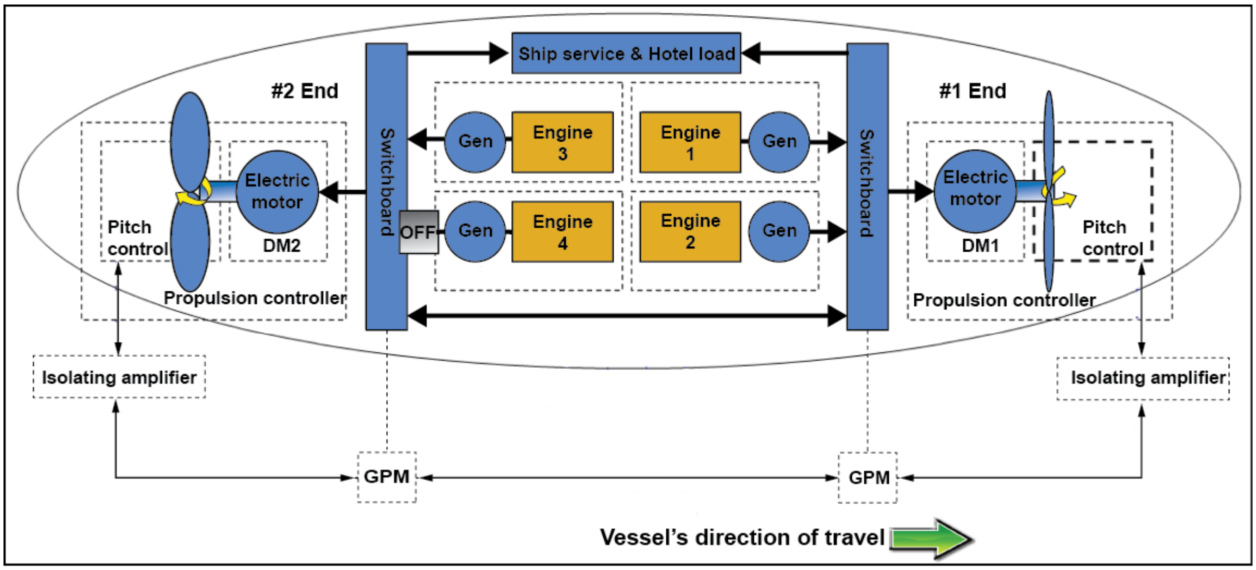


Figure 1. Propulsion system layout (3 engines online)

Modes of Propulsion

The vessel has 2 modes of propulsion, referred to by British Columbia Ferry Services Inc. as Mode 1 and Mode 2. Mode 1 is used when the vessel has completed manoeuvring and is under way. The stern drive motor uses the power generated by 3 engines to turn the propeller, which thrusts ahead in the direction of travel. During the passage, the bow propeller is in a feathered position [3] and the forward rudder is locked in mid-ship position.

Mode 2 is used during berthing, unberthing, and tight-quarters manoeuvring, and uses a minimum of 3 engines to both drive motors, with each drive motor providing power to its

---

2 The handle for the bow propeller is L-shaped, while the handle for the stern propeller is T-shaped.

3 This position offers the least resistance to water flow.

respective propeller. The amount of power supplied to each propeller can be controlled by adjusting the corresponding blade pitch.

Controllable-pitch Propellers

A controllable-pitch propeller has blades that can be rotated around the propeller axis to change pitch between ahead and astern. On the *Coastal Inspiration,* both the bow and stern propeller shafts turn in the clockwise direction when viewed from their respective stern. The time of response to actual pitch adjustment is approximately 1.8° per second, as designed.

There are several ways to control the pitch of both propellers: normal operation, remote emergency pitch control, and local emergency pitch control. There is also an emergency telegraph to provide orders for engine room pitch control using handles, emergency push buttons, or local manual control.

Normal Operation

The vessel's pitch setting for both the bow and the stern propeller is controlled from the bridge in use using the respective handles at the manoeuvring console (Appendix B). The power supplied to each propeller varies as the handles are moved. The propellers are run independently of each other but both are controlled by a power management system.

Pitch-control Displays

Movements of pitch control are indicated to the operator at the manoeuvring console via 2 displays: an analog display and a digital ladder display. The pitch-indicator range for the analog indicator is marked from 0 to 90° in the ahead direction and 0 to 30° in the astern direction. However, the actual operational range is limited to between 0 and 24° in the ahead direction and 0 and 18.24° in the astern direction. [4] At the higher end of this operational range, the pitch is at its maximum and the speed of the vessel is optimal. The only time the pitch on the indicator goes beyond 30° ahead is when the propeller is feathering to 90°.

History of the Voyage

At the time of the occurrence, the *Coastal Inspiration* was based at Duke Point, BC, and operated on the route from Duke Point to Tsawwassen, BC.

On 20 December 2011, the vessel began its scheduled crossings for the day at 0515. [5] A single 35.7 nautical mile (nm) crossing takes about 2 hours; the vessel made the first 3 crossings without incident. The vessel left Tsawwassen on time at 1245 for its fourth trip of the day, with 346 passengers, 129 vehicles, and 31 crew on board. The scheduled arrival time was 1445 with a crew change planned at 1500.

At 1254, the vessel was full away and operating on Mode 1. The bridge was manned by the master, an officer of the watch, and a quartermaster. The steering was set on autopilot and the forward rudder was locked in mid-ship position.

---

4 The pitch in the astern direction is limited electronically to 17°.

5 All times are Pacific Standard Time (Coordinated Universal Time [UTC] minus 8 hours), unless otherwise stated.

After approximately 45 minutes, the master handed over the con to the officer of the watch and left the bridge. The handle setting on the stern propeller [6] was at 7.7 ahead (Appendix C), corresponding to the vessel's speed under way of approximately 20 knots. [7] Around 1430, before the vessel passed Entrance Island (Appendix D), the chief officer arrived on the bridge to relieve the officer of the watch.

At 1438, when the vessel passed Snake Island, the chief officer switched the steering from autopilot to manual in preparation for changing to Mode 2. The master returned to the bridge around this time and was briefed by the chief officer on traffic, tide, wind, and berth conditions. The master then left the bridge momentarily. The crew were advised to have the anchors at each end on standby.

At 1442, at approximately 2.10 nm from the berth, [8] after requesting the engine room to be on standby, the chief officer reduced the stern propeller pitch setting from 7.7 to 7 ahead. The master arrived on the bridge shortly afterwards, took the con, and lined up the vessel for the final approach prior to berthing.

At 1446:46 the vessel was at a distance of approximately 0.62 nm from the berth and at a speed of 19.5 knots. At this time, the master further reduced the stern propeller pitch setting to 4 in preparation to change over to Mode 2 (Appendix E). This reduction in stern propeller pitch automatically initiated the request to start the bow propeller. The master then initiated Mode 2 by pressing the START button on the pitch control panel and advised the engine room. The engine room crew confirmed Mode 2 initiation.

The motor driving the bow propeller completed its starting cycle and, at 1448:45, Mode 2 was engaged but not tested. At this time, the vessel was at a speed of 8.3 knots and a distance of 0.18 nm from the berth. At 1448:50, when the vessel was at a distance of approximately 0.17 nm, the stern pitch was further reduced to allow for the unlocking of the forward rudder, which was then tested by the master.

At 1448:59, at a speed of 7.9 knots and at a distance of 0.15 nm, the master applied 5° of pitch in the ahead direction on the bow propeller to slow the vessel. [9] At about the same time, the master noticed that the Power Limited [10] indicator light was steady on the bow propeller pitch control panel and that the vessel's speed did not decrease in response to the pitch applied.

From 1449:07 to 1450:09, with the distance to the berth reducing from 260 m to 20 m and vessel's speed decreasing slowly to 6.4 knots, the master further adjusted pitch settings on the handle incrementally to prompt the bow propeller to respond. He also activated the emergency manoeuvre [11] setting to increase pitch response time in a further attempt to slow the vessel. The

---

6 The bridge team called it the T-handle.

7 All speeds cited are from the voyage data recorder (VDR) data and are speed over ground.

8 All distances are measured to the tie-up dolphin (No. 4 dolphin) at Duke Point, which is 160 m from the terminal ramp.

9 The VDR playback indicates there was no change in handle or pitch setting before this.

10 This indicator is part of the power management system serving to indicate an overload condition, which the system then automatically corrects by reducing or limiting the pitch of the propeller.

11 The emergency manoeuvre setting is installed on the transfer control panel at each bridge. When activated in an emergency, this setting increases the ramp times of the pitch control system by allowing faster acceleration and deceleration.

bow propeller pitch did not respond. When the emergency manoeuvre setting had no effect on the bow propeller pitch, the chief officer indicated to the master the emergency push buttons. The master operated the emergency pitch-control push buttons; these also had no effect.

The vessel passed the tie-up dolphin, and, with less than 160 m to the terminal ramp, impact was imminent. The bridge team sounded the vessel's whistle and, using the vessel's public address system, informed the passengers and crew to brace themselves. At 1450:42, with the stern pitch set ahead for berthing, the vessel struck the berth at an approximate speed of 5 knots.

After the striking, the crew mustered all passengers, checked for injuries, and conducted a damage assessment of the vessel and dock.

The relief master joined the vessel at 1500, and the senior master [12] came on board shortly after that, having been advised of the accident. They tested the system in normal mode, and found it to not function in that mode. They then set the normal/emergency selector switch to the emergency position. It was found to function as intended in this mode when used in conjunction with the PITCH AHEAD and PITCH ASTERN emergency push buttons for the bow propeller. The vessel was then transferred to Departure Bay in Nanaimo, BC; it arrived at 1700 and the vehicles and passengers were unloaded.

Injuries

Seven passengers and 9 crew members sustained minor injuries as a result of the hard landing and were treated on board.

Damage to the Vessel

The vessel sustained the following damage:

- The port side bow door link arm and its associated hinge pins and hydraulic cylinders, including the door plate with its associated stiffeners, were deformed. The forward edge of the starboard side bow door was torn off. The guide roller wheels at the port and starboard side bow doors were buckled.
- The starboard side shell plating made contact with the berth, causing sharp indentations at car deck No. 4 at Frame 102 and Frame 104 between side longitudinal (SL) No. 4 and No. 5 (counted from the upper deck). The vertical web frame was buckled at Frame 102, with associated deformation of SL No. 5.
- Shell plating below the rubbing plate at the starboard side of the main vehicle deck between Frame 213 and 217 was also deformed, and a plug weld on the shell plate fractured.

The vessel was out of service for 23 days for repairs.

---

12 The senior master is one of the masters on a watch. In command on board the *Coastal Inspiration,* the senior master is responsible for ensuring that all shipboard functions and operational safety issues are dealt with effectively.

Damage to the Berth

Extensive damage to the berth at Duke Point was as follows:

- The starboard wing-wall's 17 pile rock anchors (right-hand side facing seaward) had visible evidence of pile uplift and displacement of the structure. The steel fender panels were also damaged, and some rubber fender elements failed.
- The port wing-wall inner fender panel was buckled, the 2 adjacent steel fender panels suffered some damage, and some rubber fender elements failed.
- The lower ramp abutment hinges, lower apron hinges, fingers, and hanging bars were damaged. All hydraulic cylinders were subjected to shock loading from the vessel's impact.
- The vessel's impact also damaged various cable trays and wiring, including the ramp booth supports.

The ferry terminal was out of service for 122 days.

Personnel Certification and Experience

Master

The master held a Master Mariner certificate re-endorsed on 16 November 2011. He had worked as a master since 1985 and as a master for BCFS since 1991. The master received familiarization training on procedures specific to the *Coastal Inspiration,* and was cleared to command her on 20 May 2011.

Chief Officer

The chief officer held a Chief Mate Near Coastal certificate that was issued on 15 January 2008. He had worked for BCFS since 1988 and as second officer/relief chief officer since April 2007. The chief officer had received vessel familiarization training before he was assigned to the *Coastal Inspiration;* he had worked on the vessel intermittently since April 2008.

Vessel Certification

The vessel was crewed, equipped, and certified in accordance with existing regulations and also complied on a voluntary basis with the requirements as outlined by the International Management Code for the Safe Operation of Ships and for Pollution Prevention (the ISM Code).

Environmental Conditions

At the time of the occurrence, the weather conditions and visibility were good, with winds from the northwest at 18 knots in the approaches towards Nanaimo, BC. The tide was falling and the current was setting in an easterly direction at 1 to 2 knots in the Northumberland Channel.

Arrival and Departure Procedures

Arrival

At the end of a crossing, the master prepares for berthing by slowing the vessel and engaging Mode 2 [13] as stipulated in the pre-arrival checks in the Vessel Specific Manual (VSM). [14] The master reduces the stern propeller pitch control to 4 ahead. At this point, Mode 2 can be initiated. The bow propeller motor can be started at any speed, but the hull speed must drop below 14 knots for the Mode 2 propeller pitch to engage.

Once Mode 2 is active, the master will have bow propeller control. The vessel's speed must be further reduced to below 8 knots for the forward rudder lock to release, allowing control of the bow rudder at the master's station. Standard operating procedures in the VSM specify that when Mode 2 is enabled, bow propeller pitch control must be tested by requesting ahead and astern adjustments. The VSM does not specify the degree of movement that should be tested.

The master then uses the appropriate pitch and rudder control handles to manoeuvre the vessel into the berth.

At Berth

The vessel's design allows Mode 2 to remain in operation while at the berth; this is an extra defence in case of a problem or failure of one of the propulsion systems. After the Coastal Class vessels entered into service, it was discovered that the bow propeller caused excessive vibration and noise as well as terminal erosion and damage to propeller blades if the motor was kept running while the vessel was berthed. In order to reduce these problems, the bow (or inshore) motor is stopped. To prevent feathering of the propeller, the pitch is routinely set at zero and the control switch is set to the emergency mode. [15] Section 7.1.1 of the Vessel Specific Manual calls this "freezing" the bow propeller. The electric drive motor for the bow propulsion system is then switched off while the stern (or offshore) propeller is set at ahead pitch, which develops thrust, pushing the vessel against the dock and keeping it stationary.

Departure

Before departure from the berth, the standard operating procedure is to transfer manoeuvring control to the opposite bridge; the bow (or inshore) propeller then becomes the stern propeller. Before transferring controls, both propeller pitch-control switches are set to the Emergency mode, which locks, or freezes, the pitch. This allows the stern propeller to be started and

---

13 The bow propeller must be activated (Mode 2) for all dockings, departures, and tight quarters manoeuvring (Section 7.1.1 VSM).

14 VSMs are BCFS manuals that document vessel-specific procedures and are approved by the vessel's senior master and senior chief engineer. Appendix A of the MV *Coastal Inspiration* Vessel Specific Manual dated September 17, 2011 contains the "Pre-Arrival Checklist – Bridge."

15 If the control switch is not set to the emergency mode, the propeller, while feathering, would produce thrust in the ahead direction, as the shaft is still rotating at a considerable speed. The thrust in the ahead direction would then push the vessel out of the berth. Use of the emergency mode also prevents the load-sharing system from reducing pitch on the offshore (stern) propeller during inshore propeller (bow) engagement, in turn preventing the vessel from being pushed out of the berth.

engaged at zero pitch for Mode 2 operation. As soon as Mode 2 is engaged, the normal/emergency switch is set to normal, which activates the pitch-control handles. Once the vessel clears the berth, Mode 1 is engaged, the inactive propeller feathers to 90° ahead for the passage, and the forward rudder is locked in the mid-ship position.

Power Management System

When the vessel manoeuvres with both propellers engaged (Mode 2), the electrical power requested can exceed the capacity of the vessel's generators. In order to prevent this, the system is equipped with monitoring equipment and safety features that protect the vessel's power generators from shutting down.

The electrical load on the diesel generators is measured and monitored by a generator protection module system (GPM). In order for the GPM to provide clear signals that are free of electrical noise or interference, isolating amplifiers are used. Each propulsion switchboard contains 7 isolating amplifiers that are assigned specific functions but work together to monitor generator and motor loads. These amplifiers filter out unwanted electrical noise in an input signal, outputting a cleaner version of the same signal. If the output signal exceeds the pre-determined value, the GPM detects that the system is near or in overload condition and will limit and/or reduce the pitch on the propellers so as not to overload the system. When the pitch is limited or reduced by the GPM, the bridge and engine room crew are notified by the illumination of the Power Limited indicator light on the propulsion control panel.

After the occurrence, BCFS examined the parameters displayed on the vessel's propulsion-control interface and cross-referenced them with the vessel's electrical diagrams. They determined that the isolating amplifier that monitors generator overload conditions on the *Coastal Inspiration* had malfunctioned, causing the system to act as if it was in an overload condition. The malfunction triggered the protection mechanism, which prevented the use of the bow propeller pitch in normal mode. BCFS exchanged the amplifier with an identical type and tested it; the system worked in normal mode, as designed.

The defective amplifier was later tested on board the vessel by a technician from the company that installed the system, who verified that it had failed. If the amplifier had been functioning correctly, the device would have delivered an output voltage equal to the input voltage, but when the technician applied various input voltages, there remained a difference of 6 V direct current in each case. Additional tests conducted by a local lab in their testing facility showed the amplifier performing as designed in a static test scenario; however, the amplifier did not perform to its designed specifications when an external magnetic disturbance was applied. The test was stopped immediately to prevent any damage to the unit, as it was overheating. Afterwards, the amplifier was tested on board the vessel, but the lab was unable to replicate the malfunction or determine its original cause.

Subsequently the amplifier was sent to the TSB Laboratory where it was tested against 2 exemplar units. [16] All 3 amplifier units performed comparably and as designed. Although contaminants, which were deemed to be a by-product of the manufacturing process, were

---

16 TSB Laboratory Report LP037-2012, available on request.

observed on all 3 units, it could not be determined if this was a factor in causing the amplifier to malfunction.

Propulsion System Procedures and Familiarization

BCFS complies with the requirements of the ISM Code. As part of the BCFS safety management system (SMS), the on-board VSM contains the standard operating procedures for all aspects of vessel's operation, including bridge navigation equipment tests and checks, engine start-up procedures, pre-sailing checks, pre-arrival checks, arrival procedures, propulsion control system procedures, steering tests, as well as the procedure for isolating a propulsion motor.

The operating procedures for initial start-up, arrival, and departure also detail the use of the normal/emergency selector switch. The procedure for pre-arrival stipulates, among other things, that Mode 2 be initiated at 1 nm from Jack Point (1.2 nm from the Duke Point berth) and that the engine room be advised by means of the emergency telegraph when "stand-by" is initiated. [17] Furthermore, the propulsion control system procedure states that it takes at least 115 seconds for one propulsion system to fully activate under transit conditions when all pre-start-up conditions are met, and that this time will be prolonged if the vessel's speed through the water is over 14 knots.

The VSM further details procedures for dealing with emergency situations such as fire, man overboard, grounding, and collision. Practice and drills for emergency situations dealing with the vessel's propulsion system are conducted periodically; they are limited to testing the emergency telegraph control, which is part of the drill schedule.

Crew Familiarization

As part of the SMS, prior to being assigned to a vessel, crew and officers receive familiarization training on vessel-specific procedures. Clearance to sail in their assigned positions on board a vessel is then given if they meet the clearance parameters. Familiarization for bridge personnel includes detailed instructions to ensure that the appropriate bridge is in command as well as instructions on the operation of the propulsion system in the normal mode. Furthermore, the familiarization addresses use of the normal/emergency pitch controls during the vessel's initial start-up, after berthing, and before departure.

Senior Master's Directives

Senior masters on BCFS vessels may issue directives giving additional instructions for the officers and crew. One such directive [18] states that "all masters and deck officers shall ensure that Mode 2 is selected and cycling at a minimum distance of 0.6 nm from berth. Landing must be aborted if Mode 2 is not engaged and tested by a distance of 0.15 nm from the dock."

---

17 Though not listed in the pre-arrival procedures, it was the usual practice to advise the engine room by telephone when Mode 2 was being initiated.

18 BC Ferry Services Inc., Senior Masters Directive #19-2011 for the MV *Coastal Inspiration*, "Minimal Safe Distance for Mode 2 Engagement," Sept 22, 2011.

Emergency Pitch Control

The pitch can be operated under emergency conditions via a selector switch at each propulsion control panel, located at each bridge and engine control room. Operation of the pitch is carried out by changing the switch from Normal to Emergency. In emergency mode, the bow propeller pitch is controlled by the push buttons labelled PITCH AHEAD and PITCH ASTERN. These push buttons bypass the power load automation and operate the pitch control hydraulic valves directly. They are round, yellow, and raised push buttons situated one above the other. The Normal/Emergency selector switch is black and is situated in proximity to the emergency propeller pitch controls (Photo 2).

Photo 2. Pitch control panel

Emergency procedures in the VSM cover the use of the emergency pitch control. In the event of a pitch control system failure that does not allow the pitch to be controlled by the bridge or engine control room's normal or emergency modes, the pitch can be operated in the propulsion room for each propeller by using the handles at the hydraulic valve block itself. Ahead and astern directions can be read out from the mechanical dial located on the oil distribution unit.

There is one emergency telegraph unit for each propeller on each bridge. These units communicate commands from the bridge to the engine control room or to the emergency operation stand in the propulsion room, and are used to request desired vessel speed when bridge control fails. Propulsion pitch control is then achieved by means of the controls in the engine control room or, if that fails, by the controls in the propulsion room. In addition, the telegraph is used to signal "standby" upon departure and arrival, "full away" when under way, and "finished with engines" to the engine control room when berthing after the last crossing of the day.

Voyage Data Recorder

Marine accident investigators use the data from voyage data recorders (VDR) to support an investigation into an accident or incident. In addition to bridge audio, a VDR is designed to record parameters such as date and time; vessel heading, position and speed; VHF radio communications; radar images; engine orders and responses; and wind speed and direction measurements. VDR operational checks are carried out daily before the vessel departs for its first crossing. At the time of the occurrence, the VDR on board the *Coastal Inspiration* [19] had a removable hard disc that stored data for 24 hours. The VDR's final recording medium (FRM) stored data for 24 hours but voice and radar data for only 12 hours.

---

19 Model: SAM Electronics VDR DEBEG 4300

Following the striking, the investigation found that the removable hard disc was defective. Consequently, the only data available was on the FRM. However, given that the data was accessed more than 12 hours after the occurrence, no voice or radar data from the time of the occurrence was available.

Analysis

Events Leading to the Striking

As the vessel approached the ferry terminal at Duke Point, the bridge team began preparing for berthing. Mode 2 was initiated at a distance of approximately 0.62 nautical miles (nm) from the berth with the vessel advancing at a speed of 19.5 knots. Less than 2 minutes later (119 seconds), at a distance of 0.18 nm, the vessel's speed of advance had decreased to 8.3 knots and the bow propeller became engaged and ready for use. The pitch was not tested, as was required, and with the vessel now proceeding at 8 knots, it took approximately 14 seconds to cover the distance from where Mode 2 was engaged to the abort position. [20]

Once the vessel was at the abort position, the bow pitch-control handle was first used by the master to slow the vessel. When the bow propeller did not respond, the master made further incremental increases of pitch, but they were ineffective. A malfunction of an isolating amplifier in the propulsion switchboard had activated the overload protection system. This prevented the electronic signal from the pitch control handle from adjusting the pitch on the bow propeller. This malfunction did not trigger an alarm other than the prolonged illumination of the POWER LIMITED indication light, which was observed by the master.

The master then activated the emergency manoeuvre system but as the pitch control handle was not transmitting a signal, this did not have any effect on the bow propulsion system. The chief officer indicated to the master the PITCH AHEAD and PITCH ASTERN push buttons for use in an emergency. The master engaged the push buttons, but because he had not switched the bow propeller from normal to emergency mode beforehand, the buttons were ineffective. The vessel continued to advance towards the berth with the stern pitch handle unchanged in a forward thrust position but with zero pitch on the bow propeller.

Astern propulsion was not applied, nor were anchors deployed to stop the vessel. Without the braking effect of the bow propeller and with the astern propeller providing ahead thrust, the vessel struck the berth at a speed of approximately 5 knots.

Emergency Operation of Pitch Control

For crew to be able to respond efficiently and effectively to emergency situations, it is imperative that they be able to recognize the status of all systems used in the operation of the vessel and react in a timely manner when a system fails.

In this occurrence, when the pitch control handle was no longer eliciting a response, the master first attempted to increase the pitch, which had no effect. The chief officer then indicated the PITCH AHEAD and PITCH ASTERN push buttons. While the master pushed the buttons, these had no effect because the bow propeller pitch control was in normal mode—it had not been switched to emergency mode beforehand.

---

20 The distance designated by the senior master: 0.15 nm from the berth, at which berthing must be aborted if Mode 2 is not engaged and tested.

The *Coastal Inspiration's* bow propeller caused excessive vibration, noise, terminal erosion, and damage to its blades when it was left running at the dock. To avoid this, British Columbia Ferry Services (BCFS) adapted the designed berthing procedure by requiring the crew to stop the bow propeller motor. To stop the motor without triggering the automatic feathering of the propeller, the crew were instructed to "freeze" the pitch at zero by setting the pitch to zero with the handles, and then switching from normal to emergency mode to bypass the automation. Freezing the pitch does not involve use of the emergency push buttons associated with emergency mode.

This adapted procedure is performed every time the *Coastal Inspiration* and her 2 sister vessels are docked and when control is transferred from one bridge to another prior to departure. The designed function of the emergency mode is to enable manual control of the pitch by means of the push buttons, bypassing automation, when it is not responding in normal mode. The use of the emergency mode to freeze the pitch became regular practice for these vessels and it was incorporated into their VSMs. This operational disassociation of the emergency mode switch from its designed function is further compounded by the colour scheme and design of the various buttons, switches, and indicators on the pitch control panel since the emergency pitch buttons are a different colour (yellow) and design from the emergency mode switch (black).

As demonstrated in this occurrence, the consequence of this procedural adaptation [21] is that, in emergency situations, masters and bridge crew may not readily associate an operation habitually used to freeze propeller pitch with one that enables the manual pitch controls. The routine operation of equipment for a purpose other than the one for which it was designed may result in the equipment being disassociated from its designated function.

Both the master and chief officer had, as required, received familiarization training on the bridge equipment on the *Coastal Inspiration* before they assumed their positions on the vessel. The training included the use of the normal and emergency pitch controls. However, the emergency options available when pitch control is lost in normal mode were not reinforced with regular drills, as the drills were considered the responsibility of the engine room crew. If the bridge team crew do not participate in regular drills addressing malfunctions of the propulsion system, they may not be proficient in taking mitigating action during an emergency.

Awareness of Safety Critical Equipment Failure

It is important that safety-critical systems essential to the operation of a vessel be available at all times. To ensure that these systems are functional, operators may be required to test them prior to use to verify their availability. In the event of a malfunction of one of these systems during its use, the operator must also be alerted promptly by an effective indicator so that remedial action can be taken.

The bow propeller of the *Coastal Inspiration* was essential for berthing, unberthing, and manoeuvring the vessel. The VSM required that the bow propeller pitch control be tested once it was engaged by requesting ahead and astern adjustments. Furthermore, an additional directive from the senior master required that the berthing be aborted if the propeller had not been engaged and tested by a distance of 0.15 nm from the berth.

---

21 J. Reason, *Human Error*, 1990, Cambridge University Press.

The VDR playback for the previous 24 hours indicates that the master on the opposite shift had tested the bow propeller pitch control prior to each berthing as required by applying forward and astern thrust. However, the same playback shows that the master at the time of the occurrence did not test the pitch control during his shift of 10.5 hours.

In this occurrence, the pitch control was engaged at 1448:45 at a distance of 0.18 nm from the berth and 14 seconds later it was used in the ahead direction for the first time with the intent of slowing the vessel. When the pitch control did not respond, there was limited time for the crew to react. It is possible that the initial use of the bow propeller was perceived by the bridge team as a method of testing the system prior to berthing, but this method did not meet the requirements of the VSM or the senior master. As demonstrated in this occurrence, the lack of testing of safety-critical equipment essential for a key operation prior to its use may lead to reduced time for crew to react if the equipment fails to respond.

The malfunction of the isolating amplifier was indicated by the prolonged illumination of the POWER LIMITED indicator light on the pitch-control system. Although the crew did observe this illuminated indicator light, they were accustomed to seeing it in routine operation due to its association with the power management system. In the limited time available during the occurrence, they may not have been aware that this indicator had been illuminated for a longer period or understood that it was alerting them to the loss of the electronic signal from the pitch control handle .

Due to the lack of a clear warning or alarm to the bridge team, the master's reaction to the perceived loss of pitch control was to increase pitch rather than to take measures to rectify the problem directly.

As a result, the malfunctioning of the pitch control system on the *Coastal Inspiration* was not clearly indicated to the crew. Without an alarm specifically linked to safety-critical equipment that signals the equipment's malfunction, the crew may be unaware of the failure, putting the vessel, its passengers, and crew at increased risk.

Voyage Data Recorder

The purpose of a VDR is to create and maintain a secure, retrievable record of information indicating the position, movement, physical status, and command and control of a vessel forthe most recent 12 hours of operation. Objective data are invaluable to investigators in seeking to understand the sequence of events and identify operational problems and human factors.

In this occurrence, the VDR was non-functional because the hard disc was defective and was not able to save any data. The only data retrieved was from the final recording medium (FRM). When voyage data recordings are not available to an investigation, the identification and communication of safety deficiencies to advance transportation safety may be precluded.

Conclusions

Findings as to Causes and Contributing Factors

1. The bow propeller was engaged but not tested as required prior to arrival, which precluded the bridge team from realizing that the pitch control was not functioning.

2. The bow propeller pitch control was used once the vessel was at the abort position, in close proximity to the berth, limiting the time for the bridge team to react when it did not respond.

3. An isolating amplifier in the propulsion switchboard malfunctioned, causing the overload protection system to activate. This prevented the electronic signal from the pitch control handle from adjusting the pitch on the bow propeller.

4. The bridge team did not switch from normal to emergency mode. As the mode was not set to Emergency, the master's attempts to engage the PITCH AHEAD and PITCH ASTERN push buttons were ineffective at regaining control of the pitch.

5. Without the braking effect of the bow propeller, and with the astern propeller providing thrust ahead, the vessel struck the berth at a speed of approximately 5 knots.

Findings as to Risk

1. The operation of equipment for a purpose other than the one intended may result in the equipment being disassociated from its designated function.

2. If the bridge team does not participate in regular drills addressing malfunctions of the propulsion system, it may not be proficient in taking mitigating action during an emergency.

3. If safety-critical equipment essential for a key operation is not tested before its use, the crew may have reduced time to react in the event the equipment fails to respond.

4. Without an alarm specifically linked to safety critical equipment that signals the equipment's malfunction, the crew may be unaware of the failure, putting the vessel, its passengers and crew at increased risk.

5. When voyage data recordings are not available to an investigation, the identification and communication of safety deficiencies to advance transportation safety may be precluded.

Safety Action

Action Taken

Transportation Safety Board

On 11 April 2012, the TSB sent a Marine Safety Information letter (MSI 04/12) [22] to British Columbia Ferry Services Inc. (BCFS), copied to Transport Canada Marine Safety, advising them that the vessel's speed of advance was a significant factor in the striking.

On 23 May 2012, BCFS responded to MSI 04/12 by stating that it had implemented new standard operating procedures that highlighted all critical decision points during the passage, and that these pre-determined points for reducing speed had been standardized for each route that the vessel sailed. Safety checks were being provided at these points as the vessel approached the conclusion of the voyage. To further mitigate the risks associated with the vessel berthing phase, a series of contingency plans and drills had also been developed and implemented.

British Columbia Ferry Services Inc.

The following changes have also been made by BCFS:

- The POWER LIMITED indicator light is now connected to the vessel alarm and monitoring system. If the light remains lit for a period of time longer than 15 seconds, an audible alarm now sounds in the engine room.

- A schedule of critical failure response drills has been developed to ensure that the contingency plans are exercised by all key personnel concerned. This schedule will be standard on all Coastal Class vessels, will span a calendar year, and will record the drill conducted by each watch at the stated frequency.

- Familiarization training before clearance to work on board a vessel now includes verification of responses to critical system failures. Key personnel from the bridge team are required to demonstrate competency for their level; this is verified through periodic drills.

- Arrival procedures have been elaborated to include verification of systems prior to berthing: the initiation of Mode 2 now occurs at 0.9 nm and the system is tested by 0.4 nm. These verifications are undertaken in communication with the engine room crew to confirm that systems are functioning normally.

- Hydrodynamic models and controls have been developed for the BCFS simulators which will incorporate critical systems failure training in the Bridge Operations Skills and Systems (BOSS 2) program.

- Critical decision points, including the abort point, have been incorporated in navigational passage plans for all BCFS routes.

---

22 This letter also includes the *Queen of Coquitlam,* TSB occurrence M11W0199.

- A review and incorporation of increased distances from berth for engaging and testing Mode 2 is complete and inserted in the VSM. All bridge personnel have been directed to comply with changes through a Coastal Class Senior Master's directive. [23]

- New larger-scale pitch gauges and mounting arrangements have been designed, tested and are being installed in all coastal vessels.

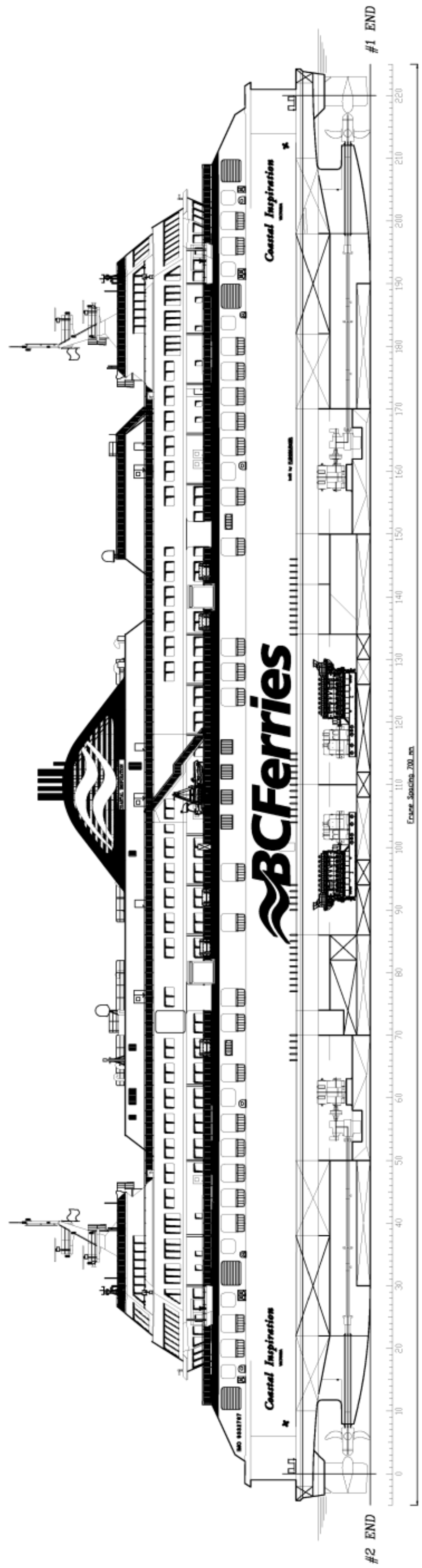
- A revised emergency-pitch standard operating procedure incorporating regular critical failure response drills has been incorporated into the vessel-specific manuals for Coastal Class vessels (Section 8, Emergency Response).

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 06 March 2013. It was officially released on 12 March 2013.

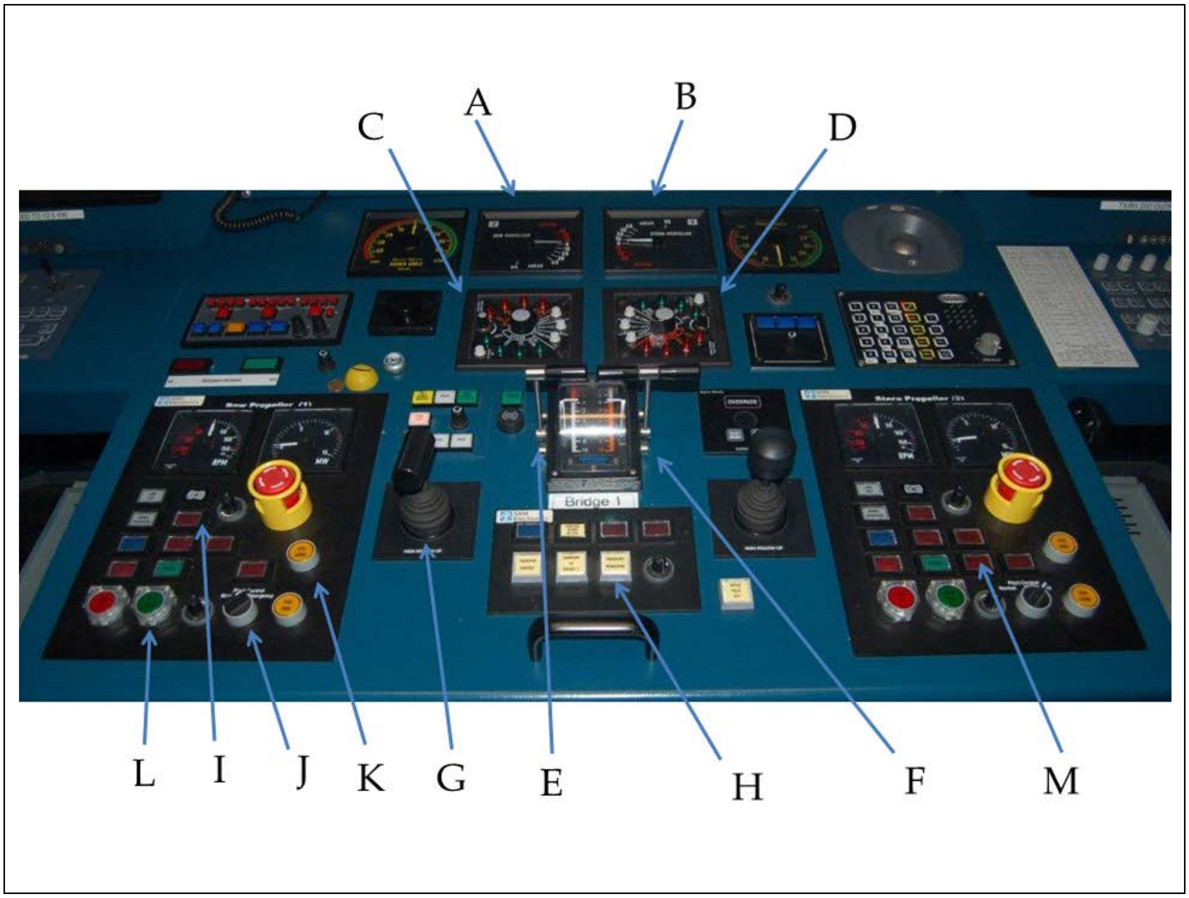
Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

23 Coastal Class C Senior Masters Directives are internal vessel-specific BCFS documents. The directives originate with BCFS senior masters and provide additional instructions to the vessel's officers and crew.

Appendix A – Vessel Profile



Appendix B – Manoeuvring Console

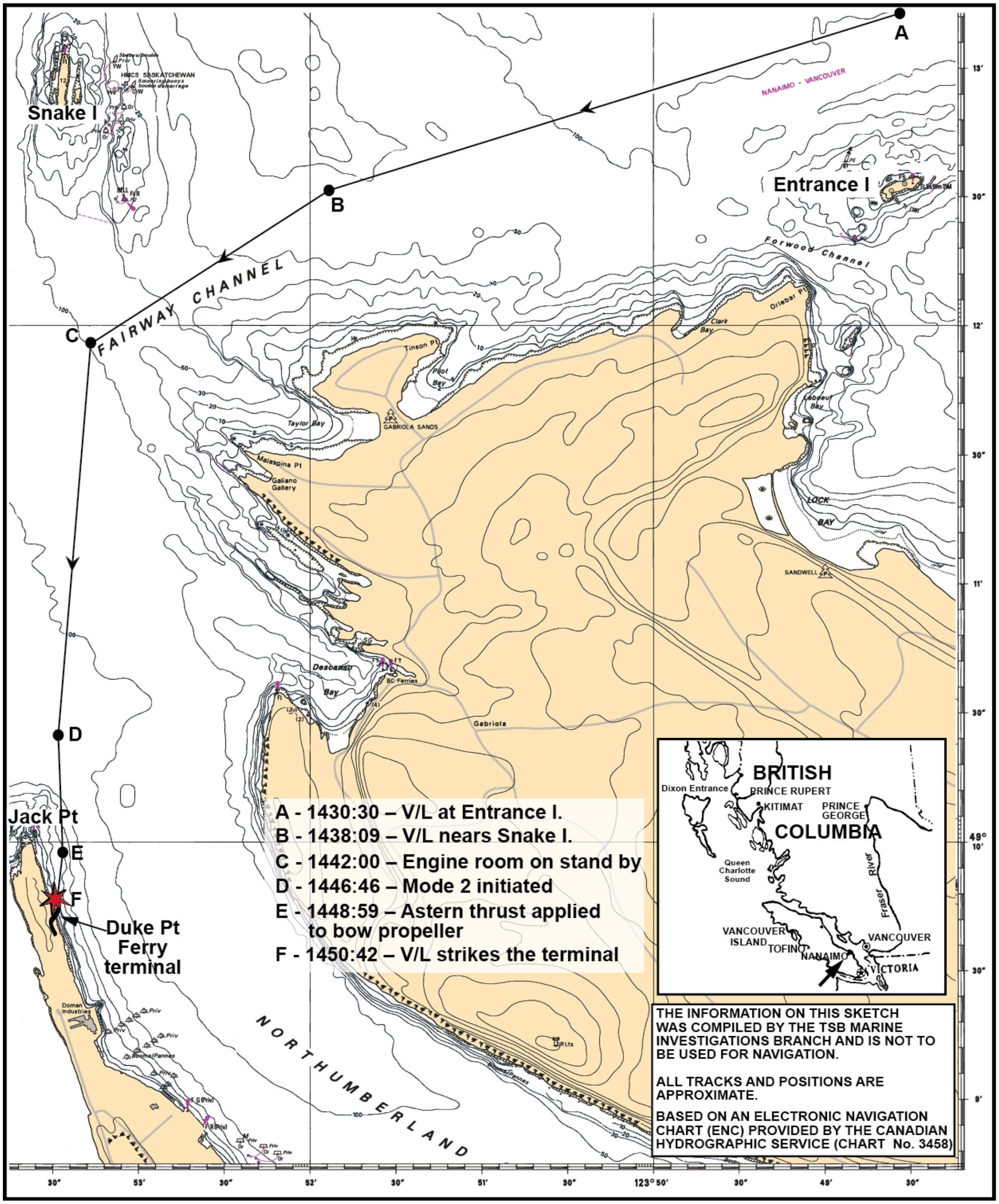


A) Pitch display – Bow
B) Pitch display – Stern
C) Emergency telegraph – Bow
D) Emergency telegraph – Stern
E) L handle – Bow pitch control
F) T handle – Stern pitch control
G) Forward rudder
H) EMERGENCY MANOEUVRE
I) POWER LIMITED indicator
J) Normal/Emergency mode selector switch
K) Pitch buttons – AHEAD and ASTERN
L) Motor START button
M) BOW PROPELLER REQUIRED indicator

Appendix C – Manoeuvring Data

HANDLE POSITION		SPEED IN KNOTS	PITCH IN DEGREES
10	NF	22.8	31.5
9		22.4	28.7
8	FULL AHEAD	21.6	25.8
7		19.9	23.0
6	HALF AHEAD	17.2	20.2
5		12.6	17.3
4	SLOW AHEAD	10.8	14.4
3		9.0	11.6
2	DEAD SLOW AHEAD	6.6	8.7
1		4.4	5.9
0	STOP	0.0	3.0
-1		-1.0	1.0
-2	DEAD SLOW ASTERN	-1.9	-1.1
-3		-2.9	-3.2
-4	SLOW ASTERN	-3.8	-5.3
-5		-4.8	-7.3
-6	HALF ASTERN	-5.7	-9.2
-7		-6.7	-11.1
-8	FULL ASTERN	-7.6	-13.2
-9		-8.6	-15.3
-10	EF	-9.5	-17.2

Appendix D – Area of the Occurrence



Appendix E – Graph Depicting Mode 2 Operation as Obtained from Engine Room Alarm and Monitoring System