MARINE INVESTIGATION REPORT
M00N0098

GROUNDING

TANKER *MOKAMI*
BRIDGES PASSAGE, LABRADOR
31 OCTOBER 2000

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Marine Investigation Report

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Report Number M00N0098

Summary

On 31 October 2000, the MV *Mokami* was transiting the narrow waters of the Labrador coast with a partial load of refined products to be discharged at Voisey's Bay, Labrador. Upon approaching Bridges Passage, the officer of the watch ordered a course alteration to follow the recommended route on the Canadian Hydrographic Service chart No. 5052. As the vessel was swinging to starboard to steer a course of 134° gyro, the *Mokami* ran aground on the shoal east of buoy NP5 at 1544 local time, causing extensive damage to the hull. The *Mokami* was refloated after transferring some cargo to the *Sybil W*. The grounding caused minor pollution in the vicinity which later dissipated. There was no injury.

Ce rapport est également disponible en français.

Other Factual Information

Particulars of Vessel

	Mokami
Port of Registry	St. John's, Newfoundland
Flag	Canada
Registry/Licence Number	819113
Type	Tanker
Gross Tonnage	3015
Length	91.14 m
Draught at the time of the occurrence	Fwd: 3.8 m Aft: 5.2 m
Built	1989, Finland
Propulsion	2868 kW diesel, driving one controllable pitch propeller
Number of Crew	15
Registered Owner	Coastal Shipping Ltd. Goose Bay, Labrador

Description of the Vessel

The *Mokami* is a small coastal tanker carrying refined petroleum products to different locations on the Labrador coast. The vessel has four centre tanks and four wings tanks for cargo and nine ballast tanks including a forepeak ballast tank.

History of the Voyage

On the evening of 27 October 2000, the vessel left Holyrood, Newfoundland, for Nain, Labrador, with 1926 cubic metres of refined petroleum product. The vessel was loaded to her marks and her draught was 4.2 m forward and 5.6 m aft. The vessel discharged a partial load of cargo at Nain and Ten Mile Bay. She then departed for Voisey's Bay at 1300[1] on 31 October to complete cargo discharge. The distance between Ten Mile Bay and Voisey's Bay was estimated at 60 miles. The chart in use was Canadian Hydrographic Service (CHS) Chart No. 5052 with North American Datum 1983 (NAD 83) chart datum.

When the vessel was north of the Bridges Passage, the officer of the watch (OOW) took over the con of the vessel and the master was calling Eastern Canada Traffic System (ECAREG). The master completed the ECAREG message when the vessel was off Stony Point. The weather was fine and clear with light winds. The current was setting to the NE at approximately 3-4 knots (kt).

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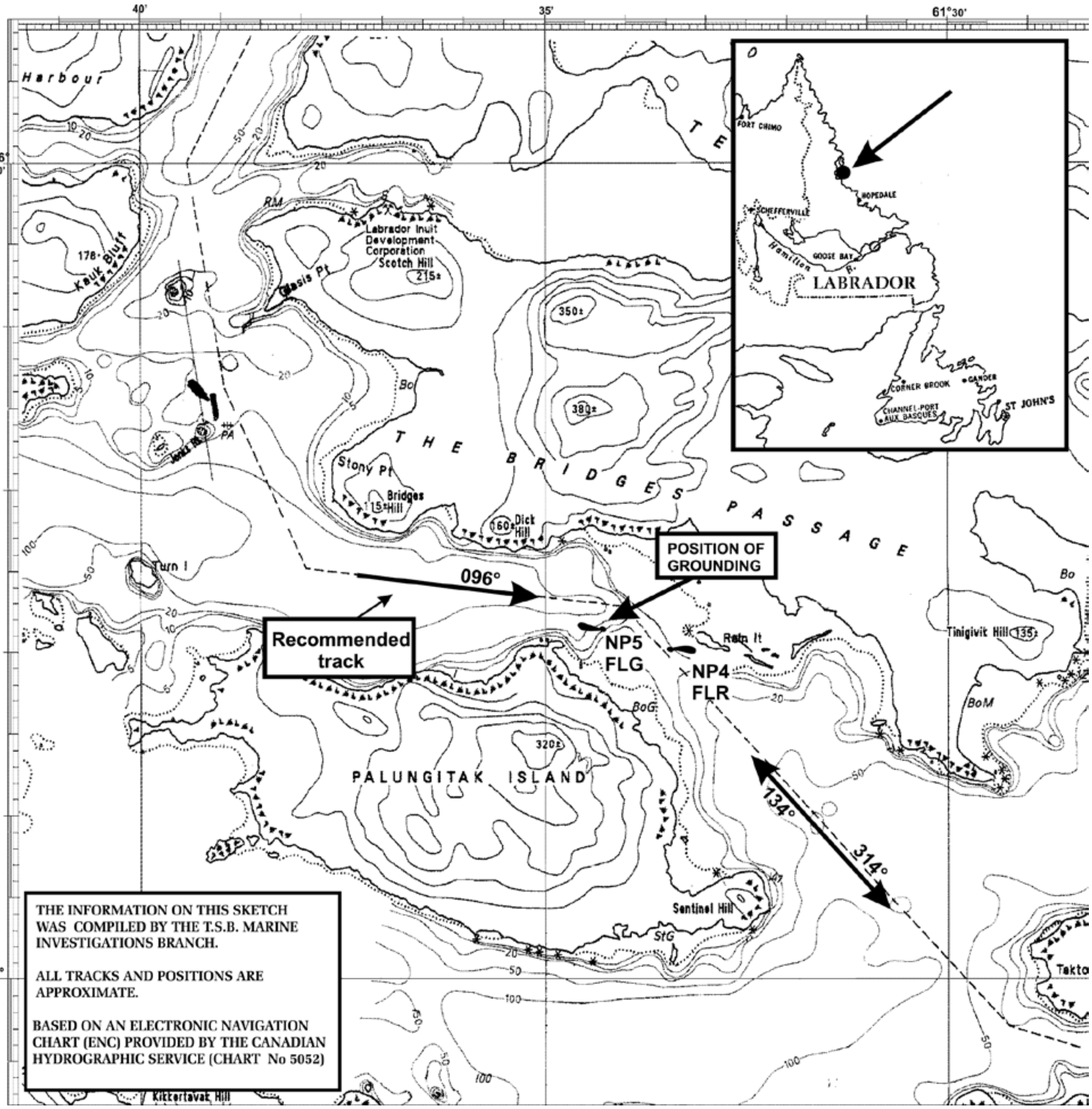
1 All times are Newfoundland standard time (Coordinated Universal Time minus three and one-half hours) unless otherwise noted.

When off Palungitak Island, the vessel's course was altered to 096° as per the recommended track. The bridge was crewed by the OOW in charge of the piloting, with the master assisting and the second officer at the helm. The third officer and the cook were standing by but were not involved in the navigation of the vessel.



The master was checking the global positioning system (GPS) coordinates and was using visual markings ahead. A couple of minutes prior to the grounding, the master used the GPS to verify the vessel's position but did not plot it on the chart. According to this observation, the vessel was mid-channel. The OOW was using parallel indexing as a method of navigation and was referring to the chart at times. The vessel's position was not plotted on the chart. The vessel was proceeding at 70 per cent of her engine speed which, combined with the current, gave the vessel an estimated speed of 10 kt.

With the buoy NP5 abeam 130 m distant and Rain Islet at 5.5 cables, the OOW ordered course alteration in increments to 105°, 110°, 120° before steadying on a course of 134° as per the recommended track. At about this time, the vessel ran aground at 1549, approximately 200 m NE of buoy NP5 (see Figure 2). The vessel sustained severe damage to the hull structure. The cargo tanks were holed, causing minor pollution.

Events Following Grounding

The master ordered sounding of the tanks and reported the occurrence to Transport Canada Marine Safety (TCMS) St. John's. The Oil Pollution Response Team was notified and divers from St. John's were requisitioned to survey the hull. As the tanker *Sybil W* was in the area, she was requested to come alongside the *Mokami* to unload a partial cargo. Meanwhile, a boom was deployed to contain the spill but it became submerged due to the current. Following underwater inspection and evaluation of the damage, TCMS gave permission to the vessel to proceed to Halifax, Nova Scotia, for repairs. The vessel proceeded at slow speed and arrived at Halifax on the morning of 7 November.

Navigation Equipment

The navigation equipment included a GPS which was interfaced with the starboard radar/ARPA (Automatic Radar Plotting Aid) and was used by the OOW. No way point was input for Bridges Passage. The gyro error was 0.5° high.

The course recorder was not recording as the crew was not familiar with its use and the instructions and the functions for its operation were in Russian. Further, all of the labels on the bridge, as well as some of the navigational instruments including the navigation console, were in Russian and their manuals had not been translated. Notwithstanding the above, at the time of the occurrence, labels and manuals for the main instruments in use for navigation were in English.

Vessel and Personnel Certification

The vessel was crewed, equipped, and operated in accordance with existing regulations for a vessel of her size and trade.

Vessel Manoeuvrability in Bridges Passage

The Canadian Coast Guard (CCG) has developed a document, titled *Canadian Waterways National Manoeuvring Guidelines: Channel Design Parameters*, which provides planners with a set of criteria to be used when determining waterway parameters required to provide sufficient manoeuvrability with no less than minimum safety margins and allowances. The *Mokami* met the criteria for safe transit through Bridges Passage.

Bridge Resource Management

The essence of bridge resource management (BRM) is the effective use of all available resources to complete an operation safely. BRM addresses managing attention, operational tasks, stress, attitudes, and risks. BRM recognizes that individual, organizational, and regulatory factors are involved in safe and effective operations. Optimizing the management of these elements has a direct effect on four factors critical to the successful outcome of any operation:

- situational awareness recognizing and defining the nature of the problem encountered;

- metacognition — reflecting on and regulating one's own judgements or decisions;
- shared mental models — involving others in the problem-solving process; and
- resource management — understanding tasks to be performed, their priorities, and required and available resources.

Successful BRM programs address several key areas, such as team building and maintenance, communication and decision-making processes, workload management, situational awareness, watch systems, and working environments.

Team Building and Maintenance

Individual characteristics of team members are important. However, in a team, work is shared, tasks are performed in a more timely and effective manner, and a higher level of performance is achieved than that by an individual working alone. Research has demonstrated that, during the team formation process, patterns of communication and interaction are established.[2] Once established, the process continues and leads to activities that can maintain patterns of effective (or ineffective) group communication.

Communication and Crew Decision Making Processes

Crew decision making is managed decision making. In this instance, the OOW was responsible for making the decisions but was supported by input from the crew, both on the bridge and from shore (e.g., traffic services). This requires a group climate that encourages participation and the exchange of information. Poor communication can result in crews not sharing a common understanding of a situation, or in a misunderstanding of the OOW's intentions.

Workload Management

The essential tasks for safe navigation of the vessel are allocated to different persons best equipped or experienced to perform them so that no member of the bridge team carries a workload that is beyond his/her capabilities.

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[2] Robert L. Helmreich and Clayton H. Foushee, "Why Crew Resource Management ? Empirical and Theoretical Bases of Human Factors Training in Aviation", Crew Resource Management, E. Weiner, B. Kanki, and R Helmreich, eds., San Diego: Academic Press, 1993.

Situational Awareness

Situational awareness is the accurate perception of factors and conditions that affect a vessel and its crew during a defined period of time.[3] More simply stated, it is knowing what is going on around you.

The safety of the voyage depends on the level of situational awareness of the individual who has the conduct of the vessel. The ease and effectiveness of communication is a fundamental factor in maintaining optimal situational awareness. It is essential that each member of the bridge team does everything feasible to support the person in charge to maximize his level of situational awareness.

No one had received training on BRM and techniques were not applied by bridge personnel to ensure safe transit. Communication between bridge personnel during the transit was minimal. Navigation was carried out in isolation with minimal input from the master. No passage plan had been discussed and/or prepared for the transit.

Safety Management System

Convention tankers are required to comply with the *International Safety Management Code*, whereas non-convention tankers such as the *Mokami*, which ply locally, are not required to have any form of a safety management system. A review of the *Mokami's* operations indicated, among others, the following:

- the company's shore-personnel provided minimal guidance to the crew on the operation of the vessel;
- the selection criteria for the crew was limited to the Transport Canada (TC) mandatory certification requirement;
- no person was assigned to identify the training needs of the crew;
- additional training, such as BRM, was left to the discretion of the crew and the company policy with respect to training lacked specifics;
- none of the crew had BRM training;
- neither the master nor the crew had received training on the use of GPS and were not aware of the need to set the selector switch to the corresponding chart datum; and
- safety bulletins issued by the company were sparse and TC Ship Safety Bulletins (SSBs) were not dispatched to the vessel.

Status of Hydrographic Charts

The CHS has the mandate of charting Canadian waters for the benefit of all mariners. Their task is to provide a reliable scientific basis to enhance the safety and efficiency of navigation for vessels operating in Canadian waters.

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[3] Geiss-Alvarado Associates, "Human Error Accident Training", *U.S. Coast Guard Training Manual*, July 1991.

A review of the chart for the area revealed the following:

- CHS chart No. 4748 had been replaced with the new chart No. 5052 on 25 April 1997.
- The scale of CHS chart No. 4748 was 1:80 000 and contained an inset of Bridges Passage on the scale 1:25 000. The chart was geographically referenced to an astronomic observation spot on Stony Islet; thus the chart is referenced to an "orphan" or "unknown" horizontal datum.
- The scale on chart No. 5052 had been increased to 1:60 000 but the inset of Bridges Passage had been removed. The chart datum used was NAD 83.

Horizontal Chart Datum and Safety

Many different definitions of a horizontal datum, also known as geodetic datum, exist. However, a practical working definition in use is:

> A horizontal datum is a reference system for specifying positions on the Earth's surface. Each datum is associated with a particular reference spheroid that can be different in size, orientation and relative position from the spheroids associated with other horizontal datums. Positions referred to different datums can differ by several hundred metres.[4]

Charts use different horizontal chart datums as a reference for specific geographical positions. The process of converting all charts to World Geodetic System 1984 (WGS-84) datum is in hand, however, a large number of charts have not yet been converted. This means that positions obtained from satellite navigation receivers are not compatible with the chart and an adjustment is warranted for position accuracy. The latitude and longitude from a navigation receiver such as a GPS are referenced to a specific horizontal datum which may be at variance with the horizontal chart datum. Consequently, unless the GPS receiver datum is the same as the chart datum, the receiver datum must be converted to the chart datum for position accuracy. GPS makes direct use of WGS-84, which is equivalent to NAD 83 now used by the CHS.

Most GPS receivers incorporate datum transformations into their software. This allows a mariner to select the appropriate datum that is compatible with the chart. Furthermore, the most accurate position is obtained by having the GPS receiver referenced to WGS-84 (NAD 83) and the application of the datum adjustment published on the chart. Familiarity with the use of the datum selection feature on the GPS receiver is essential for accurate position fixing. In this instance, the bridge personnel had little knowledge of the chart datum and the need to set the selector switch to the corresponding chart datum in use. The GPS was set to NAD 27 while the chart in use (No.5052) was referenced to datum WGS-84 (NAD 83).

The impact of chart datum on navigation safety has been recognized by the International Maritime Organization (IMO) as well as CCG. The IMO publication SN/Cir.213, dated May 2000, entitled *Guidance on Chart Datums and the Accuracy of Positions on Charts*, and the CCG publication, entitled *GPS/DGPS Made Easy*, edition 2000, provide instructions on how a datum shift can be applied to a chart.

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[4] *Guidance on chart datums and the accuracy of positions on charts*, IMO, Maritime Safety Committee, SN/Circ.213, annex 8.

Much of the Labrador coastal waters have not been surveyed to modern standards.[5] The CHS recognizes that with the advent of GPS and electronic chart systems for navigation purposes, it has become necessary to facilitate the use of a geographic co-ordinates system, WGS 84 or NAD 83. CHS has initiated action to bring the charts to the NAD 83 datum and is surveying corridors along shipping routes to modern standards. Meanwhile, many off-datum charts with unknown older horizontal datums still exist for the Labrador coast. As such, they cannot be geographically referenced to any satellite-based system. The caution contained in the *Annual Edition of Notices to Mariners* (Notice 2.7) reminds mariners that, due to differences in horizontal datum (i.e., NAD 27, NAD 83), grids of charts of an area may vary from one chart to another.

Use of Global Positioning Systems and Safety

GPS positioning does not offer integrity monitoring similar to that which is provided with a differential global positioning system (DGPS). Further, the U.S. government does not provide continuous real-time monitoring of the system's performance. Satellites can automatically remove themselves from service when they experience any of a number of specified failure modes.[6] However, when a service failure occurs that is not covered by the automatic removal capability, the failure must first be detected when the satellite is above the horizon of the monitoring station antenna before the U.S. Department of Defence (DoD) can respond by manually removing the satellite from service. Meanwhile, unhealthy signals from a malfunctioning satellite may continue to be used by receivers until taken out of service. Further, ionosphere, troposphere, receiver, multi-path, and interference can affect the accuracy of GPS positions. Consequently, caution must be exercised when GPS is used for position fixing purposes.

Responsibility of the Canadian Coast Guard for Marine Aids

CCG is responsible for providing and maintaining fixed and floating marine aids to navigation in Canadian waters. Regular and effective checking of these aids to ensure their proper position, operation, and characteristics is considered an important part of this responsibility. All relevant aspects of CCG aids service-checking activities, including checking schedules, acceptable checking methods and record keeping, are outlined in the *Marine Aids Administrative Directive 2.2400 -- Aids Checking Standard.*

In the case of floating aids, buoy data is maintained in one of two systems, the manual Buoy Data Cardex System or the Système d'information de positionnement des aides (SIPA), an electronic database. Pertinent details of the checking and servicing performed on buoys are recorded on a field document known as the Buoy Service Report (BSR).

The investigation revealed a number of discrepancies in the data cards for buoys observed by buoy tender personnel. The discrepancies were brought to the attention of the CCG Marine Navigation Services (MNS) superintendent in June 1998. The following year, it was observed

that the buoy data cards issued to the ships had not yet been corrected. Concerned about the continued discrepancies, questions were raised whether ships should continue sending this information to CCG or forward

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5 *Sailing Directions -Labrador and Hudson Bay,* Sixth Edition 1988

6 *Global Positioning Systems Standard Positioning Service Performance Standards* by the U.S. Department of Defence, October 2002

this information directly to other vessels.

History of Buoy NP5

18/07/1997: According to standard practices, buoy NP5 was established in optimal position[7] by Canadian Coast Guard ship *CCGS J.E. Bernier* following on-site assessment. It was positioned on the northeast corner of a bank extending northeasterly from Palungitak Island at 56° 27' .050 N, 061° 34′ .180 W referred to the orphan datum existing on CHS chart No. 4748 -- Bridges Passage Inset.[8] A BSR was submitted to the regional MNS program office. The "advertised position" of the buoy was the "optimal position" (see Figure 2). This position as plotted is corrected to NAD 83.

Fall 1997: Only the GPS position was recorded on the BSR when the buoy was lifted.[9]

23/01/1998: A SIPA data sheet was created for buoy NP5 without the alternative positioning method using DGPS.

August 1998: *CCGS J.E. Bernier* placed buoy NP5 using information from the previous year's BSR. The buoy was placed in the optimal position using chart No.5052 based on the new chart datum NAD 83. However, the advertised position of the buoy remained unchanged from the 1997 position. The latitude information on the BSR was inaccurately recorded as 56° 27′ .500 N instead of 56° 27′ .150 N.

2/09/1998: The SIPA data sheet was modified and all position fixing data contained in the position data section of the sheet was deleted. The annotation 'approximate' to the advertised position was deleted. The SIPA data sheet was signed, indicating that the changes were verified as correct. The advertised position was unchanged and still referred to CHS chart No. 4748 and its unpublished orphan datum even though this chart had been cancelled. This SIPA data sheet was promulgated to the navaids tenders.

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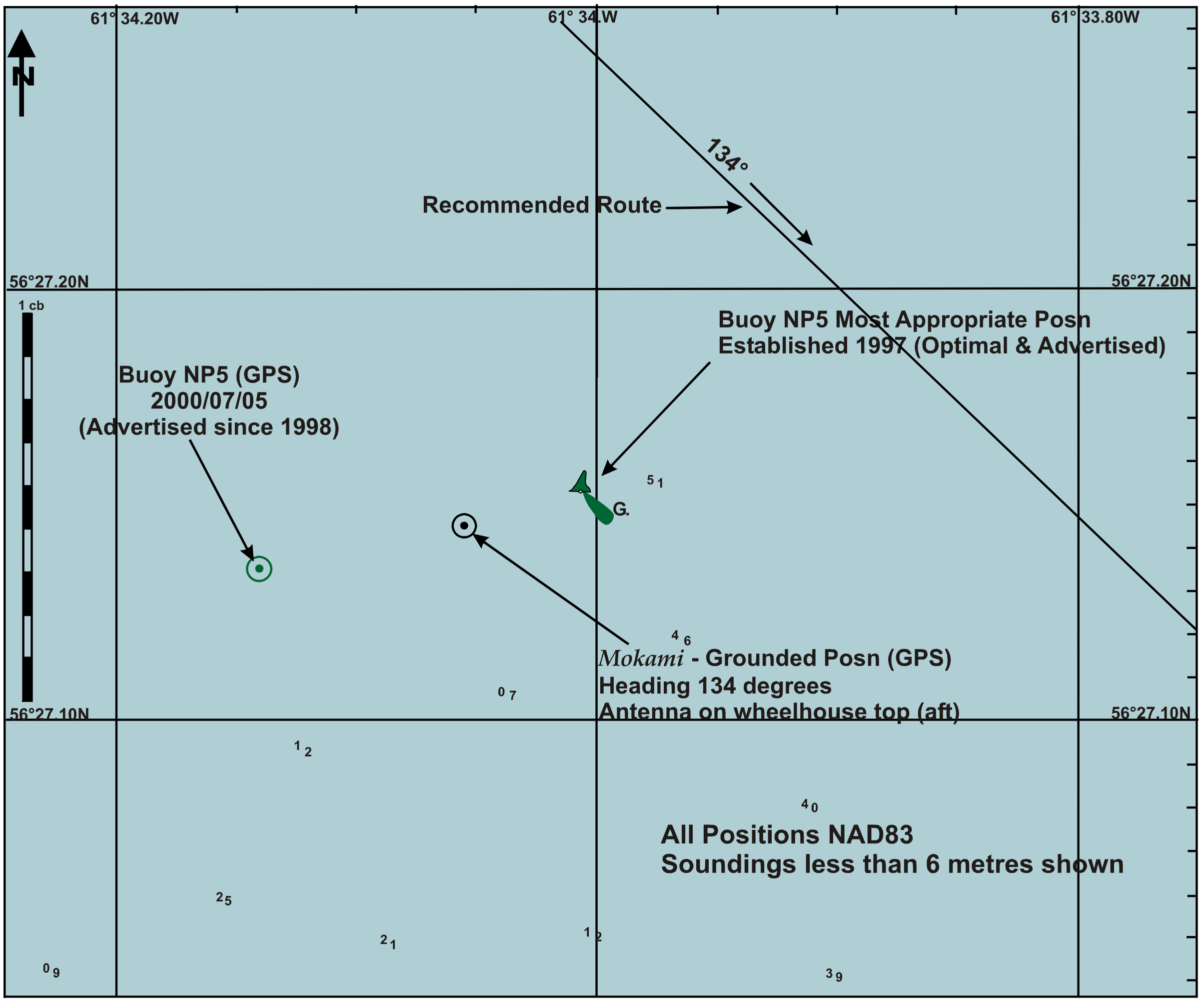
7 Optimal position refers to the most appropriate position to place the buoy in relation to the danger for a vessel to safely navigate a channel.

8 The new CHS chart No. 5052 was not in circulation at this time.

9 The *Aids Checking Standard* cautions that the fixing data obtained during a lifting operation may be less reliable.



Fall 1998: The DGPS position fix indicated buoy NP5 was off the optimal position[10] established in 1997. This fact was not noted on the BSR. The horizontal sextant angles were also observed and recorded for the buoy but they did not correlate to the DGPS position. The position, when plotted on the chart, was found to be on the opposite side of the recommended route.

21/12/1998 The SIPA data sheet was modified to reflect the data obtained when the buoy was lifted in 1998, unintentionally changing the advertised position to a less- than-optimal position, some 160 m further west of the optimal position as established in 1997. The horizontal sextant angle data was suspect. The fixing data from the first alternative positioning method based on the off-position DGPS fix now became the *de facto* primary positioning method and the advertised position for placing buoy NP5.

25/06/1999 A Notice to Mariners (N to M No. 1127) was issued advising mariners to add buoy NP5 to chart No. 5052. The position was promulgated to the general public in the notice as the “advertised position” in which to plot the buoy on the chart. The advertised position was the off-position DGPS obtained when the buoy was lifted in 1998. This advertised position was the same at the time of the accident.

[10] Outside of the acceptable range.

2/03/2000: The SIPA data sheet was modified without verification and the GPS position was added as Alternative Positioning Method 2. This position was off the optimal position.

At the commencement of the shipping season in 2000, buoy NP5 was placed using a basic navigation GPS receiver without differential corrections. Notwithstanding the discrepancies existing on the SIPA data sheet in use, the fix was not verified by another method and was off the optimal position.

Analysis

Overview of Labrador

Labrador's area measures over 265 000 square kilometres, with a coastline of almost 8000 kilometres of innumerable inlets, bays, and off-lying islands. Along the Labrador coast, the rugged topography of the coastline and unpredictable weather conditions can pose a risk to navigation. The environment, in terms of tide and current, wave height, wind, weather, pack ice conditions, icebergs and icing, is generally harsher and more severe than any other coast in Canada. Further, extremely rough and unpredictable depths of water occur along the Labrador coast. Many of these conditions are well known to local mariners and fishers. There is, however, a large fishery characterized by migratory fishers, in addition to a growing number of commercial mariners, who may not be familiar with the conditions or hazards.

Marine cargo activity is the lifeline of Labrador due to its isolation and limited land-based transportation network. Over half of the cargo currently shipped to Labrador is in the form of dangerous goods, most of which are shipped to Goose Bay. Given that the area is ecologically sensitive, it is essential that the level of services provided for vessel navigation, be it by way of combination of the scale of navigation chart, fixed, floating, and electronic aids, be such that vessels can safely transit the area.

Navigation through Narrow Channels

Reportedly, the vessel's course had been gradually altered when the vessel was 5.5 cables from Rain Islet and buoy NP5 was abeam. For the vessel to have run aground, the vessel had to have been south of the recommended track and less than 2.2 cables from the buoy. The optimal position of the buoy was some 160 m further east of the actual position. As the vessel's position was altered when the bow came abeam of buoy NP5, the optimal positioning of the buoy would have permitted the vessel to better negotiate the turn with a greater chance of success.

Good seamanship practices dictate that mariners use more than one method for position fixing as well as use all other navigation cues/information to safely navigate the vessel. The chart scale for the 300 m-wide Bridges Passage was such that it reduced the bridge team's ability to accurately plot and closely monitor the vessel's progress. On the other hand, the navigational practices used aboard the *Mokami* further hampered the bridge team's ability to successfully negotiate the Bridges Passage. These included the following:

- Way points were not used on the global positioning system (GPS). As such, cross-track information depicting how far the vessel had deviated from the recommended track was not available. This deprived the master, who was using the GPS, of essential information that would have helped him better monitor the vessel's progress.
- No passage plan was carried out and the information on the chart was not closely scrutinized. As such, neither the master nor the officer of the watch (OOW) realized that the navigation buoy NP5 was not in the optimal position, necessitating modification in the approach to negotiate the turn. However, this was not done resulting in premature course alteration.

- Effective use of parallel indexing technique would have indicated that:
  - the vessel was off the recommended track;

- the buoy NP5 was on the advertised position which was not the optimal position;
- the vessel was to the south and west of the alter course position and that initiating the turn when the bow of the vessel was in line with the buoy would result in premature course alteration;

This would indicate that the parallel indexing technique was not used effectively by the OOW.

- The visual cues used by the master were such that he did not recognize that the vessel was off the recommended track. As positions were not plotted on the chart, the use of GPS to monitor the vessel's progress would have been difficult.
- The GPS was not set to the appropriate chart datum and the position obtained therefrom would have been inaccurate. The error in setting would have placed the vessel further north of her actual position and close to the recommended track. This could account for the vessel being south of the recommended track, resulting in a premature course alteration.
- The navigation team relied on buoy NP 5, which was on its advertised position, 160 m west of the optimal position established in 1997. The team relied on the buoy to alter the vessel's course to the exclusion of other visual/ electronic cues, in spite of various navigational publications warning mariners that buoys can be out of position and that caution should be exercised in using buoys as an aid to navigation.[11]

Lack of Bridge Resource Management Training

Close monitoring of a vessel's movement is critical for navigating safely in confined waters. Time is of the essence when initiating and executing manoeuvres. Therefore, it is essential that each bridge team member fully understands his/her role and ensures that any information that can favourably or adversely affect vessel navigation be communicated to the person in charge of pilotage/navigation.

The non-implementation of bridge resource management (BRM) precepts, such as the lack of effective communication or exchange of information, has been identified as a contributing factor in a number of occurrences.[12] Concerned that lack of BRM training among ships' officers increases the probability of accidents in confined Canadian pilotage waters, the Board recommended to Transport Canada (TC) that BRM training be made a pre-requisite to the issuance of new competency certificates as well as to that of continued proficiency certificates.[13] In response to this recommendation, Transport Canada Marine Safety (TCMS), in consultation with industry representatives, has finalized the BRM training syllabus. Some Canadian marine

training institutions now offer this training program. Currently, there is no plan to make this course mandatory. However, TCMS encourages shipping companies to take the initiative in implementing BRM concepts on their vessels.

As no passage plan had been discussed and/or prepared for the transit, members of the bridge team were not fully cognisant of the OOW's planned approach, resulting in the members of the bridge team working in

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11 *Sailing Directions, Labrador and Hudson Bay, Edition 1988; List of Lights* 1998

12 TSB Report No. M97W0197 – *Raven Arrow*, TSB Report No. M98C0082 – *Federal Bergen*, TSB Report No. M99C0027– *Sunny Blossom* , TSB Report No. M98C0004 *Enerchem Refiner*

13 TSB Report No. SM9501, A *Safety Study of the Operational Relationship Between Ship Masters/Watchkeeping Officers and Marine Pilots*, Recommendations M95-09 and M95-10.

isolation. There were three bridge team members but only the OOW was involved in navigation. Communication was informal and input from the bridge team members respecting navigation of the vessel was minimal. Consequently, none of the bridge team members was aware that the vessel was not optimally positioned for course alteration to be successfully executed, nor were discrepancies in position communicated to team members.

In essence:

- all of the information that could affect the navigation of the vessel, be it favourable or adverse, was not shared with the team members;
- effective use was not made of all available resources such as visual cue, radar and the GPS to safely complete the navigation; and
- each member of the bridge team did not do everything feasible to support the OOW to maximize his situational awareness.

In doing so, BRM principles were not implemented effectively. Further, as the crew had not received BRM training, each member of the bridge team acted in isolation, leaving the OOW to rely solely on his performance, foregoing the potential for team work and leaving no room for error.

Company's Operational Practices and Safety Management System

Safe operation of the vessel, the safety of the crew and personnel, and the safety of the environment is dependant upon close co-operation and a working relationship between shipboard and owner's shore-based personnel. An effective safety management system (SMS) addresses the issue of commitment from senior officials (both ashore and onboard), competence, attitudes and motivation of individuals at all levels.[14] Although tankers pose a greater risk to the environment than most other vessels, and an accident involving the tanker can have a catastrophic impact on the economy of the region, non-convention tankers operating locally within Canadian waters are not required to have any form of safety management system, be it the *International Safety Management Code* or otherwise. The need for non-convention ships including tankers to have a formal SMS in place has been recognized by a number of Canadian owners/ operators of fleets who have voluntarily implemented such a system.

In the absence of any form of SMS, the company and the ship's complement were operating in isolation without the benefit of a coordinated and structured approach to enhance operational safety. A compromise to safety is reflected in the following:

- The extent of involvement and guidance provided by the company's shore-personnel would indicate that the operational needs of the vessel were not fully recognized.
- The company's policy with respect to crew training lacked specifics.
- The selection criteria for the crew was limited to the Transport Canada mandatory certification requirements.
- The crew was unfamiliar with the optimum use of some of the navigation equipment and were not trained in its operation. This deprived them of the benefit that could be derived from the shipboard navigation equipment.
- As the bridge team members had not received BRM training, they operated in isolation. This

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[14] *International Safety Management Code*

effectively negated the benefits of team work and converted it to a single-person operation that is more prone to failure than is team work.

- As safety bulletins issued by the company were sparse and as TC *Ship Safety Bulletins* were not dispatched to the vessel, it deprived the ship's complement of information essential to safe operation.

Buoy Tending Related Issues

Buoy Data Record

In keeping pace with changes in technology, the Canadian Hydrographic Service (CHS) charts are being updated to North American Datum 1983 (NAD 83) to facilitate the use of modern electronic navigation aids. Meanwhile several charts with old datum, particularly in the Labrador region, are in use. While chart datum information is recorded on buoy data cards, the datum selected on the GPS to obtain the position is not always recorded on board Canadian Coast Guard (CCG) vessels nor is there a mandatory field for such an entry. In the event that the datum used to obtain the GPS position is at variance with the chart datum, the information as recorded on the data cards would be incomplete. This has the potential to culminate in an error in positioning the buoy as well as information as recorded in the Système d'information de positionnement des aides (SIPA) database as in this instance. Hence, it is essential that data entry in the SIPA database be verified to ensure completeness, accuracy and integrity of the system. This was not done.

Système d'information de positionnement des aides and Safety

SIPA is an electronic database containing the particulars of every buoy maintained by CCG including its mooring, characteristics, advertised position and fixing data. The policy places the responsibility on the regional CCG Marine Navigation System (MNS) program officer to maintain the integrity of the database. Although buoy NP5 had been placed in a less-than-optimal position for a period of time and the position of the buoy reported by aids tenders was different, the reason for the variation in the position was not investigated.

The CCG *Marine Aids Administrative Directive* stipulates principles, responsibilities, and procedures involved in the service checking of marine aids to navigation. The policy is intended to assure the quality and the level of its service to further safety of vessels transiting Canadian waters. Nevertheless, some of the safety-related shortcomings identified included:

- data card positions (advertised positions) had been modified to reflect DGPS data gathered by ships instead of charted positions; and
- modifications of sextant angles and true bearings to reflect readings on buoy service reports (sometimes based on lifts).

Accuracy of recorded data for positioning floating aids is essential for the integrity of the system. Given the advancement in technology, it is possible for the system to have a means to automatically compare the new entry against past recorded data and highlight changes for further investigation. In some regions, a graphical electronic or a digital method of verifying buoy positions is used to confirm the values of navaids prior to the buoy's entry in the SIPA database. In the Newfoundland region, data input in SIPA is not always verified nor is a graphical/digital system used.

Integrity of SIPA System

To ensure quality of service, CCG has documentation in place respecting policies and procedures regarding buoy tending operations.[15] Part of the quality control measures included verification and signing off of SIPA data sheets by MNS. However, the data incorporated in the SIPA was not verified. Further, the concerns raised by the fleet personnel that the SIPA data contained errors, deletions, and unverified data essentially remained unaddressed. As the scope of these errors became more apparent, reliance on the information contained in the SIPA data sheets decreased and reliance on the unverified information contained in the buoy service reports aboard vessels increased. This effectively transformed the buoy service reports as a *de facto* primary source for laying buoys contrary to the established standards and without a central coordinating approach. This rendered the quality control measures ineffective and permitted an error in the data to remain unnoticed for an extended period of time.

In aids tending operation, an early identification of transcription or positioning discrepancies is essential to the integrity of the system and to foster the safe navigation of vessels operating in the coastal waters. Success of such a system is dependent upon the close cooperation and good working relationship between shipboard and shore-based personnel as well as prompt and effective action to address errors. While the system has checks and balances in place—such as signing off of SIPA sheets following data verification—to help ensure the integrity of the data, it was not effectively implemented. In so doing, the system was rendered ineffective, culminating in the shipboard and shore-based personnel operating in isolation to the detriment of the system and safety.

Notices to Mariners

In reference to SIPA data sheets, the *Aids Checking Standard* states, "... data contained on this card is the authoritative reference from which information from other official publications (e.g., List of Lights, Notices to Mariners) are taken." The tombstone or advertised position is the data used to generate Notice to Mariners.

To generate a Notice to Mariners, CHS is required to verify that the data on the draft notice matches the data contained in the SIPA database. Personnel in the Chart Maintenance Section at the CHS have read-only access to SIPA.

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[15] *Marine Aids Administrative Directive*

There was a number of discrepancies existing between the draft notices and the SIPA data sheet:

- the advertised position for the buoy in the SIPA database still referenced a cancelled CHS chart and differed from the position in the draft notices;
- the position in the SIPA database was entered in a non-standard format; and
- the draft notice indicated that the buoy was a conical or starboard hand buoy contrary to the colour and number.

On 15 April 1999, CHS contacted the MNS program office in St. John's to verify the accuracy of this data. The MNS officer indicated that the buoy was in the appropriate position.

To verify the position of a buoy, its position is manually plotted on the appropriate chart. As outdated charts are retained by the CCG office for reference purposes, it is probable that the position of the buoy was plotted on cancelled chart No. 4748 with an orphan datum. The resulting position would differ from the optimal position when referenced on chart No. 5052 with NAD 83. Consequently, the advertised position for the buoy in Notices to Mariners and the List of Lights differed from the optimal position established in 1997.

Under the existing system, the CHS database accepted any information from the SIPA and had no means of verifying the status of the chart or the datum in use. Consequently, the discrepancy from the SIPA data which used the orphan datum from chart No. 4748 was carried forward to Notices to Mariners which referred to the new chart No. 5052 with NAD 83.

CCG - Buoy Positioning and Safety

Navigational aids, be they fixed, floating, or electronic, are deployed to assist mariners in safely navigating waters, as well as to prevent accidents and protect the environment. A number of factors are taken into consideration in determining the type of navaid appropriate for use, including but not limited to the geographical area, shoals and other underwater obstructions, current, extent of course alteration, scale of the chart, the need for precision in navigation, and the volume of traffic. Given the danger posed by the shoal marked by buoy NP5, the 40° course alteration (to follow the recommended track) and with no leading lights to assist in navigation, the positioning of buoy NP5 should be such that it will assist the mariner in safely negotiating the bend. As such, the buoy was initially placed in the optimal position marking the NE corner of the shoal when it was established but was subsequently positioned some 160 m further west of the optimal position.

CHS - Chart Scale and Safety

The scale for Bridges Passage on chart No. 5052 was 1:60 000 whereas that on the inset in cancelled chart No. 4748 was 1:25 000; i.e., the scale had been reduced to about ⅓ of the original. The Bridges Passage being charted at a smaller scale, and the fact that there are no leading lights for transiting the 300-metre wide Bridges Passage, makes transit of the area difficult and reduces the mariner's ability to accurately plot and closely monitor the vessel's position. As one of the most commonly used methods of navigation is parallel indexing, the larger the scale of the chart, the better the mariner's appreciation of the environment which is essential for the safe navigation of the vessel.

On the other hand, the scale issue is mitigated somewhat by the fact that chart No. 5052, at a scale of 1:60 000, portrays the whole route on the face of the chart and does not require the transfer of positions to an inset seconds before a critical course alteration. In addition, it provides a continuous coastline to provide the mariner with his points of reference for parallel indexing.

CCG and CHS Interlaced Mandates and Safety

The CCG and the CHS provide mariners with the tools to safely navigate the vessel. CCG, as the agency responsible for aids to navigation, determines where the buoy is positioned, and CHS, as the agency responsible for chart production, ensures that the buoy is accurately positioned on the chart. This determination has to take into consideration the risk associated with this transit and the most appropriate risk-mitigating options. However, the mariner has no control over the abovementioned criteria. Given this interlaced mandate of CCG and CHS, close coordination between them is essential to help ensure that the scale of the chart and the type and positioning of aids to navigation deployed should be such that a mariner can safely navigate the area.

Findings as to Causes and Contributing Factors

1. None of the bridge team members was aware that the advertised position of buoy NP5 was not the optimal position. They relied on the buoy to the exclusion of other cues resulting in premature course alteration.

2. The navigating personnel had less than a thorough/complete understanding of the horizontal chart datum, global positioning system (GPS) datum selection mode, and the limitations of the electronic equipment.

3. The Canadian Coast Guard was not aware that the advertised position for the buoy in Notices to Mariners and the List of Lights differed from the optimal position established in 1997.

Findings As to Risk

1. Although tankers pose a high risk to the environment, non-convention tankers are not required to have any form of safety management system nor is there a requirement for the shore management to provide directives to the ship's staff especially in critical aspects of marine operations.

2. The scale of Canadian Hydrographic Service chart No. 5052 for Bridges Passage, the less than optimal positioning of the buoy, and the absence of ranges reduced the mariner's discernment of the environment and increased the chances of an accident.

3. Bridge resource management (BRM) was not fully implemented, resulting in each member of the bridge team operating in isolation, leaving the OOW to rely solely on his performance, foregoing the potential for team work, and leaving no room for error. The crew members had not received BRM training nor are they required to.

4. *Aids Checking Standards* were not effectively implemented in that:

   - GPS data was entered on the Buoy Service Report without amplifying information including the datum in use by the receiver;
   - in the Newfoundland region, data input in the SIPA database is not always verified, nor is a graphical/digital system used, which compromises the integrity of the SIPA system.

Other Findings

1. The Transport Canada Ship Safety Bulletins were not dispatched to the vessel.

Safety Action

Safety Action Taken

Canadian Hydrographic Service and Canadian Coast Guard

Following the occurrence, TSB issued Marine Safety Advisory 03/01 to the Department of Fisheries and Oceans which raised concerns that:

- the datum conversion on new and existing charts may introduce errors in positioning and charting of navigation aids;
- the adequacy of the level of service with respect to short range navigational aids; and
- reduction in chart scale together with the reduced details on the chart for Bridges Passage and the removal of the insert may deprive the mariner of some of the cues essential for safe navigation.

In response to the concerns, the Canadian Hydrographic Service (CHS) indicated that there is no natural leading line for Bridges Passage, and that the current scale of chart No. 5052 is adequate without the need for an inset. Further, they indicated that the review of the adequacy of the level of service provided for charts and publications in the Bridges Passage area, and the placement of buoys and other aids to navigation generally, is ongoing.

The Canadian Coast Guard (CCG) indicated that the current level of service (Labrador Region) which has been in use in the aids program since 1989, was developed with the involvement of CCG personnel, mariners, scientific researchers and university professors. Further, every aid system is reviewed at least once every five years. Therefore, CCG believes that the current level of service for the aids to navigation program is adequate for the safety of mariners and contributes towards the protection of the environment.

The CHS is concerned about the accuracy of the SIPA database and its impact on the data used to update charts. To address this deficiency, the CHS database has been rewritten such that it will not accept anything from the SIPA database that:

a) is referenced on a cancelled chart, or
b) a chart on the wrong datum.

Transport Canada

The Transportation Safety Board of Canada issued a Marine Safety Advisory (MSA 04/01) to Transport Canada (TC) expressing concern that mariners may not fully understand the need for datum selected on a global positioning system (GPS) to be consistent with the chart datum and that the method of navigation selected may deprive the ship's complement of some of the cues essential for safe navigation.

In response, TC indicated that various means that have been used to alert mariners to these concerns, including:

- *Annual Notices to Mariners*, Notice 2(7) and Notice 45[16],
- CCG publication entitled *GPS/DGPS MADE EASY, edition 2000*,
- International Maritime Organization Safety Navigation Circular 213 of 31 May 2000, entitled *Guidance on Chart Datums and Accuracy of Positions on Charts*.

Additionally, Transport Canada Marine Safety, in consultation with the CCG and the CHS, has developed a Ship Safety Bulletin (SSB No. 02/2002), entitled *Horizontal Chart Datums and Position Accuracy*. The SSB was published on 11 February 2002 to further raise awareness about this important safety issue of navigation practices and chart datums. Additionally, a notice on chart datums and position accuracy was published in the monthly Notices to Mariners, Edition No. 4 on 26 April 2002.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 05 May 2002.

Visit the Transportation Safety Board of Canada web site, www.tsb.gc.ca for information about the TSB and its products and services. There you will also find links to other safety organizations and related sites.

[16] 2001 and preceding editions

Appendix A - Photographs