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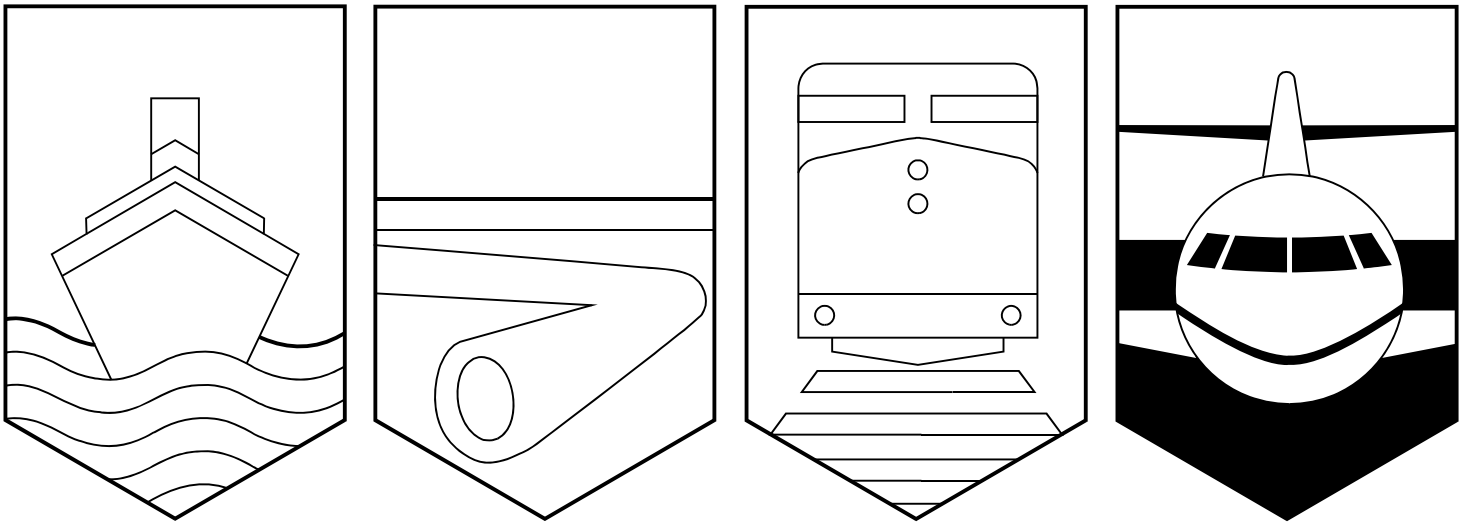

AVIATION OCCURRENCE REPORT

COLLISION WITH VEHICLE

ROYAL AIR MAROC
BOEING 747-400 CN-RGA
MONTREAL (MIRABEL) INTERNATIONAL AIRPORT, QUEBEC
21 JANUARY 1995

REPORT NUMBER A95Q0015

Canada

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Aviation Occurrence Report

Collision with Vehicle

Royal Air Maroc
Boeing 747-400 CN-RGA
Montreal (Mirabel) International Airport, Quebec
21 January 1995

Report Number A95Q0015

Synopsis

The Royal Air Maroc Boeing 747-400 was parked in the de-icing centre of Montreal (Mirabel) International Airport, Quebec. The aircraft was being prepared for a scheduled flight from Mirabel to Casablanca, Morocco, with a stop at New York, New York. The four engines were running during the de-icing operation. The crew heard "*dégivrage terminé*" (de-icing completed), and the captain asked the co-pilot to inform the apron controller that the aircraft was ready to taxi. Taxi instructions were issued. The aircraft started to move forward and overturned the two de-icing vehicles that were still in front of the aircraft's horizontal stabilizers. The two vehicle drivers sustained minor injuries; the three occupants of the cherry-pickers received fatal injuries.

The Board determined that the flight crew started to taxi the aircraft before its perimeter was clear, following confusion in the radio communications. The following factors contributed to the accident: a lack of de-icing procedures within Royal Air Maroc; non-compliance with procedures on the part of the Canadian Airlines International Ltd. de-icing crew; inadequate or inappropriate communications equipment; incomplete training of Snowman 1 (the chief de-icing attendant); a regulatory framework less demanding of foreign air carriers than of Canadian carriers; a lack of operational supervision; and a lack of adherence to radio protocol.

Ce rapport est également disponible en français.

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5.0 Appendices

1.0 Factual Information

1.1 History of the Flight

On 21 January 1995, the Boeing 747-400, registration CN-RGA, operated by Royal Air Maroc, was preparing for scheduled flight AT 205 from Mirabel, Quebec, to Casablanca, Morocco, with a stop at New York, New York. The aircraft was parked at gate 124 near fuelling station 2 on the main apron. The passengers boarded at the scheduled time, and the co-pilot asked the apron controller for authorization to start the engines and taxi to the de-icing centre.

The aircraft taxied and stopped at the de-icing centre, where two Canadian Airlines International Ltd. (CAIL)[1] de-icing vehicles were waiting for it. One de-icing vehicle moved to the front of the aircraft and raised its cherry-picker to flight deck level; the cherry-picker operator signalled to the pilot to tune his radio to 130.775 megahertz (MHz), the working frequency of CAIL, on the very high frequency (VHF) band. The crew had used this same frequency during engine start, but was unaware that it was the working frequency of CAIL.

The captain and the chief de-icing attendant (Snowman 1) agreed that only the wings and horizontal stabilizers of the empennage were to be de-iced with type I de-icing fluid. Snowman 1 initially asked the captain to shut down the engines. After the captain indicated that there would be a delay to start the APU, Snowman 1 suggested that the aircraft be de-iced with the engines running, and the captain agreed.

About seven minutes after the aircraft came to a stop, the apron controller tried unsuccessfully to contact Snowman 1 on the apron frequency. A few seconds later, the CAIL de-icing coordinator (Iceman), who was in the company offices, tried to raise Snowman 1 on the company frequency. The Iceman asked Snowman 1 to notify the apron controller when the de-icing was completed. The crew of the Boeing heard "*dégivrage terminé*" (de-icing completed) on 130.775 MHz. Neither the controller nor the Iceman received any acknowledgement from Snowman 1. The co-pilot then advised the apron controller that the aircraft was ready to taxi. Then the captain repeated "De-icing completed" twice on the CAIL frequency. The controller issued instructions for Royal Air Maroc to taxi to taxiway Kilo. As the pilot had not received a negative response or contra-indication from Snowman 1, he assumed that de-icing of the aircraft was completed and that the de-icing crew had left the area. At the time of these transmissions, the elapsed time since the beginning of the operation matched the time usually required for this kind of de-icing operation.

About 26 seconds later, after making an external visual check from the cockpit, the captain released the brakes. At that time, the two de-icing vehicles were positioned on either side of, and perpendicular to, the fuselage, forward of the horizontal stabilizers, and five de-icing personnel were still de-icing the

[1] See Glossary at Appendix C for all abbreviations and acronyms.

horizontal stabilizers. After he had taxied 95 feet, the captain stopped the aircraft suddenly when he heard a radio message directing him to shut down the engines. The horizontal stabilizers of the aircraft had struck the telescopic booms of the de-icing vehicles, causing the occupants of the cherry-pickers to fall and knocking the de-icing vehicles over on their sides. The two vehicle drivers sustained minor injuries. The three occupants of the cherry-pickers sustained fatal injuries when they struck the ground.

The accident occurred in daylight at 1652 eastern standard time (EST)[2] on 21 January 1995, at latitude 45°40'N, longitude 074°02'W.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	-	-	3	3
Serious	-	-	-	-
Minor/None	18	96	2	116
Total	18	96	5	119

1.3 Damage to Aircraft

The aircraft sustained substantial damage.

1.4 Other Damage

The two de-icing vehicles were heavily damaged by the collision with the aircraft and the impact with the ground. An undetermined quantity of de-icing fluid was spilled on the apron.

[2] All times are EST (Coordinated Universal Time [UTC] minus five hours) unless otherwise stated.

1.5 Personnel Information

1.5.1 Royal Air Maroc Personnel

1.5.1.1 General

	Captain	First Officer
Age	49	39
Pilot Licence	ATPL	ATPL
Medical Expiry Date	31 May 1995	31 May 1995
Total Flying Hours	15,000	7,000
Hours on Type	9,000	500
Hours Last 90 Days	40	24
Hours on Type Last 90 Days	40	24
Hours on Duty Prior to Occurrence	1	1
Hours Off Duty Prior to Work Period	48	48

The flight crew was certified and qualified for the flight in accordance with existing regulations. The pilots flew the Casablanca-Mirabel route on a regular basis.

The flight crew was not aware of any particular de-icing procedure at Mirabel, and followed the instructions of the aircraft manufacturer.

1.5.1.2 The Captain

This was the first time the captain had been to the Mirabel de-icing centre. In the past, his aircraft had been de-iced at the gate with the engines shut down. The communication procedures had also been different; in the past, the station attendant had communicated with the captain via the interphone in the nose gear well and had acted as an intermediary between the flight crew and de-icing crew. When the de-icing was completed, the crew had started the engines, and a marshaller, visible to the pilot, had guided the aircraft using signals.

At the time of the accident, the captain occupied the left-hand seat, was at the controls, and was handling communications with the de-icing crew on the CAIL frequency. He speaks English and French fluently.

1.5.1.3 The Co-pilot

The co-pilot had used the de-icing service at Mirabel on one previous occasion, when the aircraft was de-iced at the de-icing centre the previous year. The operation involved a different aircraft, which required a flight engineer to be in charge of de-icing. The de-icing was performed with the engines shut down.

At the time of the accident, the co-pilot occupied the right-hand seat and was in charge of communications with Air Traffic Services. He speaks English and French fluently.

1.5.1.4 The Flight Attendants

There were four flight attendants in the aft section of the cabin, with about ten passengers. From their stations, the flight attendants were in positions to observe the de-icing vehicles and inform the pilots of the progress of the operation via the intercom system.

Before starting to taxi to the runway, the flight crew advised the cabin crew that the aircraft was ready to taxi. They did not consult the flight attendants to determine whether the aircraft perimeter was clear; there was no requirement to routinely check with the cabin crew before manoeuvring the aircraft. None of the flight attendants witnessed the collision.

The Royal Air Maroc training program included cockpit/cabin coordination training for the crews. Although this training is not a requirement, it is included in the course syllabus of many air carriers.

1.5.2 Canadian Airlines International Ltd. Personnel

On the day of the accident, CAIL had to de-ice only the Royal Air Maroc aircraft. The de-icing crew consisted of four persons: two truck drivers (one of whom was the chief de-icing attendant, Snowman 1) and two cherry-picker operators. One station attendant joined the crew as a trainee after the Iceman authorized him to observe the de-icing from one of the cherry-pickers. The de-icing personnel held the required radio operator certificates.

1.5.2.1 De-icing Crew Training at Mirabel

In the fall of 1994, the de-icing crews attended a training course approved by CAIL on de-icing of aircraft with the engines shut down. Four of the five de-icing crew in this occurrence attended this course; the trainee who was observing from one of the cherry-pickers had not received any de-icing training. The manual used for the course, and available to all employees, stated that a person could not de-ice an aircraft while its engines were running unless that person had received appropriate "engines-on" training.

In the fall of 1994, some air carriers had asked CAIL to de-ice their aircraft with the engines running. On 03 January 1995, at the Mirabel base, 12 CAIL employees attended a course on de-icing the Boeing 727 and the Lockheed 1011 with the engines running. That was the first course given by CAIL on

these aircraft. Three of the five de-icing crew involved in this occurrence had attended this course; Snowman 1 and the trainee had not.

The course was adapted from CAIL's "Engines On De-Icing/Anti-icing for the B737 and A320" training program. Support material on the B727 and Lockheed 1011 was incorporated into the course. The methods used by the CAIL instructor/developer included the following: a classroom lecture supported by overheads; distribution of documentation; familiarization on the aircraft types (B727 and L1011); practical demonstrations of vehicle movement around the B727 and Lockheed 1011 with the engines shut down; and a practical exercise using an Airbus A310 with its engines running. The employees would normally have been required to complete a written examination following classroom instruction. However, the short interval between the date of the request for de-icing service from one of the air carriers and the date that the carrier wanted the service to begin did not allow the trainer enough time to prepare a test specifically for the B727 and the L1011.

The employees who attended the course were authorized to de-ice only the B727 and L1011 with engines running. The employees stated that, during the course, the trainer had approved de-icing the B747 with the engines running. However, analysis of the electronic mail prior to the accident between the Manager, System Aircraft De-icing, the Manager of Client Services at Mirabel, and the instructor/developer revealed that the participants were not authorized to de-ice B747s with the engines running. However, the Manager, System Aircraft De-icing, acknowledged the need for a study of engines-on de-icing for the B747. The three de-icers involved in this occurrence who had taken the engines-on course had subsequently de-iced some smaller aircraft with their engines running; however, because of conflicting information, it could not be determined if any of them had de-iced a B747 with its engines running.

1.5.2.2 The De-Icing Coordinator (Iceman)

At the CAIL Mirabel base, the de-icing coordinator, who was called the Iceman, was responsible for the direction of all de-icing crews and for ensuring that the de-icing crews complied with CAIL standards and procedures. The Iceman was in the CAIL offices at fuelling station 2, and he was aware that Snowman 1 had not taken the course for engines-on de-icing. However, he did not intervene when he heard Snowman 1 suggest to the captain of the B747 that he leave the engines running.

The Iceman held the qualifications required by CAIL. He had attended the engines-on de-icing and de-icing coordinator courses given on 03 January 1995.

1.5.2.3 De-icing Personnel

There are normally two persons in each de-icing truck. When de-icing requires more than one truck, the crew delegates a truck driver (Snowman 1) to handle communications with the flight crew. Snowman 1 had not attended any engines-on de-icing course; consequently, he was authorized by CAIL to de-ice only aircraft with the engines off.

The truck driver is required to drive his vehicle around the aircraft while following the instructions of the cherry-picker operator, whom he can see through an opening in the roof of the truck cab. He occasionally manoeuvres the cherry-picker. He must also convey relevant safety instructions to the cherry-picker operator, complete the appropriate forms and reports, and inform the pilot of the type of fluid used and the time of the last spray.

The cherry-picker operator aims the high-pressure spray of de-icing fluid at the contaminated surfaces. He is required to wear protective clothing and equipment when de-icing. Irritation of the eyes and skin will result if they come into contact with de-icing fluid. On the day of the accident, contrary to CAIL instructions, the cherry-picker operators were not wearing the protective eye wear, masks, or respirators provided by CAIL.

1.5.2.4 The Station Attendant

The station attendant who was in one of the cherry-pickers had no specific duties. He wanted to work as a Snowman and had been authorized to observe the de-icing.

1.5.2.5 The Lead Station Attendant

The lead station attendant provided informal training to the station attendant. The lead station attendant was responsible for serving clients safely in accordance with CAIL instructions and methods. Furthermore, he had to ensure that the de-icing crews operated effectively and complied with existing standards. He was also responsible for directing the work of, and providing practical training to, the de-icing personnel assigned to him.

1.6 Aircraft Information

1.6.1 General

Manufacturer	The Boeing Company
Type	747-400
Year of Manufacture	1993
Serial Number	25629
Certificate of Airworthiness (Flight Permit)	13 January 1994
Engine Type (number of)	General Electric CF6-80 (4)

Examination of the relevant documents revealed that the aircraft was certified, equipped, and

maintained in accordance with existing regulations and approved procedures. The central maintenance computer indicated that the aircraft systems were functioning normally at the time of the accident.

1.6.2 Procedures for Engines-on De-icing of Boeing 747-400

In the interests of ground personnel safety, the maintenance manual for the Boeing 747-400 recommends de-icing the aircraft with the engines and auxiliary power unit (APU) off. However, the maintenance manual does not constitute a reference for the pilot. If it is necessary to de-ice with the engines or APU running, the pilot must follow the procedures contained in the operations manual, which is carried in the cockpit. The operations manual contains no restrictions regarding the de-icing of the aircraft with engines running. The crew followed all the procedures with one exception; the air conditioning unit was not turned off as required by the manufacturer.

1.7 Meteorological Information

The meteorological reports describing the atmospheric conditions at Mirabel at the time of the accident are the regular observations issued at 1600 and 1700.

1600: partially obscured, measured ceiling 900 feet overcast, visibility three miles in moderate snow showers, temperature -1°C, dew point -1°C, wind 040° at 18 knots, drifting snow.

1700: measured ceiling 900 feet overcast, visibility five miles in moderate snow showers, temperature -1°C, dew point -1°C, wind 030° at 19 knots, drifting snow.

1.8 Communications

1.8.1 General

All communications equipment was functioning normally. Radio communications on the apron and ground frequencies were recorded and transcribed and indicated no technical anomalies with the radio equipment. Communications on company frequencies, like that of CAIL, are not normally recorded.

1.8.2 Communications between De-icing Crew and Apron Controller

The truck drivers contacted the ground and apron controllers before entering the de-icing centre. At the de-icing centre, the de-icing crew left the apron frequency and selected the CAIL working frequency (130.775 MHz) without informing the apron controller; they were not required to do so. The CAIL frequency is used by CAIL employees and by the flight crews of air carriers that use CAIL services at Mirabel Airport. The frequency is generally used for ground operations, including de-icing operations.

1.8.3 Communications between Royal Air Maroc Crew and Snowman 1

The digital flight data recorder (DFDR) recorded the times that transmissions were made on the cockpit VHF radios. The DFDR indicates that the crew made at least 13 VHF transmissions on a frequency other than the apron, ground, or tower frequencies. The first 11 messages were transmitted between 1 minute 9 seconds and 2 minutes 47 seconds after the aircraft was parked. The twelfth and thirteenth transmissions were made within a short period just after the accident.

Because the communications on 130.775 MHz were not recorded, the precise content of the conversations between the captain and Snowman 1 could not be determined. However, information compiled through interviews was used to make an approximate reconstruction of the communications on the CAIL VHF frequency while the aircraft was in the de-icing centre.

The pilot and Snowman 1 agreed on the type of de-icing fluid to be used and the surface to be de-iced. They did not discuss the manner in which the de-icing trucks would manoeuvre around the aircraft nor did they discuss the appropriate communication cues to expect when de-icing would be completed. Normally, flight crews are aware of the de-icing procedures and a briefing of this type is not expected prior to commencing de-icing.

The communications systems on the trucks were set up to allow the drivers to hear the captain and cherry-picker operators at the same time. After the pilot and Snowman 1 agreed on the de-icing method, the truck drivers selected the interphone buttons on their microphones in order to talk only with their cherry-picker operators. From that moment on, the drivers did not transmit on 130.775 MHz, nor did they hear any transmissions on that frequency, possibly because of background engine noise or low volume settings.

As the radio transmissions were not recorded, radio protocol could not be evaluated. It was established, however, that the message "*dégivrage terminé*" (de-icing completed) heard by the flight crew was not preceded by the aircraft call-sign or the de-icing crew call-sign. To avoid confusion, the rules of standard phraseology state that radio messages must be preceded by the receiving station call-sign, followed by the sending station call-sign, with some abbreviations to the call-signs permitted once good communications have been established.

1.8.4 Instructions to Taxi for Take-off

The co-pilot contacted the apron controller and said he was ready to taxi. In normal aviation practice, the expression "ready to taxi" means that the pilot-in-command of an aircraft has ensured that all maintenance operations and other operations on the aircraft have been completed and that the aircraft perimeter is clear. When the pilot confirms to the apron controller that his aircraft is ready to taxi, the controller indicates to the pilot by radio the route he is to follow on the apron and the order of priority assigned to him.

Before issuing instructions to the pilot to taxi to Kilo, the apron controller observed that the rotating

beacon on top of the aircraft was on, and he concluded that the pilot had started the engines without authorization. As he was not familiar with CAIL procedures, he assumed that an attendant was in contact with the pilot via interphone and that the aircraft perimeter was clear.

The Royal Air Maroc crew interpreted the issuance of instructions to taxi to Kilo as also being a confirmation that the aircraft perimeter was clear.

1.8.5 Communications Equipment

The Royal Air Maroc Boeing 747-400 has three VHF radios. Two radios were used for routine communications, and one radio was used for the ARINC Communications Addressing and Reporting System (ACARS). At the time of the accident, the captain's and co-pilot's VHF radios were selected to the CAIL and apron frequencies, respectively. The flight crew never left the apron control frequency and was monitoring both frequencies.

The CAIL offices were equipped with one VHF radio, a VHF scanner, and a UHF transceiver.

Each truck was equipped with one VHF radio, one portable UHF transceiver (walkie-talkie), and an interphone linking the cherry-picker with the truck cab. The VHF radios could operate on only one frequency at a time. The drivers wore headsets and used a push-button microphone to communicate with the VHF radio and the interphone. The cherry-picker operators wore headsets and used voice-activated throat microphones.

The truck drivers stated that communications with the pilot and cherry-picker operators were normal throughout the de-icing operation. Due to the high ambient noise level, the drivers heard the noise of the engines continuously over the interphone. Transmissions on the UHF walkie-talkies used for communications between the Snowman and the Iceman were practically inaudible due to the ambient noise.

The apron controller was not monitoring CAIL's VHF frequency and was not required to do so.

1.9 Aerodrome Information

1.9.1 General

Since 1992, a private corporation called Aéroports de Montréal (ADM) has been managing Mirabel International Airport. Transport Canada and ADM share control, with Transport Canada controlling the manoeuvring areas (taxiways and runways) and ADM controlling the main apron (cargo ramp, de-icing centre, and industrial traffic area). Because of environmental regulations, ADM has required, since January 1994, that aircraft be de-iced in the de-icing centre, where the de-icing fluid is recovered. ADM does not issue de-icing permits to de-icing companies. ADM issues type "D" airport driving permits to de-icing company personnel provided that the company has a de-icing contract with an air

carrier.

According to ADM, de-icing of aircraft was under the control of the de-icing company. ADM did not intervene in the internal procedures of the companies providing maintenance and mechanical services. ADM was aware that some aircraft were de-iced with the engines on.

1.9.2 Procedures for Flight Crews Published by ADM for Aircraft De-icing

The de-icing procedures for flight crews were developed by ADM, designed solely to achieve optimum utilization of the de-icing facility. Procedures No. 5 and 6 required that:

> 5. When aircraft de-icing is completed, the pilot shall obtain authorization to start the engines from the (apron) controller on frequency 122.4 MHz.
>
> 6. When ready to taxi, the pilot shall obtain clearance to taxi from the controller on 122.4 MHz.

A copy of these procedures was provided to air carriers, including Royal Air Maroc, as they were not published on the Mirabel aerodrome chart. These procedures were conveyed by Royal Air Maroc to their flight crews on 03 February 1995, that is, after the accident.

1.9.3 Apron Control Tower

The control tower for the apron is located above the aeroquay 1,146 metres north of the de-icing centre and about 575 metres east of the main control tower. The apron control tower location is not indicated on the aerodrome chart, but it is indicated in the *Canada Flight Supplement* (CFS).

The south station of the de-icing centre was not visible to the apron controller because the central building obstructed his view of the aircraft fuselage and activities on the ground. Only the vertical stabilizer and upper deck of the B747-400 could be seen from the tower. ADM was considering installing a video camera, as it had done for the cargo ramp, linked to the apron control tower to enable the apron controller to observe operations in the de-icing centre and to facilitate the orderly conduct of de-icing operations. The video camera was not intended to enable the controller to observe ground operations while the aircraft was parked. This type of system is not mandatory, nor is it considered by ADM to be essential to the safety of aircraft movements on the apron.

The primary role of the apron controller is to direct traffic in a safe, expeditious, and orderly manner. The tools employed to do this included frequency 122.4 MHz and the procedures developed by ADM for controlling aircraft on the apron. The controller is not required to check with the de-icing crew or the pilot to confirm that de-icing is completed and the aircraft perimeter is clear.

The apron controller was not informed by his employer that aircraft were being de-iced with engines running in the de-icing centre. According to the controller, flight crew procedure No. 5 meant that the

engines were shut down for de-icing. In addition, procedure No. 6 implied that the aircraft perimeter was clear when the pilot requested clearance to taxi.

1.10 Flight Recorders

The flight recorders were played back and analyzed at the TSB Engineering Branch. Since the APU was supplying alternating current (AC) to the aircraft after the accident, the cockpit voice recorder (CVR) continued running until it was removed from the aircraft. Given that the CVR retains only the previous 30 minutes of information, the information relating to this occurrence was lost when other information was recorded over it.

1.11 Wreckage and Impact Information

The leading edges of the horizontal stabilizers sustained substantial damage when they struck the telescopic booms of the de-icing vehicles. The impact was not sufficient to be detected by the horizontal acceleration sensor and was not recorded on the DFDR.

1.12 Survival Aspects

The three occupants of the cherry-pickers were wearing their safety harnesses. The fall from a height of approximately 15 metres was not survivable.

1.13 De-icing Aircraft on the Ground

1.13.1 Regulatory and Operational Framework of Ground De-icing

Transport Canada complies with article 33 of the Convention on International Civil Aviation with respect to the issuance of operating certificates to foreign air carriers. In short, Transport Canada recognizes as valid all operating certificates, certificates of qualification, and licences issued by a contracting state to the Convention on International Civil Aviation. Article 11 of the Convention requires that foreign air carriers abide by the laws and regulations in effect in the host country. In the event of operational problems, Transport Canada would inform the air carrier and the national civil aviation authority of the country concerned.

Air Regulations, paragraph 540.2(4)(b), states that where conditions are such that frost, ice, or snow may reasonably be expected to adhere to the aircraft, no persons shall take off or attempt to take off unless certain conditions are met. One of the conditions is that the operator establish a Ground Icing Operations Program (GIOP), in accordance with the standards specified in the Ground Icing Operations Standard, and comply with that program.

The GIOP contains a series of approved procedures, guidelines, and methods, as prescribed in Transport Canada official manuals, and is intended to ensure that no aircraft takes off with frost, ice, or snow adhering to any of its critical surfaces. Transport Canada requires that the operator's de-icing/anti-icing procedures be described in the appropriate manual. Transport Canada only approves the GIOP training program; it does not develop standards for de-icing procedures, nor does it approve the procedures and methods used for de-icing aircraft on the ground. Transport Canada inspectors ensure that aircraft are operated in accordance with the clean aircraft concept. Inspectors conducting in-flight inspections will monitor general de-icing procedures, including communications with the de-icing personnel. Transport Canada does not monitor the quality or compliance of the de-icing procedures used at airports.

Air Navigation Order (ANO), Series VII, No. 2 required that an air carrier establish a training program approved by the Minister on the adverse effects of surface contamination and provide such training

annually to crew members and other persons designated by it to perform inspections pursuant to section 540.2 of the *Air Regulations*.

Transport Canada encourages air carriers to develop their own de-icing procedures for the aircraft they operate; consequently, there are differences between the various de-icing companies in terms of their methods of communication and aircraft marshalling. For instance, some use a marshaller, visible to the pilot, who guides the aircraft before and after de-icing, while others, when the aircraft stops, have the de-icing crew chief talk to the pilot via the aircraft interphone. CAIL procedures recommend that VHF radio be used to communicate with the pilot. Snowman 1 must act as the aircraft marshaller until the aircraft is brought to a halt.

Other private contractors have developed basic de-icing procedures that are suitable for all aircraft types whether the engines are on or off. These contractors are not required to develop an employee training program. An operator who contracts de-icing/anti-icing services from another organization is responsible for ensuring that the training program of the contractor and application of standards meet the operator's own Ground Icing Operations Program criteria. If a contractor provides de-icing services to a Canadian operator, the standard would require that training be provided to the contractor. According to Transport Canada, the same basic techniques and similar procedures should be applied when providing de-icing services to foreign air carriers, even if no previous arrangements have been made in this regard.

1.13.2 Canadian Airlines International (CAIL)

The CAIL Maintenance Department was responsible for the implementation, monitoring, and compliance functions of the CAIL de-icing program. CAIL had developed de-icing procedures and training standards for the implementation of those procedures; they were published in the Ramp Services Manual, which employees could refer to at any time.

The latest operational audit carried out by CAIL concerning its own de-icing operations was done on 18 January 1994. However, because weather conditions were favourable, the auditor was unable to observe de-icing operations. The audit was a review of the personnel files of de-icing crew members, and the audit report noted no irregularities.

CAIL de-icing procedures used for contract aircraft were to be consistent with the procedures set out in the Ramp Services Manual. Section 3-7-18 of the manual provides as follows:

> At NO time will a lesser standard be used. A formal contract covering the provision of de-icing service must exist between Canadian Airlines and the affected carrier, e.g. a Ground Handling Agreement. If the carrier's aircraft are different from Canadian aircraft, or if the carrier has specific requirements, then a qualified representative of the carrier must provide the required training to Canadian Airlines personnel.
>
> If the carrier approves the use of Canadian Airlines De-icing procedures on its aircraft, this must be covered in the contract...

CAIL did not provide Royal Air Maroc with a copy of its de-icing procedures, and Royal Air Maroc did not request a copy.

1.13.3 Royal Air Maroc

Royal Air Maroc held an operating certificate issued by Transport Canada in accordance with article 33 of the Convention on International Civil Aviation. Under its operating certificate, Royal Air Maroc was subject only to the provisions of the following Canadian ANOs: *Sparsely Settled Areas Order*, *Aircraft Speed Limit Order*, *Emergency Radio Frequency and Visual Interception Signals Order*, and *Sonic and Supersonic Flight Order*.

As Royal Air Maroc was not subject to the provisions of ANO, Series VII, No. 2, *Air Carriers Using Large Aeroplanes Order*, Part V, respecting employee training and qualifications, it was not required to establish a ground icing operations program. Royal Air Maroc had not developed specific de-icing procedures for its operation; its pilots were required to comply with the instructions of local authorities, service companies, and the aircraft manufacturer.

Royal Air Maroc made three flights a week to Mirabel, with the aircraft stopping at Mirabel for a few hours before departing for New York and Casablanca. A station manager, who had held that position at Mirabel for the past two years, was in charge of administrative management at the station. His duties included controlling passenger and baggage embarkation, arranging crew accommodations, and serving as liaison between Royal Air Maroc and CAIL and ADM. He received all information intended for the crew and forwarded it to Royal Air Maroc management, which then distributed it. The station manager had no experience with aircraft de-icing.

1.13.4 De-icing Aircraft with Main Engines On

On 22 August 1994, Transport Canada issued Air Carrier Advisory Circular No. 0072, intended to encourage air carriers to allow their aircraft to be de-iced/anti-iced with the main engines running where technically feasible; to describe, as part of their Ground Icing Operations Program, the procedures to be followed for each aircraft type; and to train their operational personnel in the proper use of these procedures. The purposes of this initiative were to improve the speed and efficiency of de-icing operations, to reduce departure delays in adverse weather, and to maximize the use of hold-over times.

According to the International Civil Aviation Organization (ICAO), the following information must be given to the pilot-in-command on completion of de-icing: the type of fluid used, the time of the last application, and confirmation that the aircraft complies with the clean aircraft concept. The captain released the brakes before receiving this information.

Aircraft de-icing was the responsibility of air carriers. Neither Transport Canada nor ADM monitored the quality or compliance of the de-icing operations of de-icing companies. ADM felt Labour Canada was responsible under the *Canada Labour Code* for the safety of employees performing de-icing, and that Transport Canada oversaw the aeronautical aspects under the relevant regulations. Consequently, the de-icing operations of several foreign air carriers were not controlled by the authorities.

1.14 Additional Information

1.14.1 De-icing Contractors at Mirabel

CAIL operated from its secondary base at Mirabel, which includes offices, maintenance facilities, and support staff. At the time of the accident, CAIL operated two flights a week at Mirabel. Service contracts with air carriers were the base's principal source of revenue. De-icing of aircraft was one of the services offered by CAIL.

Seven companies offered aircraft de-icing service at Mirabel. Two of these companies were air carriers and the other five were private de-icing contractors; the latter were not required to comply with ANO, Series VII, No. 2. As these contractors were not air carriers, they were not required to develop either a GIOP or de-icing procedures.

De-icing can be a lucrative business, and there is strong competition between the de-icing contractors at Mirabel. Because most were unregulated, they could respond quickly to client demands, whereas CAIL, by following all of the applicable provisions of the ANO, could not. Several of these contractors de-iced aircraft with their engines running.

Investigation revealed that there was considerable animosity between CAIL personnel and one of the private de-icing contractors, and that CAIL had complained to ADM about the practices of that contractor. CAIL alleged that the contractor took up a position at the de-icing centre without authorization and de-iced aircraft that were already under contract to CAIL.

1.14.2 Coroner's Inquest

A coroner's inquest regarding this occurrence began on 15 May 1995 at the courthouse in Laval, Quebec. The inquest lasted 12 days, ending on 02 June 1995. The individuals and companies given standing as interested parties were the families of the three deceased employees, CAIL, ADM, the International Association of Machinists, the TSB, Royal Air Maroc, and the Attorney General of Canada. The TSB worked with the coroner on the inquest.

The coroner did not make recommendations regarding this occurrence. In the conclusion to his report, the coroner recognized the expertise of the TSB in the field of aviation and left it to the TSB to determine whether there were any safety deficiencies and to make recommendations if appropriate.

2.0 Analysis

2.1 Introduction

The investigation established that the VHF radios in the aircraft and de-icing vehicles functioned normally during the de-icing and at the time of the accident. However, there was a lack of communication between the flight crew and Snowman 1 that resulted in the captain believing that the de-icing was completed. The analysis will examine the reasons why the flight crew believed that the de-icing equipment and personnel were clear of the aircraft, the lack of positive procedures on the part of the de-icing crew, and the contributing factors which led to the accident.

2.2 Decision to Taxi

The flight crew did not realize that 130.775 MHz was the CAIL working frequency. They mistakenly concluded that this frequency was reserved for de-icing. In addition, the pilots assumed that 130.775 MHz was a communication system analogous to the interphone, although the frequencies used for air-ground communications are in the VHF band, 118-136 MHz. Consequently, the pilots presumed that the Iceman's message about the completion of de-icing came from Snowman 1, that the message was intended for them, and that it indicated that de-icing was completed.

The pilots heard the words "*dégivrage terminé*" (de-icing completed). Although this message was not preceded by the flight call-sign or the de-icing crew call-sign, the pilot read back "de-icing completed" twice. As the duration of the operation up to that point matched the time usually required for this type of de-icing, and as they received no acknowledgement from Snowman 1, the flight crew thought the de-icing crew had left the frequency and departed the area. The co-pilot then advised the apron controller that the aircraft was ready to taxi, and, in doing so, the co-pilot conveyed to the apron controller that de-icing was completed and the aircraft was clear. Relying on that information, the controller indicated to the co-pilot his assigned route for taxiing from his current parking spot to Kilo turn-off. The pilot mistakenly interpreted the issuance of taxi instructions as confirmation that the aircraft was clear.

According to the rules of standard phraseology, to avoid confusion, radio messages must be preceded by the receiving station call-sign, followed by the sending station call-sign. While these rules may not apply to interphone communications, the "open" nature of VHF radio communications requires that the international rules of radio procedure be followed. In this case, the pilot heard the words "dégivrage terminé" and made a number of erroneous assumptions: that the radio transmission was directed to him; that the de-icing operation was completed; and that all equipment and personnel were clear of the aircraft's taxi path.

2.3 Communications Equipment

Except for the background noise of the engines on the interphone, communications between the drivers and cherry-picker operators were clear. During the de-icing, the Iceman and the pilot tried without success to communicate with the de-icing crew on the CAIL frequency. By all indications, the

noise of the engines prevented Snowman 1 from hearing the pilot and the Iceman when they tried to communicate with him. The fact that the truck drivers did not hear these messages attests to the ineffectiveness of the vehicles' communication systems in blocking out the noise of the engines.

2.4 Regulatory Framework for Foreign Air Carriers

Transport Canada certified and controlled foreign air carriers in accordance with standards different from those applicable to Canadian air carriers. Canadian air carriers were required to comply with section 540 of the *Air Regulations* and with ANO, Series VII, No. 2. Foreign air carriers were not subject to the provisions of ANO, Series VII, No. 2. Consequently, Royal Air Maroc was not required to develop a program of procedures for de-icing aircraft on the ground, although it operated its aircraft in the same environmental conditions as Canadian air carriers.

Since, in accordance with ANO, Series VII, No. 2, air carriers were responsible for implementing their de-icing procedures, it was not necessary to regulate the services provided by de-icing contractors. Air carriers were responsible for the safety and effectiveness of de-icing operations. As Royal Air Maroc had neither an approved ground icing operations program nor de-icing procedures, it relied on Canadian Airlines International in regard to de-icing procedures. As Royal Air Maroc did not have a copy of the CAIL procedures in its possession, the captain was not in a position to monitor the work of the de-icing crew. The captain thereby accepted the de-icing of the aircraft but was not familiar with the de-icing procedures being used.

2.5 Training in Engines-On De-icing

Examination of the electronic mail between the Manager, System Aircraft De-icing, the Manager of Client Services at Mirabel, and the instructor/developer prior to 03 January 1995 revealed that the need for the engines-on de-icing course was somewhat urgent in order to satisfy client demand and to compete against other de-icing companies. The course given on 03 January 1995 was different from that given by CAIL for engines-on de-icing of the Boeing 737 and Airbus 320. The test on the theoretical portion, which is normally required, had not been devised for the course given on 03 January 1995, and the procedures for the Boeing 727 and Lockheed 1011 had not been developed.

The practical engines-on exercise was not conducted on the aircraft covered in the classroom; instead, an Airbus 310 was used, an aircraft on which the employees had not been trained, and which they were not authorized to de-ice with the engines running. It is possible that the course created some confusion for the employees as to which aircraft they were required to de-ice with engines off and which they could de-ice with engines running. Some employees mistakenly thought they were authorized to de-ice Boeing 747 aircraft with the engines running.

Contradictory testimony regarding the conduct of the course precluded a determination as to whether the employees had been told that they could de-ice Boeing 747s with the engines running. But correspondence between the instructor/developer and the System De-icing Program Manager indicates that the employees were not qualified to de-ice Boeing 747s with the engines on. Further, Snowman 1 had attended a de-icing course supported by an appropriate manual in which it was stated that de-icing an aircraft while its engines were running was not authorized unless the employee was trained to do so. As he had not attended any "engines-on" de-icing course, he had no reason to believe he was authorized by CAIL to de-ice an aircraft with its engines running.

2.6 Competition Between De-icing Contractors

Seven companies were authorized by ADM to de-ice aircraft according to their practices in the Mirabel airport de-icing centre. Rivalry was especially fierce between the employees of CAIL and those of other private contractors. Several de-icing contractors de-iced all aircraft types with the engines running. As private de-icing contractors were not regulated, they were able to respond quickly to client demands. The regulatory requirements applicable to CAIL, with the attendant requirement to develop procedures and provide training, meant that CAIL, working within the rules, could not provide as fast and ready a service as could the private contractors. This undoubtedly heightened competition between CAIL and private de-icing contractors in their desire for de-icing contracts, and this competition might have led some CAIL employees to take liberties with the established safety standards.

When the Royal Air Maroc captain indicated that there would be a delay in starting the de-icing if he had to shut down the engines and start the APU, Snowman 1 decided to de-ice the aircraft with the engines running, though he had not taken the necessary "engines-on" training. He was also aware, having taken the initial de-icing course, that he was not supposed to de-ice an aircraft with its engines running. Some factors that could have influenced his decision were a normal desire to improve the speed and efficiency of de-icing operations and to maximize the use of hold-over times for the de-icing fluid. It is probable that a significant additional factor was the competition between de-icing contractors.

2.7 Control of De-icing Area

The apron controller performed his tasks in accordance with established procedures and his assigned responsibilities. He guided the aircraft until it was stopped at the south station. The aircraft came fully under the responsibility of the captain after it was stopped for de-icing. Before issuing taxi instructions to the aircraft, the controller verified that the taxiway was clear. It was not his responsibility to consult the flight crew and de-icing personnel to determine whether the aircraft was clear and ready to taxi. That responsibility was assumed by the captain when the co-pilot declared the aircraft ready to taxi.

That the apron controller issued taxi instructions when de-icing was not completed indicates that he was not aware that de-icing was in progress. Although he fully discharged his responsibilities, the controller probably did not have enough information or sufficient tools to accurately assess the situation in the de-icing centre. ADM had recognized the value of video coverage of the manoeuvring area which the apron controller could not see from his work station. The cargo ramp was covered by a panning video camera and the same installation was being considered for the de-icing area.

2.8 Marshaller

Snowman 1 performed the duties of marshaller and truck driver. He was not in a position to prevent the aircraft from advancing, given that he was behind the aircraft and the noise of the engines prevented him from hearing the transmissions of the pilot and the Iceman.

Several air carriers prefer to place a marshaller in front of the aircraft to minimize the possibility of the aircraft moving until the de-icing procedure is complete and all personnel and equipment are safely out of the way. Some carriers utilize an interphone cord plugged into the aircraft to maintain constant communication between the ground crew and the flight deck. This procedure eliminates the risk of confusion between flight crew/marshaller communications and other VHF communications. CAIL has not chosen the direct interphone cord method of communication because it is felt that the area around the aircraft is too dangerous an environment in light of the slippery footing conditions due to the glycol, particularly with the engines running.

2.9 Supervision of De-icing Operations by Royal Air Maroc

The Royal Air Maroc station manager performed only administrative duties, and the company did not have capable personnel at Mirabel to evaluate operational procedure requirements. This task fell, by default, to the flight crew who, depending on the task, were not necessarily qualified. As a result, it is possible that Royal Air Maroc was not made aware of its responsibilities regarding ground de-icing. Consequently, Royal Air Maroc was not in a position to assess the importance of developing de-icing standards or, at a minimum, obtaining the CAIL procedures and distributing them to their crews. As Royal Air Maroc did not have a copy of the CAIL de-icing procedures in its possession, neither the station manager nor the pilot could monitor compliance with the existing de-icing standards.

2.10 Coordination between Flight Crew and Flight Attendants

The pilots did not consult the cabin crew before releasing the brakes. The flight attendants had been advised that the aircraft was about to taxi. Given that the pilots could not see the aft section of the aircraft from the flight deck and they did not see the de-icing vehicles depart the area, consulting the flight attendants was a conceivable and reasonable option in this particular situation. The aim of cockpit/cabin coordination training is to enhance the quality of this type of decision.

2.11 Communications

Analysis of the communications recordings indicates that, on some occasions, standard aeronautical phraseology and terminology were not used. For example, the co-pilot and de-icing attendants did not always state their own call-sign and the receiving station call-sign when communicating with the apron controller, and the captain read back "de-icing completed" twice without stating his call-sign.

2.12 Supervision of De-icing Operations by CAIL

The Iceman and the lead station attendant were chiefly responsible for day-to-day monitoring of the quality and the safety aspect of de-icing services. They were responsible for ensuring that the work was performed by qualified personnel and that the standards and procedures were adhered to. It was established that, at the time of the accident, the persons in the cherry-pickers were not wearing the required safety equipment, and neither Snowman 1 nor the station attendant had the training or qualifications to de-ice aircraft with the engines running. Completion of the training would probably have sensitized Snowman 1 to some of the complications associated with engines-on de-icing, such as poorer quality radio communications. As two members of the crew had not received the required training, the crew, as a whole, was not qualified to perform the de-icing safely.

On two separate occasions prior to the accident, supervisors could have intervened to halt the sequence of events that culminated in the accident. First, the supervisors did not intervene when Snowman 1 did not follow his company's procedures when he suggested to the pilot that the engines be left running during de-icing. Later, the Iceman did not intervene when the co-pilot declared the aircraft ready to taxi; he apparently did not correctly analyze the previous communications in the short time available to him to make an intervention. It appears that the supervisors were not performing adequate supervision to intervene and take corrective action.

2.13 Summary

The Royal Air Maroc flight crew were not familiar with the engines-on de-icing procedures of CAIL, but de-icing their aircraft with its engines running was permitted by their operations manual. Training for the CAIL de-icing crew with regard to engines-on de-icing procedures was minimal, and Snowman 1 and a trainee had not received the training. The CAIL engines-on de-icing course attended by three of the five de-icers was poorly structured, apparently put together and delivered in a short period of time, and was incomplete in that there was no test required at the end of the training. The course did not include B747 training.

The regulations governing CAIL, a licensed Canadian air carrier, made it difficult for CAIL service crews to compete with other de-icing contractors, who could operate with virtually no Transport Canada overview. The competitiveness among the de-icing contractors at Mirabel certainly could affect the decisions of the participants regarding de-icing.

There was little supervisory overview of the de-icing operation in that the supervisor (the Iceman), knowing that de-icing of a B747 was taking place with its engines running and that the de-icing crew were not trained or qualified to do the job, did not stop the de-icing.

The de-icing crew's communications equipment may have been adequate for the job, but only if it was used in a manner such that the noise from the aircraft engines did not render the equipment ineffective. Some radio transmissions from the flight crew and the de-icers did not include call-signs, introducing confusion and ultimately leading to the flight crew commencing taxiing before the de-icing equipment was clear of the aircraft.

This occurrence was the result of a combination of factors, not a single omission or error. The above factors, in combination, led to deviations from safe operating practices and ultimately to the accident.

3.0 Conclusions

3.1 Findings

1. All communications equipment functioned normally before and after the accident.

2. Engine noise probably prevented the de-icing crew from hearing the pilot and the Iceman when they tried to communicate with the de-icing crew.

3. CAIL communication equipment was neither adequate for nor designed to be used in engines-on de-icing operations, as it did not block out engine noise.

4. The pilot and de-icing crew did not use standard aeronautical terminology and phraseology on some occasions.

5. The pilots thought that the Iceman's message to Snowman 1 was addressed to them and that it meant that the de-icing was completed.

6. Following confusion in the radio communications, the flight crew started to taxi the aircraft before its perimeter was clear.

7. Snowman 1 suggested that the pilot keep the engines running during the de-icing operation and the pilot agreed. The flight crew was not familiar with the de-icing procedures and methods approved by CAIL.

8. At the time of the accident, the cherry-picker operators were not wearing the protective equipment required for the de-icing.

9. Snowman 1 was not in a position to prevent the aircraft from advancing, given that he was behind the aircraft where he could not be seen by the flight crew and where the noise of the aircraft engines prevented his hearing the radio transmissions of the pilot and the Iceman.

10. As a signatory to the International Civil Aviation Organization (ICAO), Canada accepts the certification of other ICAO signatories to ICAO standards. As a foreign air carrier, Royal Air Maroc was not required to develop a set of procedures regarding de-icing of aircraft on the ground.

11. Royal Air Maroc did not have a copy of CAIL's de-icing procedures in its possession and had not asked CAIL for a copy of the procedures.

12. Royal Air Maroc did not have personnel at Mirabel capable of evaluating the de-icing procedural requirements.

13. CAIL had not developed procedures for de-icing a B747 with the engines running, and the de-icing crew was not authorized by CAIL to de-ice B747s with the engines running.

14. The CAIL engines-on de-icing course held in Mirabel on 03 January 1995 was presented in a manner that left some employees unsure as to which aircraft they were permitted to de-ice with engines running.

15. Several air carriers favour having a marshaller in front of the aircraft and using the interphone for ground communications during de-icing. CAIL recommends the use of VHF radio to communicate with the pilot and to guide aircraft on the ground.

16. The apron controller performed his tasks in accordance with established procedures and his assigned responsibilities.

17. The apron controller did not have enough information or sufficient tools to accurately evaluate the situation in the de-icing centre, which he could not see from his work station.

18. Transport Canada did not monitor the quality or compliance of the de-icing procedures developed by the air carriers.

19. Private de-icing contractors are not regulated by Transport Canada, whereas air carriers such as CAIL must follow regulatory requirements set out by Transport Canada.

20. It is possible that competition between the de-icing companies and a concern for efficiency influenced Snowman 1's decision to de-ice the aircraft with engines running despite the fact that he had not had the formal training.

21. There was no other de-icing operation in progress at Mirabel at the time of the occurrence.

3.2 Causes

The flight crew started to taxi the aircraft before its perimeter was clear, following confusion in the radio communications. The following factors contributed to the accident: a lack of de-icing procedures within Royal Air Maroc; non-compliance with procedures on the part of the CAIL de-icing crew; inadequate or inappropriate communications equipment; incomplete training of Snowman 1; a regulatory framework less demanding of foreign air carriers than of Canadian carriers; a lack of operational supervision; and a lack of adherence to radio protocol.

4.0 Safety Action

4.1 Action Taken

The Board notes that, following this occurrence, several changes were made to procedures, regulations, and manuals affecting the de-icing/anti-icing of aircraft operating in Canada. These measures, to a large extent, address the significant aviation safety deficiencies identified during the investigation, and therefore reduce the probability of a recurrence of this type of accident. As such, the Board believes that recommendations with respect to additional corrective actions are not warranted at this time.

4.1.1 ICAO Manual of Aircraft Ground De/Anti-Icing Operations

At the end of 1995, ICAO published "stand-alone" Document No. 9640, *Manual of Aircraft Ground De/Anti-Icing Operations*, for use by member state aircraft operators. This document, *inter alia*, states that:

> 7.3 The de/anti-icing program shall clearly define areas of responsibility for the operator. All persons involved in ground de/anti-icing activities shall be trained and qualified in the procedures, communications and limitations of their area of responsibility. The de/anti-icing programme shall cover all locations within the operator's route network including contract de/anti-icing accomplished by others.
>
> 10.1 The communications between ground and flight crews are an integral part of the de/anti-icing process and must be included in every de/anti-icing procedure....
>
> 10.3 Upon completion of the de/anti-icing procedure and the associated check of the aeroplane, which ensures that it complies with the Clean Aircraft Concept, the following information shall be communicated to the flight crew:
>
> a) fluid type;
>
> b) fluid/water ratio (Type II fluids only);
>
> c) start time of the last step in the de/anti-icing procedure;
>
> d) confirmation that the aeroplane is in compliance with the Clean Aircraft Concept.

4.1.2 Canadian Aviation Regulations - Ground Icing Operations

At the time of the occurrence, foreign air carriers operating in Canada were not subject to the provisions of ANO, Series VII, No. 2. Consequently, Royal Air Maroc was not required to develop a program of procedures for de-icing aircraft on the ground.

In October 1996, the new Canadian Aviation Regulations (CARs) came into force. In addition to describing "General Operating and Flight Rules Standards Regarding Ground Icing Operations" in section 622.11, the new regulations state the following in section 701.25 (4) of "Foreign Airline Operations," Division III, "Inspection and Aircraft Icing Operations":

> Where conditions are such that frost, ice or snow may reasonably be expected to adhere to an aircraft, no person shall conduct or attempt to conduct a take-off in the aircraft unless:
>
> (a) the aircraft has been inspected immediately prior to take-off to determine whether any frost, ice or snow is adhering to any of its critical surfaces; or
>
> (b) the foreign air operator or the holder of the flight authorization has:
>
> > (i) established, in accordance with ICAO Document No. 9640 entitled *Manual of Aircraft Ground De/Anti-icing Operations*, an aircraft ground icing operations program that has been approved by the state of the foreign air operator or of the holder of the flight authorization, or
> >
> > (ii) submitted to the Minister an aircraft ground icing operations program that meets the applicable *Commercial Air Service Standards*.

4.1.3 Royal Air Maroc - De-icing/Anti-icing Operations

In October 1995, Royal Air Maroc published interim procedures pending the amendment of the "De-icing/Anti-icing Operations" section of the Royal Air Maroc policy manual.

Section 6, "Final Inspection Before Aircraft Dispatch," requires that ground crew now report the anti-icing code to the pilot-in-command when de-icing is completed, stating as follows:

> Reporting the anti-icing code to the Pilot in Command confirms the correct and complete accomplishment of the de-icing/anti-icing of the airplane.

Section 10, "Communication," states that "For safety purposes it is important to establish a clear communication with the ground team." The policy manual describes in detail the verbal communications required during de/anti-icing operations and requires that ground

crew advise that ground materiel is removed and that flight crew stand by for a visual signal. Phraseology to be used by flight crew and ground crew during de-icing is outlined in a table.

4.1.4 CAIL - De-icing/Anti-icing Procedures

CAIL completed a review and made changes to their de/anti-icing procedures. CAIL's policy is now such that the engine-on de/anti-icing process will be used only on aircraft being operated by Canadian Airlines International or Canadian Regional Airlines.

The procedures indicate that both visual and verbal communication must be received and acknowledged by aircraft flight crew before the de-icing process can be started or terminated. Cue cards to support correct verbal radio communication have been developed and deployed to all de-icing vehicles and designated team members. The reporting structure, briefing, training, audit process, and base de-icing team leadership along with the use of designated VHF radios have been upgraded to further enhance the de-icing procedure with particular emphasis on team work and related communication. De-icing team check sheets and daily shift briefings have also been developed to further support this process.

A copy of CAIL's de-icing procedures has been provided to all contract carriers, both at the local base and head office levels, to which CAIL provides de-icing services. Particular emphasis has been placed on the communication procedures.

4.1.5 Labour Canada Directive

After the accident, a directive was issued by a Labour Canada Safety Officer under Part II of the *Canada Labour Code* requiring that CAIL provide its employees with the supervision necessary to ensure their health and safety.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 19 March 1997.

Appendix A - Mirabel Airport De-icing Bay

Appendix B - List of Supporting Reports

The following TSB Engineering Branch Report was completed:

> LP 6/95 - Flight Recorders Group Report on the Investigation of the B747-400 Royal Air Maroc Occurrence, Mirabel International Airport.

This report is available upon request from the Transportation Safety Board of Canada.

Appendix C - Glossary

AC	alternating current
ADM	Aéroports de Montréal
ANO	Air Navigation Order
APU	auxiliary power unit
CAIL	Canadian Airlines International Ltd.
CARs	Canadian Aviation Regulations
CFS	Canada Flight Supplement
CVR	cockpit voice recorder
DFDR	digital flight data recorder
EST	eastern standard time
GIOP	Ground Icing Operations Program
ICAO	International Civil Aviation Organization
MHz	megahertz
TSB	Transportation Safety Board of Canada
VHF	very high frequency