PART II

The Factual Circumstances of the Accident

The 767 belongs to a new generation of aircraft. Its instruments in particular are very sophisticated, most of them being operated by systems developed in the field of avionics. The term avionics refers to the application of electronics to aviation. Because of this new technology, the manufacturers were able to design an aircraft of the size of the 767 for operation by a two-man rather than a three-man crew. This was achieved by making the work load for the pilots easier by the use of advanced systems which, when working properly, furnish information about the aircraft quickly and accurately. The aircraft is designed to fly a pre-determined course to its destination and, under certain restricted circumstances and after receiving the necessary command from the crew, to land itself. The pilots are thus relieved of any functions that can be better performed by computers. They are able to manage the flight more efficiently, aided by instruments some of which resemble small television screens directly facing each pilot. These can be operated so as to produce all necessary flight information such as the hydraulic system pressure, the fuel pressure, the attitude of the aircraft and its flight path, and a plan of the airfield at the next destination.

The accident happened on July 23, 1983, when the aircraft was being flown by Captain Pearson in command, assisted by First Officer Quintal. However, to understand the sequence of events which culminated in the emergency landing at Gimli, it is necessary to go back to the previous day when the aircraft was in Edmonton.

During a routine service check, the three fuel quantity indicators, or fuel gauges, situated on an overhead panel between the two pilots, were found to be blank. One gauge is for the centre auxiliary tank, one for the left main tank and one for the right main tank. The tanks are located in the wings. The centre tank has not so far normally been used for flights within Canada. It will, however, necessarily be used when overseas flights begin. These gauges are operated by a digital fuel gauge processor which has two channels. Either one of the channels is normally sufficient to ensure satisfactory operation of the processor to provide fuel indication on the gauges in the cockpit. The processor is located underneath the floor of the aircraft, immediately behind the cockpit. Circuit breakers, one for each channel, are located on a panel on the ceiling of the cockpit, above and slightly to the rear of the pilots' seats.

Mr. Conrad Yaremko, a Certified Aircraft Technician, Category 1 (CAT-1), who had experienced this problem of blank fuel gauges before on the same aircraft, found that he could obtain fuel indication by pulling and deactivating the channel 2 circuit breaker. This rendered channel 2 of the processor inoperative and channel 1 took over. Mr. Yaremko tagged or collared the circuit breaker with a piece of yellow tape which was marked "inoperative". He also stuck another piece of yellow tape above the fuel indicators. This was marked "see log book". Mr. Yaremko made a note in the journey log book of the problem with channel 2. Such problems with equipment are commonly referred to as snags. In Edmonton, Mr. Yaremko deferred the snag and entered reference to it in the computerized system which informs on-line stations of deferred snags. Such a snag is called a deviation because it affects the airworthiness of the aircraft. With this kind of problem an aircraft can only be dispatched after compliance with the conditions of the Minimum Equipment List (MEL). The computerized system referred to is the Deferred File Display (DFD). Mr.

Yaremko then dispatched the aircraft after complying with the qualifying conditions of MEL item 28-41-2. Under this item of the MEL, because one of the processor channels was inoperative, the fuel load had to be confirmed and was confirmed by the use of the fuel measuring sticks located under the wings of the aircraft. This procedure is usually called "doing a fuel drip" or "doing a drip check".

The Minimum Equipment List is a document developed by Air Canada from the Master Minimum Equipment List (MMEL) issued by the Federal Aviation Administration (FAA) in Washington, U.S.A. and approved by Transport Canada in Ottawa. It lists those circumstances and conditions under which an aircraft may safely be dispatched, even though some of its equipment is inoperative. This is possible because most items of equipment vital to the operation of an aircraft in flight are protected by a system of redundancy. This means that such systems are duplicated so that, if one fails, the other can be used provided that certain stipulated conditions set out in the MEL are met to ensure the safe flight of the aircraft.

The MEL is part of the Boeing 767 Aircraft Operating Manual carried on board the aircraft.[14] It is found in Chapter 1 under the heading "Limitations".

Before dispatching the flight, Mr. Yaremko not only made a note in the log book of the snag with channel 2 of the processor, he also discussed it with Captain John Weir. The latter, as captain of the aircraft, had the final decision as to taking or not taking the aircraft. Captain Weir satisfied himself that it was legal to operate the aircraft under the provisions of the MEL. He did, however, get the impression from his discussion with Mr. Yaremko that the aircraft had arrived in Edmonton from Toronto with the same snag. Mr. Yaremko had, in fact, been referring to a similar problem on a flight from Toronto to Edmonton experienced on July 5, 1983, rather than on July 22. This misunderstanding is important in the light of a conversation that Captain Weir had with Captain Pearson when the aircraft arrived in Montreal on July 23.

Captain Weir and his first officer, Captain Donald Earl Johnson, left Edmonton on the morning of July 23 and flew the aircraft to Montreal via Ottawa. The flight was uneventful. All three fuel gauges operated normally. Upon landing in Montreal, Captain Weir and Captain Johnson met Captain Pearson in the vicinity of the parking lot and discussed briefly the problem relating to the fuel system.

Captain Weir's recollection of the conversation is that they discussed in general terms the fact that there was a problem with the fuel system and that enough fuel should be boarded to go right through to Edmonton. Captain Pearson's recollection of the conversation is that Captain Weir had informed him that the fuel gauges were inoperative, that a fuel drip had to be done to ascertain the amount of fuel on the aircraft and that the aircraft had been operating in that fashion from Toronto to Edmonton and from Edmonton to Ottawa and to Montreal.

Captain Pearson, therefore, received the impression that the snag had been outstanding since the aircraft left Toronto the previous day and that the aircraft had been flown throughout this period with inoperative fuel gauges.

Before the new flight crew arrived on board, Mr. Ouellet entered the cockpit. He was a Certified Avionics Technician, Category 38 (CAT-38), who had been assigned to the aircraft in order to perform the drip check required to satisfy the requirements of MEL item 28-41-2. He noted the entry made in the log book by Mr. Yaremko. He also noticed the circuit breaker which had been pulled and tagged. He was confused by the entry in the log book which did not appear to coincide with what he had been taught about the processor in recent training. Because of his confusion, he tried to get to the bottom of the problem by doing what is known as a BITE test on the processor.

BITE stands for Built-in Test Equipment. It refers to the fact that the processor had been designed and built so as to be able to identify faults within its own system. Before doing the test, he reset the number 2 channel circuit breaker. This caused the fuel gauges in the cockpit to go blank.

Mr. Ouellet was not satisfied with the test and decided that the processor had to be replaced. When he tried to order a new one, he was told that none were available in Montreal, but that one had been ordered to be available that night in Edmonton.

On returning to the flight deck, Mr. Ouellet was distracted by the arrival of the fueller and forgot to pull the number 2 circuit breaker, so as to deactivate it as Mr. Yaremko had done. Thus, when Captain Pearson arrived on board and saw the blank fuel gauges in the cockpit, this circumstance reinforced his misunderstanding of the conversation with Captain Weir.

When Captain Pearson noticed the collared circuit breaker, he assumed that it had been deactivated and, further, that it was the circuit breaker for the fuel gauges in the cockpit, rather than for the processor which operates them. Both of his assumptions were incorrect. The circuit breaker had not been deactivated, nor was it, strictly speaking, the circuit breaker for the gauges. However, his assumptions were certainly consistent with his misunderstanding of the conversation with Captain Weir. As a result of the action taken by Mr. Ouellet, the fuel gauges were blank. When Captain Pearson entered the cockpit, he expected the fuel gauges to be blank. Similarly, the log book entry made by Mr. Yaremko further confirmed his false assumption about the fuel gauges.

Captain Pearson then consulted the MEL, where he read the provisions of section 28 dealing with the fuel system. Item 28-41-1 clearly indicates that in order to permit the dispatch of an aircraft, at least two of the three fuel gauges must be working. Item 28-41-2 refers to fuel processor channels. Of the two channels, one is required for dispatch.

Captain Pearson knew that the aircraft was not legal to go with blank fuel gauges. He testified that he had raised the question of legality with one of the attending technicians who assured him that the aircraft was legal to go and that a higher authority, Maintenance Central, now renamed Maintenance Control, had authorized the operation of the aircraft in that condition. No such authorization had in fact been given. There is even some question as to whether this conversation took place.

In any event, because of the mistaken assumption already in his mind, Captain Pearson formed the opinion that he could safely take and fly the aircraft, provided the fuel quantity on board the aircraft was confirmed by use of the fuel quantity measuring sticks in the fuel tanks. These are commonly called the drip sticks.

Before dealing with the drip procedure, it should be noted that for some years now all aircraft in Canada have been fuelled in litres. That is to say that fuellers deliver fuel in litres and charge for the fuel by the litre. On the other hand, those who calculate the load of the aircraft and those who fly the aircraft do not work in litres, which is a measurement of volume, but rather in a weight measurement.

Prior to the introduction of the Boeing 767 type of aircraft into the Air Canada fleet — 12 had been ordered and 4 delivered at the time in question — weight calculations were made in pounds, an Imperial measurement. When the new aircraft were ordered, a decision was taken, in line with Canadian government policy, to order them with their fuel gauges reading in kilograms, a metric measurement. Similarly, calculations of the take-off weight of the new type of aircraft were to be made in kilograms.

Fuel quantity measuring sticks, or drip sticks, are used to measure the amount of fuel in an aircraft. They are only used in an abnormal situation, when the aircraft is being dispatched under the qualifying conditions set out in the section of the MEL relating to fuel. A drip stick is pulled from underneath the aircraft and is so designed that the fuel will not drip out when the stick is pulled. Hence the term drip stick. The stick is also calibrated. Different calibrations are used by different airlines and in Air Canada they vary from one aircraft type to another. Suffice it to say at this point that Air Canada ordered drip sticks for the 767 calibrated in centimetres.

Before leaving Edmonton, Captain Weir and the ground crew complied with MEL item 28-41-2 which at that time stipulated, in part, that one fuel tank quantity processor channel could be inoperative, provided fuel loading was confirmed by use of a fuel measuring stick. In Montreal, before departure, Captain Pearson, First Officer Quintal, and members of the ground crew, all attempted a similar confirmation of the amount of fuel on board the aircraft. The attempt was made even though departure was not permitted by MEL item 28-41-1. This stipulated, in part, that one left or right wing tank fuel gauge might be inoperative, provided fuel quantity in the associated tank was determined by measuring stick. Captain Pearson, who had the final authority on whether to take and fly the aircraft, left Montreal and later left Ottawa with blank fuel gauges, contrary to the provisions of the MEL.

Critical to the determination of the correct fuel quantity by the drip stick method is the conversion from centimetres to litres and from litres to kilograms. The first part is easy because drip tables are provided and kept on board the aircraft. The drip tables, as they existed at the time of the Gimli accident, provided a simple means of converting centimetres to litres. On the other hand, converting litres to kilograms involves using a conversion factor. At the time, the conversion factor was called specific gravity. The term, as used to describe the conversion factor of 1.77 lbs. per litre, is a misnomer. The term, however, has been used in the aircraft industry throughout the world for a long time. Unfortunately, the conversion factor, or specific gravity as it was mistakenly called, supplied to those making the calculations in Montreal and Ottawa was 1.77. This is the figure used to convert litres to pounds. The conversion factor to convert litres to kilograms is typically around .8. There are slight variations in any such conversion factor depending on the temperature.

There was disagreement among counsel as to whose responsibility it was to make the calculations. Counsel for CALPA submitted that the job had been assigned, according to the provisions of the MEL, to maintenance personnel. Counsel for Air Canada took the position that there was a gap in the system and that the task had not been assigned to anyone. Whoever was supposed to do the calculations, it is clear from the evidence that both in Montreal and Ottawa there was a joint effort on the part of the flight crew and the maintenance personnel to determine the fuel load. On each occasion all concerned used the incorrect conversion factor. As a result, the aircraft left each airport in turn with only half the amount of fuel the flight crew thought they had. Using the conversion factor of 1.77 resulted in a conversion from litres to pounds. To arrive at the correct weight in kilograms, the resulting figure would have had to be divided by 2.2. This was not done.

Normally, the aircraft would have been fuelled in Montreal and again in Ottawa. However, because of the problem with the gauges, Captain Pearson decided to load enough fuel to go right through to Edmonton with a drip check to be made both in Montreal and in Ottawa. Unfortunately, the same mistake in calculations and conversion was made on both occasions. As a result, the aircraft ran out of fuel in flight.

The first signs of trouble appeared shortly after 8:00 p.m. Central Daylight Time when instruments in the cockpit warned of low fuel pressure in the left fuel pump. The Captain at once decided to divert the flight to Winnipeg, then 120 miles away, and commenced a descent from 41,000 feet. Within seconds, warning lights appeared indicating loss of pressure in the right main fuel tank. Within minutes, the left engine failed, followed by failure of the right engine. The aircraft was then at 35,000 feet, 65 miles from Winnipeg and 45 miles from Gimli. Without power to generate electricity all the electronic gauges in the cockpit became blank, leaving only stand-by instruments, consisting of a magnetic compass, an artificial horizon, an airspeed indicator and an altimeter. It soon became evident that they would not be able to make it to Winnipeg. Thus, at 8:32 p.m. Central Daylight Time, in consultation with Air Traffic Control, Captain Pearson redirected the aircraft towards Gimli, some 12 miles away on the western shore of Lake Winnipeg. By this time, the flight attendants in the cabin had instructed the passengers in emergency procedures.

Fortunately for all concerned, one of Captain Pearson's skills is gliding. He proved his skill as a glider pilot by using gliding techniques to fly the large aircraft to a safe landing. Without power, the aircraft had no flaps or slats with which to control the rate and speed of descent. There was only one chance at a landing. By the time the aircraft reached the beginning of the runway, it had to be flying low enough and slowly enough to land within the length of the 7200 foot runway.

As they approached Gimli, Captain Pearson and First Officer Quintal discussed the possibility of executing a side-slip to lose height and speed in order to land close to the beginning of the runway. This the Captain did on the final approach and touched down within 800 feet of the threshold.

During the descent, First Officer Quintal had tried, without success, manually to lower and lock the nose wheel. As it turned out, his failure to do so helped to slow down the aircraft when it was on the ground, because of the friction caused by contact of the bottom of the nose with the concrete runway. This averted disaster to people at the far end of the runway.

The airfield at Gimli is a disused military base. The far end of the runway from where the aircraft touched down has been adapted for use as a drag racing strip. Just beyond the strip used for racing, drag racing drivers and their families were staying for the weekend in tents and caravans. Fortunately, the aircraft came to a stop before it reached them. The passengers and crew were safely evacuated. Both fuel tanks were found to be dry.

PART III

The Contributory Causes of the Accident

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The Contributory Causes of the Accident

A. Overview

The Air Canada Boeing 767 accident in Gimli resulted from a combination of a number of different causes. To suggest that the accident was the result of a metric mix-up is simplistic and inaccurate. To suggest that the accident was caused by a shortage of fuel begs the question. The question is how this shortage could have occurred.

Mr. Beauchamp, Counsel for CALPA, in his submission, drew a distinction between the dominant cause of the accident and the contributing causes of the accident. He urged that the single effective or dominant cause of the emergency landing was "the boarding of an insufficient amount of fuel in Montreal". He argued that this was "directly caused by the use of the wrong conversion factor in the determination of how much fuel was on board".

This submission, although true as far as it goes, does not answer the basic question as to causation.

Mr. Saul, Counsel for Air Canada, in his submission, urged that no one was to blame for the accident but rather that it resulted from an unfortunate chain of events which neutralized three safety nets. These safety nets were, in his words:

> "First, highly accurate fuel gauges indicated the fuel load in each tank. Second, in the absence of these gauges the Minimum Equipment List prohibited dispatch. Third, in the event of an erroneous dispatch the requirement of a manual procedure ensured an accurate check of fuel on board."

He further argued that the contributing factors evolved along at least three unrelated causal chains:

"1. The events resulting in blank fuel gauges on the aircraft in Montreal;

2. The events leading to the dispatch of the aircraft from Montreal and Ottawa in contravention of the Minimum Equipment List; and

3. The events leading to the miscalculation of the fuel on board."

While Mr. Saul's submission is attractive, it is my view of the evidence that the causal chains which he described as neutralizing the three safety nets were not unrelated. Thus, if the gauges had been working there would have been no need to resort to the MEL. However, once the MEL was resorted to, it necessarily led to the manual calculation of the fuel. To some extent, therefore, Mr. Saul's submission falls short of answering the basic question as to who or what caused the entire series of events.

It is clear from the evidence that there were errors on the part of both maintenance personnel and the flight crew in Montreal and Ottawa. There were several human errors made which contributed to the cause of the accident. These included taking off with inoperative fuel gauges; taking off contrary to the provisions of the MEL; miscalculation of the fuel load both in Montreal and in Ottawa; the failure to advise Captain Pearson of the exact nature of the problem referred to in the aircraft log book; the unclear log book entry itself; the failure to deactivate the circuit breaker in Montreal; and the failure by maintenance personnel to consult the Minimum Equipment Deactivation Procedures (MEDP)[15].

However, the responsibility for the accident does not lie only with on-line maintenance personnel and flight crew. It goes well beyond them into the upper echelons of management within Air Canada. The most serious fault that can be attributed to Air Canada as a whole was the failure of communication within the organization. This was manifest not only among those immediately responsible for the dispatch of the aircraft, but also at the corporate levels responsible for the operation, maintenance and engineering of the aircraft. The failure of communication was particularly evident in the dealings of the personnel of Flight Operations with those of Engineering when the 767 was being introduced into the Air Canada fleet. This was the time when those two departments were supposedly co-operating in the preparation of the MEL. The MEL is the crucial document which sets out those conditions under which an aircraft may properly be dispatched even though some of its equipment is inoperative.

The corporate responsibility for the accident also extends to the circumstances surrounding the introduction of a metric aircraft into an otherwise non-metric fleet. The end result was a mixed fleet and I am far from convinced that Air Canada has moved as quickly as it could towards standardization of the whole fleet. The corporate responsibility also extends to the production of manuals to be used by flight crews and by ground personnel which were not clear at the time of the Gimli accident and remain unclear to this date. It embraces failure to stock enough spare parts, failure to provide sufficient training for either flight crews, flight attendants, or ground personnel and failure to assign clearly the responsibility for the manual calculation of fuel in circumstances where a fuel gauge or gauges were inoperative.

As indicated above, the evidence of a failure of communication at all levels of Air Canada is alarming. While this may in fact be a problem with all large corporations, it is of particular concern in an industry which is daily responsible for untold numbers of human lives.

Among the many examples of either insufficient communication, or a total lack of communication, it is worth emphasizing the ones which follow.

There was a lack of communication as between the on-line maintenance personnel and the flight crew on July 23, 1983, when Flight 143 was being dispatched from Montreal. This problem related specifically to the calculations of the fuel load on the aircraft and generally to the dispatchability of the aircraft. When Captain Pearson arrived in the cockpit he saw that the fuel gauges were blank. No one, however, communicated to Captain Pearson the exact nature of the problem as it existed when the aircraft arrived in Montreal from Edmonton. There was no such communication by way of an accurate or understandable log book entry. Beyond that, no one told Captain Pearson that the problem, as he saw it, was not the same problem that had occurred in Edmonton. No one made it clear to him that the fuel gauges had operated normally en route from Edmonton to Montreal, in spite of a problem with the fuel processor, or that the problem of blank fuel gauges was a new development.

Because of insufficient communication in Edmonton, Captain Weir received the impression that the problem with the fuel processor had existed since the previous day when the aircraft was flown from Toronto to Edmonton. This was not the case.

As a result of what Captain Pearson saw when he arrived in the cockpit in Montreal, both in the log book and when he looked at the fuel gauges, he was persuaded that the aircraft had arrived from

Edmonton with blank fuel gauges. This belief was reinforced by his conversation with Captain Weir in the vicinity of the parking lot prior to his taking over the aircraft. The conversation gave him the impression, rightly or wrongly, that, not only had the aircraft been flown from Edmonton to Montreal with blank fuel gauges, but also that it had been flown from Toronto to Edmonton with blank fuel gauges on the previous day.

Another glaring example of a total lack of communication is in relation to what used to be termed specific gravity but which is now referred to within Air Canada as the conversion factor. The conversion factor appropriate to a conversion of fuel volume in litres to fuel weight in pounds is approximately 1.77. With the introduction of the 767 and the change on that aircraft to kilograms as an expression of fuel weight, the appropriate conversion factor to convert litres to kilograms is approximately .8. The vast majority of aircraft in the Air Canada fleet continued to use pounds for fuel weight and, therefore, for those aircraft, the provision of a conversion factor of about 1.77 was correct. However, it seems that no one had advised the fuellers that the conversion factor to be supplied to ground personnel and flight crew in the case of a 767 was the one relative to a conversion to kilograms, namely about .8.

Communication by way of the various manuals produced by Air Canada and authorized by Transport Canada for use by flight crew and ground personnel was, in many cases, unclear and confusing.

When flight crews go to the flight planning area at the terminal in preparation for a flight, they receive a flight plan. The document is known as the AFPAC, which stands for Automatic Flight Planning Air Canada. This document provides flight dispatch personnel and flight crews with detailed computerized flight plan documentation in accordance with Air Canada and government regulations. However, the deviation as set out on the AFPAC provided to Captain Pearson and First Officer Quintal, was not clear in its description of what the problem was. It purported to describe the problem with the aircraft when it arrived in Montreal. However, as we now know, the problem in Montreal in fact became something quite different and much more serious. Accordingly, what the AFPAC said the problem was and what, in fact, the problem was, were two different things. No one took any steps to correct the description of the problem on the AFPAC.

There was a failure within the Air Canada system to communicate to all concerned the previous problems that the aircraft had experienced with its fuel indication system. Whilst Maintenance Performance Analysis and Engineering might have been aware of the previous incidents, caused by what turned out to be a faulty fuel processor, and whilst that group within Air Canada might have been monitoring the fuel processor, there appears to have been no communication of the history of the problems with the fuel processor on aircraft 604 to the on-line maintenance personnel who had to deal with the aircraft on a day-to-day basis.

In addition to the human factors and errors and the corporate deficiencies, there was also, of course, defective equipment. All these matters are dealt with in greater detail below.

B. Human Factors and Errors

1. Miscalculation of the Fuel Load

The responsibility for the miscalculation of the fuel load on Flight 143 on July 23, 1983 has to be borne by both the flight crew and the maintenance personnel involved, particularly those in Montreal.

The issue of corporate responsibility for failing to assign the duty to compute the fuel load in an abnormal fuelling situation is a separate issue which is dealt with below.

However, no matter whose responsibility it was, both the flight crew and maintenance personnel participated in computing the fuel incorrectly. The evidence indicates that there was a joint effort in Montreal to determine the number of kilograms of fuel on board and the number of kilograms of fuel to be boarded.

There is no evidence to suggest that anyone either shirked or attempted to shirk his responsibility in computing the fuel load on the day in question. Rather, all of the individuals involved attempted to assist each other either by providing figures for the calculations, doing the calculations or checking the calculations.

The discussions about whose responsibility it was, or whose fault it was, arose after the accident with the various individuals and departments involved within Air Canada taking different positions. This was evident from the testimony of personnel from both Maintenance and Flight Operations.

The calculation of the fuel load by way of the drip procedure is a three step process:

(1) the drip or measurement of the fuel depth in the tanks in centimetres by use of the measuring or drip sticks;

(2) conversion of the drip stick readings in centimetres to the volume in litres; and

(3) conversion of the volume in litres to the weight in kilograms.

There were three drips done in Montreal. It is important to note that most of the calculations of the fuel load in Montreal were made on the first drip. The first drip was necessary in order to determine how much fuel was on board the aircraft prior to fuelling. This had to be determined in kilograms in order to compute how much had to be added.

In order to determine the amount of fuel that had to be put on the aircraft, it was necessary to subtract the amount that was already on board from the total required to fly to Edmonton according to the flight plan. The resulting figure should have been in kilograms and would then have to be converted to litres so that the fueller could be told how many litres to pump.

There is no dispute, and it is quite clear from the evidence, that maintenance personnel, both in Montreal and Ottawa, performed the first step of the drip procedure by pulling the drip sticks and recording the readings in centimetres.

The evidence indicates that the next two steps in the calculation of the fuel by way of this drip procedure, that is, conversion of the readings to litres and conversion of the litres to kilograms, was a joint effort of maintenance personnel and flight crew in Montreal. This was the case, to some extent, in Ottawa as well.

The evidence was at times conflicting and confusing. It does not clearly establish who did what in terms of calculating the fuel load. However, there are common threads in relation to the calculation of the fuel load. One such thread is that each of the principal maintenance personnel in Montreal, Messrs. Ouellet and Bourbeau, and each of the flight crew, Captain Pearson and First Officer Quintal, participated to some degree in calculating the fuel load.

Another common thread indicated by the evidence is that no one involved in making the calculations in Montreal seemed to know how to convert litres to kilograms. Neither the maintenance personnel nor the flight crew had had any training or experience in converting drip stick readings in centimetres to litres and then litres to kilograms.

The following excerpts from the evidence demonstrate this lack of knowledge, training or experience in converting the drip measurement to litres or the litres to kilograms:

i) Mr. Rodrigue Bourbeau, a Certified Aircraft Technician, Category 1 (CAT-1), testified that after Mr. Ouellet gave the drip reading to First Officer Quintal:

> "Mr. Quintal says that he never done it before, and we says we haven't done it before either, and we agreed that we are going to do the — our best to convert it, or — so I grabbed the blue book from the aircraft library, there, and I went from the pitch and axis and I end up at 64 and 52 —".[16]

ii) First Officer Quintal testified that maintenance personnel did not understand what figures they arrived at when they consulted the drip manual and he pointed out to them that it was litres.[17]

iii) Mr. Bourbeau testified that he started off himself to make some calculations but he was not too sure about what he was doing and he was not going so fast and he therefore gave up on doing the calculations himself.[18]

iv) First Officer Quintal testified that he believed that by multiplying the number of litres by the specific gravity of 1.77 he would have arrived at kilograms.[19]

It is clear that if First Officer Quintal had been given the correct specific gravity, his calculation for arriving at kilograms may well have been accurate. However, he was given the wrong specific gravity for a conversion directly to kilograms. The correct specific gravity in the metric system for the weight of a litre of fuel is approximately .8.

v) First Officer Quintal testified that he had no training in the use of the drip manual or in fuelling procedures.[20]

vi) Mr. Bourbeau quite frankly pointed out that he had the feeling that if he had carried on with the multiplication he would have "made maybe the same mistake — not dividing by 2.2".[21]

vii) Mr. Ouellet, testified that he started to do some calculations but never finished them because all the figures got "so crowded" that he ran out of paper. He said that he started to "look up" his multiplication and figured that it was not right. He said that he had an idea that the resulting figure would have to be divided by roughly fifty percent to get kilograms, but he did not have the exact figure. He decided to quit and leave Mr. Bourbeau and First Officer Quintal to do the calculations.[22]

viii) Captain David Walker, Chief Flying Instructor for the Boeing 767 at Air Canada, testified that no training was provided to pilots with respect to fuel conversion.[23]

ix) Mr. Roger Morawski, Senior Director of Aircraft Maintenance at Air Canada, with reference to the procedure for converting the drip stick readings to weight, testified:

"I can state it positively that the maintenance people have never performed that function, nor were they trained to perform that function, because always, in Air Canada, ever since I can remember, that function was not assigned to maintenance to perform."[24]

The following excerpts from the evidence indicate that:

(1) the calculation of the fuel load that was on the aircraft prior to fuelling done after the first drip;

(2) the calculation as to how much fuel had to be added; and,

(3) the calculation or confirmation of the fuel load after the second drip,

were all a joint effort on the part of Captain Pearson, First Officer Quintal, Messrs. Bourbeau and Ouellet:

i) Mr. Bourbeau testified that "We agreed that we are going to do the — our best to try to convert it".[25]

ii) Mr. Bourbeau testified that he himself did some calculations and in fact said that he "had multiplied by 1.77. I don't remember the exact — which figure that I had."[26]

iii) Mr. Bourbeau testified that First Officer Quintal was doing some calculations.[27]

iv) Mr. Bourbeau testified, as well, that First Officer Quintal asked the fueller what the specific gravity was and that he was given the wrong conversion factor of 1.77.[28]

v) Mr. Bourbeau testified that:

"The first thing that I knew of, they were leaving, the fuel man and Jean — were leaving the cockpit, and they seemed to know how much fuel they were going to board, so I left my calculations, and that's it."[29]

vi) First Officer Quintal confirmed Mr. Bourbeau's evidence that he, Quintal, made some calculations and requested the specific gravity from the fueller. First Officer Quintal testified: "Oui, j'ai fait la multiplication."[30]

vii) First Officer Quintal also testified that he offered to help maintenance personnel in their calculations when he saw them having some difficulty with the drip manual when he entered the cockpit.[31]

viii) Mr. Ouellet indicated that "we got the blue book out" referring to himself and Mr. Bourbeau and went on to testify that "we all worked through it" referring to himself, Mr. Bourbeau and First Officer Quintal.[32]

ix) Mr. Ouellet also testified that while Mr. Bourbeau and First Officer Quintal were doing some calculations he too started to do some calculations. He did these calculations on his own because he "figured it was a bit crowded to be three guys in the same book, all gathered together on the same page".[33]

x) Mr. Ouellet went on to describe that he added up the number of litres in the two wing tanks and multiplied by 1.77 on a sheet of paper that he had in his pocket. That piece of paper was subsequently lost. He also pointed out that he did not finish his calculation because all the figures got "so crowded" that he ran out of paper.[34]

xi) Captain Pearson testified that he participated in the calculation of the fuel load. He testified that "I confirmed the figures from the second drip".[35]

xii) Captain Pearson testified that he requested the maintenance personnel to show him their figures and that one of the maintenance personnel on board held a sheet of paper between himself and the first officer. Captain Pearson said that he took out his calculator and went over the computations which had been done longhand.[36]

xiii) Captain Pearson again confirmed that he checked these calculations and in his own words "I went over these calculations with my Jeppesen computer and found them to be mathematically accurate and I stated that. I said, 'Well, your calculations to me look mathematically correct'."[37]

The evidence referred to above indicates that all of the individuals in Montreal, both maintenance personnel and flight crew, participated to some degree in determining the fuel load. It also indicates that they really did not know what they were doing in terms of the fuel load calculations and had not been trained for this function. At times, during their testimony, they were uncertain as to what they actually did. They were in fact uncertain as to what was required to be done.

These excerpts from the evidence also indicate that the wrong specific gravity figure was provided although it may have been what Air Canada requested the fueller to provide.

If the flight crew had consulted their 500 Flight Operations Manual they would have found in Chapter 10 at page 20.1 a formula for arriving at kilograms.

Specifically, paragraph 10 of that chapter provides:

"Weight/Volume conversion

Pounds loaded = Imp. gals. X Spec. Wt.
= Imp. gals. X S.G. X 10
= Liters X Sp. Wt. (1b./liter)
= Liters X S.G. X 2.2
= U.S. Gals. X Sp. Wt. (1b./U.S. Gal.)
= U.S. Gals. X S.G. X 8.33

Kilograms loaded = pounds loaded divided by 2.2."[38]

In fairness to the flight crew, however, they would also have found a different specific gravity figure than the one with which they had been provided by the fueller. They would have found in the manual the figure .80 for Jet A fuel. It is disconcerting to note that the specific gravity used and accepted by Air Canada in their day to day on-line operations was different than that set out in the manuals.

The crucial miscalculation of the fuel load on Flight 143 came in Montreal, not Ottawa. In Montreal, the fueller was requested by the flight crew to board 5000 litres, one quarter of the required amount. It is interesting to note how this figure was probably arrived at.

In Montreal the drip stick readings after the first drip were 64 and 62 centimetres. According to the handwritten calculations made by Mr. Ouellet in Exhibit 17, these readings translated to 3924 and 3758 litres of fuel in the two tanks, for a total of 7682 litres. Multiplying 7682 by 1.77, the figure supplied as the specific gravity, one arrives at 13,597. This represented the fuel on board before fuelling. It was in pounds but everyone involved believed it to be kilograms. This figure, if subtracted from the minimum fuel required by the flight plan, 22,300 kilograms, would produce the figure of 8703. Again it must have been assumed that the latter figure represented the number of kilograms of fuel that had to be added although it was actually pounds. Since fuel is loaded in litres, the 8703 figure had to be converted to litres. This was probably done by dividing by 1.77. If that division is done, one arrives at the figure of 4916 representing the number of litres to be added. This figure coincides with the evidence of the fueller, Mr. Tony Schmidt, who testified that the 4900 litres was rounded to 5000 litres at his suggestion.[39]

An illustration of the foregoing calculation is as follows:

STEP 1: Computation of the fuel on board:

Drip stick readings: 62 and 64 centimetres
Converted to litres: 3758 and 3924 litres
Total litres on board: 3758 + 3924 = 7682 litres.

STEP 2: Conversion of litres on board into kilograms:

7682 litres X 1.77 = 13597
Multiplying by 1.77 gave pounds, but everyone involved thought they were kilograms.

STEP 3: Computation of the fuel to be added:

Minimum fuel required, 22,300 kilograms — fuel on board, 13,597 assumed to be kilograms = 8703 kilograms.

STEP 4: Conversion into litres of kilograms to be added:

8703 kilograms ÷ 1.77 = 4916 assumed to be litres.

The correct calculation using the minimum required fuel as a base, that is, 22,300 kilograms, as called for by the flight plan, would be as follows:

STEP 1: 3924 + 3758 litres from the first drip stick readings of 64 and 62 centimetres = 7682 litres of fuel on board.

STEP 2: 7682 X 1.77 ÷ 2.2 = 6180 kilograms of fuel on board, prior to fuelling.

STEP 3: 22,300 − 6180 = 16,120 kilograms of fuel to be boarded.

STEP 4: 16,120 ÷ 1.77 X 2.2 = 20,036 litres to be boarded.

One can see that if the correct calculation had been made, the amount of fuel that should have been boarded was in the area of 20,000 litres. This is four times what in fact was added. It is based on the minimum fuel required of 22,300 kilograms, and not the actual fuel required of 22,600 kilograms. The latter figure, also set out in the flight plan, includes an estimated 300 kilograms for taxiing. If the latter figure had been used, then more than 20,000 litres should have been boarded.

In any event, the method of calculation set up by Air Canada was a convoluted way of arriving at the number of litres to be boarded and was unduly complicated for a busy flight crew or for equally busy maintenance personnel at departure time.

It must be remembered, however, that it was never intended that this calculation be made because, with inoperative fuel gauges, the aircraft should have been grounded.

As indicated above, the crucial miscalculation of the fuel load came in Montreal not Ottawa. The drip procedure in Ottawa was requested as a check. The same error was made in Ottawa, that is, a conversion to pounds that was believed to be kilograms. Since the calculations produced approximately the same figures as in Montreal, allowing for the fuel burned, and since the figures were what the flight crew expected to see, there was no alarm and the calculations were accepted.

In Ottawa, as in Montreal, there was a joint effort between maintenance personnel and flight crew to determine the fuel load. Maintenance personnel pulled the drip sticks, took the readings and converted them to litres. The figures in litres were then given to Captain Pearson who checked them with his Jeppesen computer after he requested the specific gravity.

With respect to what happened in Ottawa concerning the calculation of the fuel load, the following evidence is relevant:

i) First Officer Quintal, although he did not participate in the calculations in Ottawa, said that Captain Pearson got the number of litres and the specific gravity and multiplied the figures with his Jeppesen computer and then compared them to what maintenance had on a sheet of paper.[40]

ii) Mr. Richard Simpson, a Certified Aircraft Technician, Category 1 (CAT-1), in Ottawa, said that he gave the Captain the total number of litres of fuel that was in both tanks, 11,430. The Captain asked for the conversion factor and received the figure 1.78 from the fueller. He testified that the Captain then took out his circular slide rule and calculated that he had over 20,000 "units of fuel".[41]

iii) Mr. Simpson did not know how to arrive at kilograms from litres.[42]

iv) Mr. Robert Eklund, a Certified Aircraft Technician, Category 1 (CAT-1), in Ottawa, testified that he got the drip readings in centimetres and the litre readings for each of the two wing tanks from Mr. Simpson. He said that Mr. Simpson gave the total number of litres to the Captain who took out his Jeppesen computer, asked for the specific gravity of the day, and was given 1.78. The Captain then did some calculations and came up with a figure in excess of 20,000. The Captain did not say what the figure represented.[43]

Thus, in Ottawa, a similar miscalculation of the fuel load was made. In both Montreal and Ottawa, maintenance personnel and flight crew alike displayed very little knowledge of how to do the calculations. They obviously lacked both training and experience in this respect.

It is instructive to examine what was done in Edmonton before the aircraft left on July 23, 1983 under the command of Captain Weir. Because only one channel of the fuel processor was working properly, and notwithstanding the fact that the actions of Mr. Yaremko had restored fuel indication in the cockpit, the aircraft had to be dispatched under the provisions of MEL item 28-41-2. This is because of the qualifying conditions of the MEL based on the principle of redundancy. Thus, in the case of the fuel processor, an aircraft can be dispatched with only one of its two fuel processor channels working, provided the conditions of MEL item 28-41-2 are complied with.

MEL item 28-41-2 refers to Fuel Tank Quantity Processor Channels. These are the channels of the digital fuel gauge processor. The qualifying conditions relating to that item read:

> "(M) One may be inoperative provided fuel loading is confirmed by use of a fuel measuring stick, or by tender uplift, after each refuelling and FMC fuel quantity information is available."[44]

These qualifying conditions relating to the fuel processor contemplated that if one of the two channels was not working, the other would take over and provide normal fuel indications on the gauges in the cockpit.

In compliance with the above conditions, it was decided to fuel the aircraft and confirm the amount of fuel on board before its departure by doing a drip, that is by using the fuel measuring sticks in the wings. Mr. Paul Wood, the fueller, went into the cockpit with Mr. Yaremko to take the readings from the cockpit gauges of the remaining fuel on board in kilograms. He had to do this because, with the fuelling panel on the wing open, the gauges at that station were blank. Fuelling, therefore, could not be done automatically from the wing position where the hose from the fuel tanker was connected to the nozzle which enables fuel to flow into the wing tanks.

It was not the duty of Mr. Wood to do the conversion from kilograms to litres to know how many litres to board for the flight, but he made the calculations because the captain, first officer and aircraft mechanic were busy.[45]

The fueller had to know the amount of fuel on board the aircraft in order to calculate how many additional litres to board. He knew how to convert from kilograms to litres.[46]

Asked why he knew how to make such calculations when others seemed to have such difficulty, he said that it was a regular practice of his, so that he would know how many litres he had in his truck, and could call dispatch if he was likely to run short. He used a calculator to do the conversions.[47]

When he had completed the fuelling, he went back into the aircraft and gave the fuel load to the Captain in litres.[48]

To comply with the provisions of MEL item 28-41-2, a drip was done by Mr. Yaremko assisted by a mechanic, Mr. Robert Serizawa. Mr. Serizawa took down the drip stick readings and gave them to Captain Weir.[49] Captain Weir and his first officer, Captain Johnson, had time to spend about a minute and a half before departure to check the amount of fuel on board, using the measurements from the drip sticks, the drip stick tables and the conversion factor.[50] The drip stick tables are more properly called the fuel measuring stick tables and are commonly referred to as the drip manual or the blue book. Captain Weir knew from previous experience that the correct conversion factor, or specific gravity as it was called at that time, was around .8 to convert litres to kilograms.[51]

The fuelling referred to above was done on the morning of July 23, 1983 at the Edmonton International Airport. It is true that the fuel gauges in the cockpit were working. However, because of the faulty processor, fuel calculations had to be made manually and they were made correctly. The fueller, Mr. Wood, clearly knew how to make the correct conversion, and so did Captain Weir and his first officer, Captain Johnson.

2. Illegal Dispatch Contrary to the MEL: Taking Off With Blank Fuel Gauges

The fact that Flight 143 took off from Montreal on July 23, 1983 with blank fuel gauges was a significant cause of the accident. It was an illegal dispatch contrary to the provisions of the Minimum Equipment List.

As noted in Part II of this report, the MEL is that part of the Operating Manual which governs the legality of the dispatch of an aircraft with inoperative equipment. It details which equipment, under what conditions, may be unserviceable and the aircraft as a whole still be fit to be dispatched.[52]

Air Canada's Minimum Equipment List, as well as the Minimum Equipment List for every major airline which operates the 767, has as its base the Master Minimum Equipment List prepared by the Federal Aviation Administration in the United States. The preamble to the Master Minimum Equipment List states the purpose of the MMEL to be:

> "... to provide owners/operators with the authority to operate an aircraft with certain items or components inoperative provided the Administrator finds an acceptable level of safety maintained by appropriate operations limitations, by a transfer of the function to another operating component, or by reference to other instruments or components providing the required information."[53]

Neither Air Canada's MEL nor the MMEL include obviously required items such as wings, rudders, flaps, engines or landing gear.

I deal in more detail later on in the report with the MEL, but it is important to note, when considering Captain Pearson's decision to dispatch the aircraft, that item numbers 28-41-1 and 28-41-2 of the MEL are relevant.

Item 28-41-1 of Air Canada's MEL, relating to the Fuel Tank Quantity Indication Systems (Flight Deck) at the time of the accident provided:

"One left or right wing tank fuel gauge may be inoperative provided:

(a) Fuel quantity in associated tank is determined by measuring stick, or by tender uplift, after each refuelling, and

(b) All pumps for associated tank must be operative, and

(c) FMC fuel quantity information is available."[54]

Item 28-41-2 of Air Canada's MEL relating to Fuel Quantity Processor Channels provided:

"One may be inoperative provided fuel loading is confirmed by use of a fuel measuring stick, or by tender uplift, after each refuelling and FMC fuel quantity information is available."[55]

It is clear that at least two of the three fuel tank gauges must be working before a passenger aircraft can legally be dispatched. If there is more than one fuel tank gauge inoperative, then the aircraft is required to be grounded.

The dispatch of Flight 143 on July 23, 1983 from Montreal was therefore illegal because none of the fuel tank gauges were working. It was contrary to the MEL. Captain Pearson himself acknowledged, after the fact, that he had not been legal to operate. He testified that he addressed the topic of the MEL by saying "to the maintenance fellow": "We are not legal to operate in this configuration", pointing to the indicators, "with all of the fuel quantity indicators unserviceable".[56]

He appears to have consulted the MEL in a very cursory way. He testified that he took out the MEL, read the two items that seemed to apply to the situation and then put the manual back.[57]

Captain Pearson further testified:

"Q. All right. I take it that it had to be a question because you were of the view that you were not, according to the MEL, legal to operate?

A. That's right."[58]

Captain Pearson, therefore, acknowledged in his testimony that, on the day in question, he was of the view that he was not legal to operate according to the MEL. Unfortunately, at the time, he came to the opposite conclusion in his own mind.

Questions arise as to why Captain Pearson, a professional pilot of exceptional ability, did not pay more attention to the requirements of the MEL, and why he did not check the legality of the dispatch with his superiors or with someone in Maintenance Central.

The same questions apply equally to the conduct of First Officer Quintal, and of Messrs. Bourbeau and Ouellet. These individuals seem to have paid little attention to the requirements of the MEL and to have done virtually nothing to ensure a legal dispatch.

For the answer to these questions, it is necessary to consider the circumstances under which Captain Pearson made his decision to accept the aircraft with inoperative fuel gauges and also to consider his resulting state of mind.

Objectively there was an illegal dispatch, which Captain Pearson had the authority to avoid. Mr. Bourbeau also had the authority to avoid the dispatch. He too could have grounded the aircraft. Captain Pearson, however, had the ultimate authority.

Subjectively, Captain Pearson formed the genuine and honest opinion that he was legal to operate. This opinion stemmed from a number of factors including, among others, the conversation with Captain Weir in the vicinity of the parking lot in Montreal, the log book entries made both in Edmonton and Montreal, the belief that there was an overriding authority in Maintenance Central to circumvent the MEL, and, finally, because of his understanding that maintenance clearance for departure had been given.

As for Captain Pearson's state of mind, he gave the following evidence under questioning by Mr. Saul, Counsel for Air Canada:

"Q. So in this case, on the 23rd of July, Captain, you formed an opinion with respect to the legality of the aircraft?

A. Yes.

Q. And that is what the MEL requires that you do, you form an opinion?

A. Yes.

Q. The only problem, as I see it, Captain, is that your opinion was not based on the MEL, but it was based upon a series of assumptions which you had accumulated through the afternoon, do you agree with me?

A. Yes, that's true.

Q. It was, was it not, a long trail of unfortunate incidences which inevitably led you to this conclusion, that the aircraft was legal?

A. In hindsight, yes. Looking back.

Q. And that was a conclusion which clearly was wrong, also in hindsight of course?

A. Well, absolutely everything made me believe that it was legal: reading the log book, maintenance clearance. Right from the time I arrived at the parking lot till we pushed back, every single thing that happened in relation to this problem only reinforced my belief that it was legal.

Of course, if I didn't believe that, I would never have considered operating the aircraft... "[59]

An examination of the various factors which prompted Captain Pearson to leave Montreal with inoperative fuel gauges leads to an understanding of his decision but it does not, and cannot, justify his decision.

I now turn to an examination of these factors in detail.

i) *Conversation With Captain Weir in the Vicinity of the Parking Lot*

Captain Weir and his first officer, Captain Johnson, brought aircraft 604 from Edmonton to Montreal on July 23, 1983. They met Captain Pearson, who was taking the aircraft to Edmonton, on the way to the terminal parking lot. Captain Weir discussed with Captain Pearson a problem with the fuel system on the aircraft and recommended that he board enough fuel in Montreal to take him right through to Edmonton.[60]

Captain Weir's recollection was that they discussed the problem of the fuel system in general terms and that the conversation probably lasted two to three minutes in total. He could not say for sure whether or not he had indicated to Captain Pearson that the fuel gauges were blank.[61]

Captain Weir met First Officer Quintal in the flight planning area. He told him that there was a problem with the fuel system and that they should board enough fuel in Montreal to go right through to Edmonton. Again he could not recall telling First Officer Quintal whether or not the gauges were blank although he said that he might have mentioned the fact.[62]

It is not likely that Captain Weir mentioned that the gauges were blank because they had operated normally on the flight from Edmonton and were not blank when Captain Weir left the cockpit. The only occasion on which the gauges went blank and inoperative for Captain Weir was when the door of the fuelling panel situated under the left wing was opened.

Captain Pearson testified that his conversation with Captain Weir and Captain Johnson lasted about three to four minutes and that the fuel system was discussed for about a minute and a half. He testified that he could not recall specifically the nature of the discussion. He was left with the understanding that the gauges were inoperative and that the aircraft had been operating without fuel gauges for at least a day and a half. This view was reinforced by the deviation he saw on the flight plan, what he saw in the cockpit and what he saw in the log book.[63]

ii) *Deviation on the Flight Plan*

The flight plan, under the heading "ACFT DEVIATIONS", had an abbreviated description of the deviation:

"28-41-2 FUEL QTY PROC #2 CHNL INOP..DIP REQD... "[64]

This entry caused Captain Pearson to be reinforced in his view that the gauges were not working. In his evidence Captain Pearson testified:

"Q. And so effectively in your mind the AFPAC confirmed everything that you thought you already knew?

A. That is correct."[65]

iii) *What Captain Pearson Saw in the Cockpit When He Boarded the Aircraft*

What Captain Pearson saw when he boarded the aircraft and looked at the gauges was exactly what he expected to see, namely, blank fuel gauges.

In his evidence Captain Pearson stated that he looked at the fuel gauges and they were blank as he expected they would be. He continued:

"Q. So what you are saying is that you had no fuel gauges when you got on the plane?

A. Yes.

Q. And that is what you expected to see?

A. That is what I expected to see, yes."[66]

iv) *Log Book Entries*

The log book entries about the problem with the fuel quantity indication system confirmed the mistaken impression in Captain Pearson's mind that the fuel gauges were blank and had been blank for some time. They reaffirmed what Captain Weir had told him, what the AFPAC seemed to indicate and what he himself saw when he looked at the gauges in the cockpit.

Shortly after Captain Pearson entered the cockpit he consulted the log book.[67] On the maintenance side of the page for July 23, 1983 he noticed under the section entitled "Rectification" the handwritten note:

"FUEL QTY. IND. U/S SUSPECT PROCESSOR UNIT AT FAULT P.N. 28-40-563 NIL STOCK."[68]

This entry was made by Mr. Ouellet in Montreal. It confirmed that the fuel quantity indicators, or fuel gauges, were unserviceable.

Captain Pearson went back in the log book to the previous day and looked at the maintenance page for July 22, 1983 and saw Mr. Yaremko's entry made in the early morning hours of July 23.

He saw under the Section entitled "WORK CARRIED FORWARD" the following note:

"I001 — @ SERVICE CHK — FOUND FUEL QTY IND. BLANK — CH 2 @ FAULT — FUEL QTY 2 C/B PULLED & TAGGED — FUEL DRIP REQ'D PRIOR TO DEP. SEE MEL 28-41-2"[69]

He also noticed under the "Rectification" section the note:

"FUEL QTY CH 2 U/S — SEE MEL 28-41-2"[70]

These entries reinforced Captain Pearson's view that the aircraft had arrived from Edmonton with blank or inoperative gauges. It confirmed what he saw:

"Q. And what did that tell you when you went back over the log and you saw the work carried forward under box 10, and also the note the day before?

A. Well, it told me that, as I saw it when I came in, that the quantity indicating system was unserviceable."[71]

v) *Belief That the MEL Could Be Circumvented*

Captain Pearson believed that somehow it was possible to deviate from the MEL on board the aircraft. He believed that Maintenance Central within Air Canada had the overriding authority with respect to the Minimum Equipment List. He believed that Maintenance Central possessed a Master Minimum Equipment List which was more comprehensive than the one on board the aircraft. Captain Pearson testified:

"Q. And yet you were satisfied in your own mind when you read the MEL that it was not legal to operate?

A. Well, in our MEL it was not legal to operate. Now, in Air Canada, to my understanding, Maintenance Central are responsible for the MEL for all the technical data on the aircraft, and that the manuals that we have on board are a reduced version, if you will, of what is in Maintenance Central."

He continued:

"Q. ... your MEL indicated that you were not legal to operate, yet somehow you received clearance from Maintenance Central.

A. Yes. Maintenance Central are the overriding authority on our MEL."[72]

Referring to his belief that there was a Master MEL which allowed deviation from the MEL kept in the cockpit, Captain Pearson said:

"Q. And how did you know that there was a Master MEL?

A. Well, I knew because of the way things operate that we are at times — if something is contrary to our MEL, there are times when we are cleared by Maintenance Central to operate, despite the fact in our MEL we are not, and in fact the Master — the question of the Master MEL is now — I don't know when it first — when the words first came into use in our manual, but they are there today with reference to the Master MEL."[73]

Captain Pearson expressed his view of the overriding authority of Maintenance Central prior to giving evidence at the Inquiry. When Transport Canada was investigating the accident he told Mr. Stewart, one of the accident investigators, in a taped telephone conversation that:

"Yeah, that's right, but there's also the, you know, I'm sure I'm not alone, in assuming that Maintenance Central who are the final authority on the MEL can, not violate it, I don't think that's the right word, but deviate from the MEL, because I know in my career that there have been times when, 'Captain, we've got clearance from Lockheed, or Boeing,' or whatever, you know. Every day this is taking place, that pilots are being told that it's legal to operate, whether they always get an explanation or not, you know... We did not get an explanation and I probably would have asked for an explanation had I not assumed that we were not breaking new ground. The aircraft was being operated as it came in."[74]

Therefore, according to Captain Pearson, deviation from his MEL was possible and not something that was completely out of the ordinary for him. While he realized that the MEL on board the aircraft directed him not to take off with inoperative fuel gauges and that such a take-off was illegal, he believed that Maintenance Central could override that MEL, on the basis of a Master MEL, and legalize the take-off without operative fuel gauges.

vi) *Maintenance Clearance*

The most serious conflict in the evidence at the Inquiry was whether or not Captain Pearson was told by one of the maintenance personnel that he was "legal to operate" and had been "cleared for dispatch by Maintenance Central".

According to his evidence, Captain Pearson commented to one of the maintenance personnel who was working on aircraft 604 on July 23, 1983, as follows:

"We are not legal to operate in this configuration with all of the fuel quantity indicators unserviceable."[75]

He testified that he made this comment in the form of a statement but that he was looking for a response. He agreed that his intonation in making the comment put it in the form of a question.

Captain Pearson went on to testify that the person he addressed responded:

"Yes, Captain, it is legal to operate. The aircraft has been cleared for dispatch by Maintenance Central and we have a drip procedure and we drip the aircraft before refuelling, we put on a known uplift, and we drip the aircraft after refuelling."[76]

It is difficult to say with certainty whether or not this comment was made to Captain Pearson. No one else in the cockpit, including First Officer Quintal, heard the comment. Both maintenance individuals who were involved with Captain Pearson, Messrs. Bourbeau and Ouellet, deny that they made such a statement.

Mr. Bourbeau was asked the following questions and gave the following answers:

"Q. Did you hear Captain Pearson say that, "We're not legal to operate"?

A. No, sir.

Q. Either to you, or to Jean, or to anyone?

A. No, sir.

Q. Did you — or yourself hear Jean Ouellet tell Captain Pearson that he was legal to operate, that he had been cleared by Maintenance Central?

A. No, sir.

Q. You didn't say that, yourself?

A. No, sir."[77]

Mr. Ouellet testified as follows:

"Q. Did you discuss the legality of dispatching that aircraft with the crew?

A. No, I did not discuss the legality with the crew.

Q. You heard Captain Pearson testify under oath that Maintenance told him on the aircraft that, "Yes, Captain, you're legal. You've been cleared for dispatch by Maintenance Central."

A. No, I don't recall. I never said that to the Captain for sure.

Q. You never said that to the Captain?

A. No, I don't recall at all.

Q. Did you hear Mr. Bourbeau say that to the Captain?

A. I didn't hear Mr. Bourbeau say that either."[78]

The evidence of Captain Pearson on this point was not something that came up for the first time at the Inquiry. Captain Pearson from the moment of the accident maintained that he had been told by one of the maintenance personnel that he was legal to operate. He told this to accident investigators as well as to officials within Air Canada shortly after the accident.

It is not necessary to make a finding one way or the other as to whether or not this assurance was given to Captain Pearson. If the comment were made by maintenance, it was simply another factor leading Captain Pearson to the opinion that he was legal to operate, despite the fact that the MEL made it quite clear that he was not. The answer he said he received from maintenance personnel was what he had expected to hear.[79] It confirmed his view that he was legal to operate.

Even if the comment were not made, there were enough other factors leading Captain Pearson to this subjective opinion that he was legal to operate and that the aircraft had been flown with blank fuel gauges for at least a day and a half. If Captain Pearson had had any doubt in his mind about the legality of the dispatch, it is unlikely that he would have accepted such a statement from an on-line maintenance person without checking it with Maintenance Central or with his superiors.

In conclusion, there is no doubt that, from an objective perspective, the dispatch from Montreal without fuel gauges was illegal, that is, contrary to the MEL. On the other hand, there is equally no doubt that Captain Pearson, subjectively, on the basis of the factors and assumptions examined above, formed the opinion that it was legal to dispatch the aircraft.

It is hard to understand, in principle, how such an experienced or, indeed, any qualified pilot could form such an opinion. It is, on the basis of all the surrounding circumstances outlined in the evidence, to a certain extent understandable. It was not, nor could it be, justifiable in any circumstances.

3. Log Book Entries

The log book entry made by Mr. Yaremko in Edmonton did not convey to the flight crew, and in particular to Captain Pearson, the fact that the fuel gauges had been restored to operation in Edmonton, and that the aircraft had arrived in Montreal with fuel gauges in working condition. It may well have produced the opposite impression, that is, that the aircraft had arrived with blank fuel gauges.

Moreover, the log book entry made in Montreal did not convey to Captain Pearson the fact that the nature of the snag had changed since the arrival of the aircraft in Montreal.

During the hearings, the clarity of the log book entry made by Mr. Yaremko was called into question. I preface my remarks on this issue by noting that it is clear from the evidence that Mr. Yaremko is an efficient and experienced member of the maintenance staff of Air Canada. He was the one who, because of his ingenuity and knowledge, managed to restore working fuel gauges on aircraft 604 prior to its departure from Edmonton.

When Mr. Yaremko found the three fuel gauges in the cockpit blank, he deactivated and tagged the circuit breaker for channel 2 of the fuel processor. This action restored the fuel gauges to operation.

He then made an entry in the log book, referring to the problem that he had found and dealt with. He discussed the snag with Captain Weir and dispatched the aircraft in accordance with the MEL.

The log book entry made by Mr. Yaremko reads:

"I001 — @ SERVICE CHK — FOUND FUEL QTY IND BLANK — CH 2 @ FAULT — FUEL QTY 2 C/B PULLED & TAGGED — FUEL DRIP REQ'D PRIOR TO DEP. SEE MEL 28-41-2"[80]

The difficulty with this log book entry is that it refers to fuel quantity indications as being blank. It does not refer to functioning fuel gauges. It does not indicate that while the fuel quantity gauges were found to be blank at the outset, they were in fact restored to operation. There are those who, after referring to MEL item 28-41-2, and understanding its provisions, and particularly understanding that the aircraft could only be dispatched with at least two of the three fuel gauges operative, may have realized, after a careful consideration of the log book entry, that the gauges had been restored to operation. However, a cursory reading of the log book entry, without consulting the MEL, might well have led to the conclusion that the gauges were blank to start with and remained blank.

Mr. Bourbeau, who worked on the aircraft when it arrived in Montreal, found the entry confusing. His understanding of the snag was that the gauges were blank when the aircraft arrived in Montreal. He thought that the aircraft was going to be flown back to Edmonton with blank gauges. He testified that he relied on the fact that Maintenance Central knew about the problem and that there was nothing that maintenance personnel in Montreal could do about it since they had no spare processor.[81]

Mr. Bourbeau was confused because there was no reference in the log entry to fuel indication having been restored before dispatch of the aircraft from Edmonton. He knew from a conversation with Mr. Gary Geldart, a Line Maintenance Foreman with Air Canada, that a computer processor was awaiting the aircraft in Edmonton that night. He assumed that Captain Weir and Captain Johnson had flown the aircraft with blank fuel gauges and that Maintenance Central knew about the situation. He made the latter assumption on the basis that the number I001 in the log entry indicated that the snag had been entered in the Maintenance Central computer. He made the assumption that the aircraft could be flown with blank fuel gauges, in spite of the fact that he had, in all his years with Air Canada, never seen an aircraft dispatched with blank fuel gauges.[82] Because of the reference in the log entry to MEL item 28-41-2, he only looked at that item which deals with the fuel tank quantity processor channels. He did not refer to the item above it which deals with the fuel tank quantity indication systems on the flight deck.

Mr. Ouellet had been assigned to do the drip check on the aircraft when it arrived in Montreal. It was also part of his job to assist Mr. Bourbeau in doing the drip check on the aircraft and reviewing the deferments in the log book. They were to review any recorded snags, to ensure that any existing snags were the same as reported, and to bring to the attention of the flight crew any different snags.

It was the responsibility of the ground crew or the flight crew to report to Maintenance Central any unacceptable anomaly. Mr. Ouellet had the authority to ground the aircraft.[83]

Mr. Ouellet too was confused by the entry made by Mr. Yaremko in the log book. It was the word "BLANK" which confused Mr. Ouellet. He had noticed that the circuit breaker had been pulled and tagged, but he did not see the need for this. He had been taught in recent training that the two channels of the fuel processor were completely independent and that if one failed, the other would take over.[84] From all this, Mr. Ouellet concluded that the fault must lie outside of the processor. He believed, as a result of his understanding of the log book entry, that the aircraft had arrived from Edmonton with blank fuel gauges. He also pointed out in his evidence that, as he understood it, the snag had not changed. He expected that if it had, Captain Weir would have made a note of the change in the log book. Therefore, Mr. Ouellet believed he was dealing with the situation faced by the incoming crew.[85]

Mr. Simpson, a CAT-1 in Ottawa, also expressed some doubt as to what the log book entry made in Edmonton meant. He testified that he could not say what he would have thought the entry meant if he had read it at the time it was made.[86]

Captain Walker agreed that he could have been puzzled by the log book entry and that it could have many interpretations. At one point he testified:

> "And my concern is that if it's not properly written the pilot — or the pilot doesn't have the adequate training — he may look at that and say, well, that's blank fuel gauges, the aircraft came in with blank fuel gauges, it says right there 'fuel quantity indications blank'."[87]

Mr. Paquette, in his testimony, discussed the findings of the Transport Canada investigation team which are set out in the accident report marked as Exhibit 108. In particular he referred to the following:

> "2. The fuel indications were obtained in Edmonton by pulling both circuit breakers and resetting the number 1 channel circuit breaker of the fuel quantity processor. The number 2 channel circuit breaker was left pulled and tagged. The subsequent log entry did not alert other maintenance personnel to ensure the circuit breaker remained out. When it was later reset in Montreal, all fuel indications disappeared."

He described the Edmonton entry as inadequate as it did not explain to the next person what to expect.[88]

Mr. Robert Lebeau, Quality Superintendent with Air Canada's Maintenance Department, testified that he understood Mr. Yaremko's entry but that he did not understand Mr. Ouellet's. He said that he understood Mr. Yaremko's entry, not because he was familiar with the MEL, but:

> "It's because this is the style of one maintenance man to another, that if I make an entry or one of my compatriots makes an entry in this log book, we don't use, we'll say, full grammatical sentences. We use more or less a cryptic language that we understand."[89]

There is, of course, nothing wrong with using cryptic language provided there is a clear and adequate description of the problem. This was certainly not the case with the entries under present consideration.

Mr. Ouellet's entry in the log book was:

> "FUEL QTY. IND. U/S SUSPECT PROCESSOR UNIT AT FAULT P.N. 28-40-563 NIL STOCK."[90]

In discussing this entry, Mr. Lebeau said that he could not tell what Mr. Ouellet meant. He did not know whether Mr. Ouellet had obtained fuel quantity readings or not. He said that he was unable to tell from the entry whether there were no fuel quantity indications at all or whether there were no fuel quantity indications for one or more of the left, right or centre tanks.[91]

Furthermore, Mr. Lebeau indicated that he could not tell from the entry whether it was the same snag that Mr. Yaremko had dealt with or a different snag.

The significance of Mr. Lebeau's testimony is that Captain Pearson was not informed by way of the log book entry that the snag had changed in its nature since the aircraft arrived in Montreal. Mr. Ouellet testified that he thought the aircraft had come in from Edmonton with blank gauges. It is, therefore, not surprising that he worded the entry as he did, especially after seeing blank fuel gauges.

This confusion on the part of Messrs. Bourbeau and Ouellet with respect to the meaning of Mr. Yaremko's log book entry contributed to the dispatch of the aircraft from Montreal with blank fuel gauges. It should not have been dispatched in that condition. The ground crew and the flight crew alike should have known that it was not legal or safe to fly an aircraft with blank fuel gauges. They should have known this without reference to manuals, in spite of anything recorded in the log book, also in spite of their mistaken assumption that the aircraft had previously been dispatched with blank fuel gauges.

The actions of all concerned were predicated on an accumulation of mistaken assumptions. It is reasonable to suppose that such assumptions might not have been made, had Mr. Yaremko's entry gone a little further and included reference to the fact that, after pulling the number 2 circuit breaker, fuel quantity indications had been restored.

4. Failure to Deactivate Circuit Breaker in Montreal

One of the mistakes made by maintenance personnel in Montreal was made by Mr. Ouellet, when, with the best of intentions, he undertook to investigate and try to find the cause of the snag recorded in the log book. He had not been instructed to do this work nor was he equipped to do it either by training or experience.

On July 23, 1983, Mr. Ouellet was instructed by his foreman, Mr. Geldart, to do a drip of aircraft 604 prior to its being dispatched to Edmonton. Mr. Ouellet testified that when he was initially told to do the drip he did not know why, nor did he know the nature of the snag at the time.

When Mr. Ouellet arrived at the aircraft he noticed the entry in the log book made by Mr. Yaremko in Edmonton to the effect that the number 2 channel was unserviceable. He also noticed that the circuit breaker had been pulled out. He remarked to Mr. Bourbeau that it was a fairly old snag, that it had been repeating itself and that it had a long history.[92]

Mr. Ouellet could not understand the need to deactivate the number 2 channel of the fuel processor by pulling the circuit breaker because, according to his recent training, if one channel was inoperative the other channel would take over.

Mr. Ouellet's testimony regarding the condition of the fuel gauges when he entered the cockpit was generally vague and ambiguous. However, it was clear in one respect. He noticed that the centre tank gauge showed two zeros. This evidence by itself probably indicates that all three gauges were working at that time.

After looking at the snag as recorded in the log book, Mr. Ouellet came to the conclusion that the same snag had existed at least since the aircraft left Edmonton and that it had not changed. He arrived at the conclusion that the nature of the problem was the same because no further entry had been made by Captain Weir on the following page of the log book. The snag in fact had not changed but, unfortunately, Mr. Ouellet did not understand what it was. Despite this, and despite the fact that he had only been asked to do a drip, out of curiosity he decided to investigate. In his words:

> "I had a look on the left side to a cabin window to see if the truck, the fuel truck, had arrived, and since I did not see the truck there, and Rod had gone to the other airplane, he wasn't in the cockpit any more, I thought, 'Well, I've got a couple of minutes until the truck shows up,' and as a matter of interest I thought I would go and do a BITE test on the processor, so I pushed in the breaker in the cockpit that was deactivated."[93]

Before doing the test, he first pushed in the number 2 channel circuit breaker that had been deactivated and collared. He did not remove the tape around it. He was able to reset the breaker without taking the tape off.

He then went down into the main electrical/electronics equipment centre of the aircraft, and started to do a BITE test. He said that when he tested channel 1, he got an F8 on the screen of the processor. This indicated that channel 1 was operational. He could not get an F8 when he tested channel 2.

After doing what he could to test the processor, Mr. Ouellet left the aircraft and became involved in the drip procedure without again deactivating the circuit breaker for channel 2. The aircraft left Montreal with the circuit breaker pushed in or activated. The circuit breaker was, therefore, in a different position than when the aircraft had arrived from Edmonton.

It is doubtful whether working fuel gauges would have been restored even if Mr. Ouellet had remembered to deactivate the circuit breaker. According to the expert evidence in relation to the fuel processor and the recycling of the circuit breakers, it seems that it would have been necessary to deactivate both circuit breakers and then reset the circuit breaker for channel 1, leaving the circuit breaker for channel 2 deactivated, before the fuel gauges would again function.

There is support for this conclusion in the experience of Mr. Simpson in Ottawa. He pulled out the circuit breaker that was tagged and pressed the fuel test switch. Neither action had any effect on the fuel gauges which all remained blank. He then pushed the circuit breaker back in and the aircraft left for Edmonton in that condition.[94]

If Mr. Ouellet had not touched the deactivated circuit breaker, the fuel gauges in the cockpit would in all probability have continued to work. The flight crew would have been able to use them as a further check of the boarding of the correct amount of fuel. The aircraft could then have safely left both Montreal and Ottawa with working fuel gauges giving a constant reading of the fuel quantity in each tank and the total amount left at any given time. In Edmonton a new fuel processor awaited its arrival.

The well-intentioned but misguided curiosity of Mr. Ouellet resulted in blank fuel gauges in the cockpit, and contributed significantly to the subsequent accident.

5. Overcrowded Cockpit

There is at least a possibility that the flight crew might have detected the error in the computation of the fuel load and might have been more attentive to the MEL requirements had the cockpit not been so crowded just prior to the departure of the aircraft from Montreal. The evidence indicates that as many as six to eight people were in and out of the cockpit after the flight crew came on board prior to departure. They included maintenance personnel, the fueller, an Air Canada pilot travelling as a passenger, and flight attendants.

Ms. Anne Swift, one of the flight attendants, testified:

"Q. Was there a lot of people coming in and out?

A. Yes, there was a lot of traffic in there.

Q. Was it crowded?

A. Some of the time."[95]

Captain Pearson said that when he first arrived in the cockpit:

"... it was very crowded; in fact I had to squeeze by — there were quite a few people in the flight deck."[96]

He estimated there were three additional maintenance men besides the fueller and First Officer Quintal. He testified:

"Yes. It was quite congested in the flight deck, and it seemed that if you know the dimensions of the flight deck, it seemed to me there must have been about five people there."[97]

The fueller, Mr. Schmidt, also described the cockpit as crowded:

"Q. Was the cockpit crowded?

A. Yes, it was.

Q. So there would have been ... seven people in the cockpit then?

A. Yes."[98]

Obviously, it was essential for some of these individuals to be in the cockpit. However, it appears that the presence of others may not have been necessary. The Air Canada pilot, Second Officer Ralph Krusch, who was travelling as a passenger, came to the flight deck so that he could ride in the cockpit. Ms. Swift went up front with another flight attendant, Ms. Danielle Riendeau, to say "hi" to the flight crew and talk to their friend the pilot passenger. Ms. Swift said she remained there about five to seven minutes.[99]

Ms. Riendeau testified that she was in the cockpit talking to Ms. Swift and Second Officer Krusch for "a few minutes, maybe five minutes at the most". During that time there was a lot of conversation between maintenance personnel and the flight crew and she could feel some tension.[100]

All of the different people coming and going in and out of the cockpit just prior to departure may well have created a serious distraction for the crew at a critical time.

6. Inadequate Communication

One of the human factors which contributed significantly to the Gimli accident was the inadequate communication between individuals who were involved with the aircraft on July 23, 1983. It is clear from the evidence that there was both inadequate written and verbal communication between flight crew and ground personnel. There was inadequate communication about the nature of the snag, the fuelling of the aircraft and the dispatchability of the aircraft.

I have already commented above that, in my view, Mr. Yaremko's entry in the aircraft journey log book on the morning of July 23, 1983 in Edmonton, was inadequate. It did not indicate the result of his actions, namely, that by deactivating the channel 2 circuit breaker of the fuel processor, the fuel gauges in the cockpit were restored to normal operation. This was a lapse in written communication.

A lapse in verbal communication took place in Edmonton on July 23, 1983 when Mr. Yaremko left Captain Weir with the impression that the aircraft had arrived from Toronto with a faulty fuel processor. In fact, as we now know, Mr. Yaremko was describing a similar incident with the same fuel processor on the same aircraft which took place on July 5, 1983.[101] Because of the misunderstanding, Captain Weir concluded that the snag had been outstanding since at least the morning of July 22 when the aircraft left Toronto.

Unfortunately, Captain Weir's misunderstanding became part of his conversation with Captain Pearson in Montreal on July 23. On this occasion, Captain Weir and his first officer, Captain Johnson, met Captain Pearson on the way to the parking lot at the Dorval terminal in Montreal. The recollection of both Captain Weir and Captain Johnson of the conversation is somewhat different from Captain Pearson's recollection. Neither Captain Weir nor Captain Johnson recalled having informed Captain Pearson that the fuel gauges were blank. The fuel gauges had in fact operated throughout the flight from Edmonton to Montreal and only became blank after Captain Weir and his first officer left the cockpit, and before Captain Pearson entered the cockpit. Therefore, it is highly unlikely that Captain Weir or Captain Johnson would have told Captain Pearson that the fuel gauges were blank because they were not blank when they left the aircraft. They became blank afterwards when Mr. Ouellet pushed in the circuit breaker and forgot about it when he left the aircraft.

Captain Pearson, for his part, received the impression from the conversation that the fuel gauges were blank and inoperative and, further, that the aircraft had been flown in this condition from Toronto to Edmonton and from Edmonton to Ottawa and then to Montreal.[102] All this contributed to Captain Pearson's state of mind when he made the decision to take off from Montreal with blank fuel gauges.

There was further evidence of inadequate communication in relation to the decision made by Captain Pearson in Montreal to take on enough fuel to go to Edmonton. During the conversation on the way to the parking lot, Captain Pearson accepted Captain Weir's suggestion that he fuel in Montreal for the journey to Edmonton, rather than fuelling again in Ottawa. Captain Pearson told First Officer Quintal of his decision to follow this advice but, unfortunately, it seems that he did not mention it to anyone else.[103] Only Flight Dispatch and Load Control knew of his decision. Neither Mr. Ouellet nor Mr. Bourbeau knew that there was to be no fuelling in Ottawa. The fueller, Mr. Schmidt, apparently did not even know where the aircraft was going.[104]

The litany of examples of inadequate communication continues. Of the two technicians involved in Montreal, only Mr. Bourbeau read the MEL item 28-41-2.[105] This is the only item he read and it appears that he did not give it very much consideration. Mr. Ouellet did not read the MEL at all. They had no discussion about the snag itself, nor did they discuss the provisions of the MEL. Apart from this, neither of them had been briefed by their superiors about the snag, other than being told that a drip check was required.

As Mr. Blais pointed out in his submission, several witnesses testified that it is normal procedure for the flight crew to discuss with maintenance personnel any particular snag and also to discuss with them the relevant provisions of the MEL. In this context, it should be remembered that before the departure of any flight, maintenance personnel are responsible for signing a clearance. It is then up to the pilot to decide whether it is legal to operate, having regard to the established procedures, and particularly the provisions of the MEL. Even if it is legal to operate, the Captain of an aircraft always has the final authority and, in fact, he may decide not to go for another reason. An obvious example would be in the case of particularly bad weather. Normally, therefore, if there is a problem, the flight crew discuss the problem with maintenance personnel. If they cannot resolve the problem or agree on the interpretation of the provisions of the MEL, they seek assistance and advice from Maintenance Central or Flight Operations.[106]

In Montreal, on July 23, 1983, no such procedure was followed, either by the flight crew or by maintenance personnel.[107] According to the maintenance personnel, Maintenance Central was not advised that the aircraft had blank fuel gauges in Montreal.[108] According to First Officer Quintal, Captain Pearson did not discuss with him the log book entries or the legality of the departure. Nor does First Officer Quintal remember discussing with him the blank fuel gauges.[109] It is also clear from the evidence of Captain Pearson, First Officer Quintal, Messrs. Ouellet and Bourbeau that they did not discuss the provisions of the MEL or the legality of the dispatch of the aircraft in any detail.

Another example of inadequate written communication is the description of the deviation on the AFPAC or flight plan. Except for notifying the flight crew that there was a deviation, the description was virtually useless in terms of explaining the nature of the deviation.

The flight plan under the title "ACFT Deviations" included a very brief description of the deviation. It was as follows:

> "28-41-2 FUEL QTY PROC #2 CHNL INOP... DIP (sic) REQD... "[110]

This description of the deviation does not indicate that the fuel gauges went blank. It does not indicate that the gauges had been restored to operation. It does not indicate how long the deviation had been on the aircraft. It is almost worse than putting nothing at all on the flight plan. It could well have given the flight crew a false sense of security and lulled them into inaction by suggesting that all that was required before departure was a drip.

The communication which took place between the maintenance personnel and the flight crew, in relation to the calculation of the fuel load, is also questionable. The in-charge flight attendant, Mr. Robert Desjardins, testified that the flight crew and maintenance personnel were "arguing" about the calculations of the fuel load. In his handwritten notes made shortly after the Gimli accident, Mr. Desjardins recorded:

> "Then everyone comes back, go over some figures again. They still argue over what's in the book and what they have on the small piece of paper that one maintenance guy just came on board with."[111]

He confirmed in his evidence that there was "argument" or "animated discussion" about the fuel figures.[112]

Such instances of either a total lack of communication or inadequate communication in varying degrees give cause for concern. It is to be hoped that these problems with communication between on-line pilots and on-line maintenance personnel were only an isolated incident. As Captain Pearson pointed out, he and all other pilots must necessarily rely on many different maintenance and technical experts whose job it is to ensure that their aircraft are serviceable. In these circumstances it is most important that there be clear and unequivocal information given to the flight crew. Such communication must not be vague.

On the other hand, if flight crew have questions or doubts about the serviceability or dispatchability of their aircraft they must ask the necessary questions. They must seek advice. They must take the time, even if it means delays in departures, to question and to communicate with the on-line maintenance personnel and, if necessary, with Maintenance Control. The facilities are there. The experts are there in Air Canada. They should be used.

C. Corporate Deficiencies

Foreword

The Air Canada accident on July 23, 1983 was not only attributable to a combination of human errors but also to a combination of corporate deficiencies. These deficiencies include practices, procedures and decisions flowing from policy established at the upper levels of the corporate structure of Air Canada.

The distinction between human errors and corporate deficiencies is, of course, somewhat fictional because a corporation is composed of individuals. However, for the purposes of discussing the contributory causes of the accident, there is a distinct line to be drawn between those on-line individuals who were directly involved in the maintenance, dispatch and operation of the aircraft on the day in question, and the company practices, procedures and policies under which those individuals operated.

I also realize that there is a good deal of overlapping between the human errors and the corporate deficiencies. This can be seen particularly when considering the questions of whose responsibility it was to calculate the fuel load, the lack of training of flight crew and maintenance personnel alike and the questionable status of the MEL. There is overlapping because the confusion about whose responsibility it was to calculate the fuel load, the lack of training, and the questionable status of the MEL were corporate deficiencies which manifested themselves in the actions or lack of action by the individuals involved in the maintenance and operation of aircraft 604 on July 23, 1983.

The corporate deficiencies which I consider to be contributory causes of the accident are the decision to have a mixed aircraft fleet, that is, a mixture of metric and non-metric aircraft; the failure to assign clearly the responsibility for calculating the fuel load on an aircraft flown without a second officer; confusion about the status of the MEL; a lack of training of both pilots and maintenance personnel; the use of the wrong conversion factor or the term specific gravity; the lack of spare parts; inadequate communication as evidenced in the manuals and in the preparation of the MEL; lack of an adequate flight safety organization; and deficiencies in the certification process.

Not all of the responsibility for these deficient practices, procedures and decisions rests with Air Canada. The fuellers and also Transport Canada must bear their share of the responsibility. The fuellers must bear some responsibility with respect to the use of the term specific gravity and the wrong conversion factor. Transport Canada must bear some responsibility for its role in the certification process. These deficiencies will be discussed in more detail below.

In considering the corporate deficiencies in Air Canada, it should be kept in mind that Air Canada is a large corporation. It operates over 100 aircraft and has approximately 25,000 employees. The aircraft fleet is now composed of twelve Boeing 767's; thirty-five Douglas DC-9's; thirty-six Boeing 727's; six Douglas DC-8 freighters; seven Boeing 747's; twelve standard Lockheed L-1011's; and six Lockheed L-1011-500's.

An impression arising out of the evidence is that Air Canada is somewhat top heavy in terms of its personnel, with something like 26 vice-presidents. There seems to be a rather complex decision-making process relating to the actual operation of its aircraft.

The Inquiry was particularly concerned with the Technical Operations Branch of the corporation. An illustration of the Technical Operations structure of the corporation is contained in the charts marked as Exhibit 138 and set out in Appendix "C".

Because the Technical Operations Branch of Air Canada includes Maintenance and Engineering and Flight Operations, it was that aspect of the corporate structure with which the Inquiry was most concerned. The Legal and Government Affairs Branch, the Finance Branch, the Marketing and Sales Branch and the Human Resources Branch of the corporation were not of particular concern under the terms of reference of the Inquiry.

There follows an examination in detail of the various corporate deficiencies which contributed to the Gimli accident.

1. Introduction of Metric Aircraft into a Non-Metric Fleet

One of the contributory causes of the Gimli accident from a corporate perspective was the decision by Air Canada to put a metric aircraft into an otherwise non-metric fleet. This introduced into the system an additional possibility for error which manifested itself in the Gimli accident.

Mr. Geoffrey Haigh, General Manager of Operations and Engineering at Air Canada, agreed in his evidence that because there are two different systems within the Air Canada fleet, an additional possibility of error and danger is created.[113]

The system popularly called the metric system is being introduced by law for eventual general use in Canada pursuant to the *Statute Law (Metric Conversion) Amendment Act*, 1976. Thus, in the aircraft industry in Canada, all fuel is sold to the users, whether domestic or foreign, by the litre. Accordingly, whether an aircraft is classed as metric or non-metric, it will be fuelled in litres. Apart from the general use of celsius in temperature readings, the only other metric measurement used in the commercial aircraft industry in Canada is kilograms for fuel weight and load measurement. This slight extension of the use of metric measurements is confined in the Air Canada fleet to the Boeing 767 aircraft.

The metric system, as used in the aircraft industry throughout the world, is a system based on the International System of Units which is known as SI from the French version of the phrase "Système International d'Unités". The system began with an attempted standardization of units of length and mass in France in 1795. It became known as the metric system. Beginning in 1870, work towards general international standardization began. Insofar as the aviation industry is concerned, the metric system has been modified to be used as a basis for an international standardized system of units of measurement. This particular adaptation of the metric system contains both metric and non-metric units. Some non-metric units have been incorporated into the system for permanent use, others for temporary use. The latter are to be phased out over a period of time. The non-metric units have been incorporated into the system in line with the overriding consideration for air safety. The historical background of this development is set out at page 5 of Annex 5 to the Convention on International Civil Aviation:

> "International Standards and Recommended Practices for Dimensional Units to be used in Air-Ground Communications were first adopted by the Council on 16 April 1948 pursuant to Article 37 of the Convention on International Civil Aviation (Chicago, 1944) and were designated as Annex 5 to the Convention. They became effective on 15 September 1948 and became applicable on 1 January 1949."[114]

The Council referred to is that of the International Civil Aviation Organization, headquartered in Montreal. By Article 38 of the Convention on International Civil Aviation, Contracting States are required to notify the Organization of any differences between their national regulations and practices and the International Standards. Not all States comply with this requirement since it is purely voluntary. It is clear, however, from the supplement to Annex 5 dated May 1983, that most States in the world, including all the European countries, do comply and have adopted the system. The United States, notably, has not yet adopted the system. Canada has with some small differences. Other evidence indicates that the U.S.S.R. and its dependencies, and also China, have completely metric systems to an extent greater than the system set out in Annex 5.

As noted above, the system set out in Annex 5 is not a purely metric system. This is pointed out at page 9 of Annex 5:

> "This standardized system of units of measurement is based on the International System of Units (SI) and certain non-SI units considered necessary to meet the specialized requirements of international civil aviation."[115]

Thus, curiously enough, in Annex 5 the litre is categorized as a non-SI unit for permanent use in the standardized system developed for civil aviation. This standardized system and its units are referred to generally throughout this report as the metric system.

What happened at Gimli has been referred to as a metric mix-up. The term implies that there was confusion as between the metric system and the Imperial system. This was not the case. The mix-up was from volume metric measurements to weight metric measurements. Mr. Lebeau, referring to the findings of the Fuelling Committee, put it thus:

"A. I guess it's fair to say that the Committee felt that it wasn't basically the measuring methodology that created the situation that occurred. It was more a mathematical computation — possibly the definition of a format or a process clearly was not defined. Had it been defined, possibly this would not have occurred.

Q. So the Committee at that early stage did not attribute the Gimli accident — at that early stage to a mix-up in metric?

A. Correct. Especially bearing in mind that the tables go from — the tables, as they are defined, go from centimetres into litres, et cetera.

Q. Yes. So it would have been more a mix-up from metric — the volume metric to weight metric?

A. Correct."[116]

All aircraft in Canada are fuelled in litres, a metric measurement. To convert volume to weight in the case of the 767, the appropriate conversion factor to convert litres to kilograms must be used. In the events leading up to the Gimli accident, the appropriate conversion factor was not used. The conversion factor to convert litres to pounds was used.

A wider and vital question arises out of the incorrect fuel calculations made in Montreal and Ottawa. It relates to the introduction of a metric aircraft into a non-metric fleet. Thus, whilst all Air Canada aircraft are fuelled in litres, it is only in the case of the 767's that the litres are converted to kilograms. In the case of all other aircraft in the fleet, the conversion is from litres to pounds.

It should be noted that when reference is made to a metric or a non-metric aircraft in the Canadian context, the term metric implies only that the fuel weight and other load calculations are made in kilograms. The term non-metric implies that such calculations are made in pounds. Even the 767 is not strictly a metric aircraft. Other systems in the aircraft are non-metric. For example, the altimeter measures height in feet, air speed is measured in knots per hour.

The 767 is referred to in this report as a metric aircraft purely for the sake of convenience and in spite of the fact that the only metric features of the aircraft are the fuel gauges measuring in kilograms, load calculations made in kilograms and drip sticks calibrated in centimetres.

The decision to buy the 767 was made by Air Canada some time around July 1979. Air Canada, the Boeing Company and Transport Canada participated in the process of introducing the 767 into the Air Canada fleet. By this time, the Government of Canada had established its policy of conversion to metric. Metric conversion committees existed within Air Canada and a decision was taken to introduce the 767 as a metric aircraft.[117]

Thus, the decision to introduce a metric aircraft into the Air Canada fleet was made within the wider context of a movement towards conversion to the use of metric measurements in Canadian society as a whole. There is evidence that Transport Canada particularly wanted the 767 to be introduced into Canada as a metric aircraft.[118] There is also evidence that the Canadian government put pressure on Air Canada to introduce the 767 as a metric aircraft. As Mr. Haigh put it:

"Q. And I understand that there was some direct pressure from the government on Air Canada to in fact introduce the 767 as a metric aircraft?

A. Yes."[119]

It was, however, Air Canada which finally made the decision to move towards metrication. It did so cautiously and, in fact, did not go as far as Transport Canada wished it to go. It is clear from the evidence that the decision was carefully made and that if Air Canada had been at all concerned about flight safety, it would have resisted pressure from any direction, including the Government of Canada, through Transport Canada, and would have retained gauges in Imperial measurements.[120]

It is important to remember that we are only talking about fuel gauges which read in kilograms and drip sticks which read in centimetres. No other instruments in the aircraft indicate metric measurements. It should also be emphasized that the drip sticks are rarely used, even though there is considerable discussion of their use in this report.

Another important fact to note is that when the 767 was introduced with fuel gauges reading in kilograms and with drip sticks calibrated in centimetres, it was not introduced into a fleet which was otherwise uniform in its measurements. It is true that, apart from the 767, all other aircraft in the Air Canada fleet have gauges reading in pounds. On the other hand, when a drip check is done, the calculations to be made vary from one aircraft type to another. Thus, on the Boeing 767, the drip sticks are calibrated in centimetres and the conversion is from centimetres to litres to kilograms; on the Boeing 747, the Lockheed L-1011 and the Douglas DC-9-32, the drip sticks are calibrated in Imperial gallons and the conversion is from Imperial gallons to pounds; on the Boeing 727 and the Douglas DC-8, the drip sticks are calibrated in inches and the conversion is from inches to Imperial gallons to pounds; on the Douglas DC-9-15, the drip sticks are calibrated in inches and the conversion is from inches to U.S. gallons to pounds.[121]

Therefore, when calculations are to be made from drip stick readings, everything depends on the formula which is used and the professional expertise of the individuals who use it.

The best illustration of this statement is the experience of First Officer Iftah Zemer of the Israeli Pilots Association. He gave evidence at the hearings in Egham, near London, in England, the headquarters of the International Federation of Air Line Pilots' Associations (IFALPA). First Officer Zemer is a pilot with El Al Israel Airlines, flying from Israel to Europe on Boeing 767's and Boeing 737's. In addition, he is a reserve officer in the Israel Air Force. He is also an instructor on light aircraft. When he gave his evidence, he testified that he was currently flying aircraft with four different types of fuel gauges, one in kilograms, one in gallons, one in litres and one in pounds. His comment was "so you have to know what you read on the gauges".[122] He testified that all El Al captains and first officers receive training on how to use the drip sticks and do the fuel conversions.[123]

A fundamental question that had to be faced by the metric conversion committees within Air Canada was how to implement the decision to move towards metrication. It was decided to do it by aircraft type. So it was that the 767 was introduced as a metric aircraft. On the other hand, a new version of the Lockheed L-1011, the Lockheed L-1011-500, acquired at about the same time, was not introduced as a metric aircraft. It was not considered safe to mix metric and non-metric measurements within the same classification or type of aircraft.[124]

After Gimli, another fundamental question had to be decided, namely, whether to revert to Imperial measurements in the case of the 767. An alternative question, equally fundamental, was whether to speed up the process of metrication within the whole fleet and, in particular, to move towards standardization of fuel gauges and drip sticks in metric measurements.

The Fuel Committee established after Gimli recommended against reconversion of the 767 to Imperial measurements. The basis of this recommendation was their finding that the cause of the accident was not a metric mix-up. According to Air Canada, the miscalculation of the fuel weight arose basically from a failure within Air Canada to allocate responsibility for making the mathematical computation from litres to kilograms in the abnormal situation which arose. In a normal situation, with the fuel gauges operating and the flight management control system working, the conversion would have been done automatically within the computerized system.

In the circumstances under consideration, an attempt was made by the personnel involved to do the calculations themselves. Without the aid of the computerized system, which was not working, the wrong conversion factor was used and the fuel load miscalculated. The Fuel Committee came to the conclusion that the process of making the computation was not defined in the manuals.[125]

As noted above, when using the drip procedure for calculating fuel weight, different conversions are made, depending on the type of aircraft. Conversions are made not only as between Imperial and metric, but also conversions using the U.S. gallon which is different in size from the Imperial gallon. What is important in all these cases is to use the right number, that is, the right conversion factor.

Mr. Chown, the Secretary of the Fuel Committee, referred to the need to institute procedures for such calculations, and to see that they are carried out. Speaking of the decision of the committee not to recommend a reconversion from metric to Imperial in the case of the 767, he said:

"A. It has its roots in ... the fact that the differences in the airplanes were such that there was no common thread. The only commonality part that we found in the other airplane types was the fact that all the fuel gauges were in pounds and the 767 differed to be in kilograms. But there were various units used. And so we felt to deal with any airplane, you have to be fully aware of which units you were dealing with. So to handle the non-metric airplanes in the fleet, we needed specific procedures. We felt those procedures would cover the difference between Imperial and metric as well.

Q. So that ... to change an aircraft from metric back to Imperial or whatever, would still not bring conformity in the system necessarily?

A. That's corrrect.

Q. The conclusion then being that the only way you can safely do it is to institute procedures and be sure the procedures are followed for the computations."[126]

The airline also examined the converse question, that is the metrication of the entire Air Canada fleet. When Air Canada introduced the Boeing 767 as a metric aircraft, it was its intention, and it still is, to metricate the fleet by type as each new type of aircraft becomes available. This process would obviously take a long time and certainly well into the next century.

This is all too evident when it is noted that Douglas DC-8 aircraft, which are now used exclusively for cargo rather than passenger transportation, have recently been fitted with new engines which will expand the service life of this type of aircraft within Air Canada for another twenty years.

Mr. Haigh said that it would take about two years to metricate the whole of the existing Air Canada fleet. He testified:

> "Well, we've examined the matter in some detail. It would involve changing gauges on airplanes, as many as 13 individual gauges on a 727, and considerably more on a 747. These gauges are the fuel tank quantity gauges, the fuel tank totalizer gauges and the engine fuel flow gauges.
>
> In addition, in some airplanes, it will be necessary to modify various electronic equipment like fuel quantity processors. It will be necessary to modify or reprogram — or both — operational systems such as the flight management system on the 767 — well, if we were going metric that wouldn't be — but on the 1011 or the performance management system on the 727. It's a considerable program.
>
> We estimated that it would take about two years to accomplish it and in consultation with the manufacturers and vendors, we determined it would take about six months to start up."

He continued:

> "It's not impossible to do. It's a fair task. It's a fairly expensive task and for the duration of the program and for sometime thereafter it introduces a great possibility for errors to be made. There would be two different systems of units in service; there would be two types of each airplane in service, side by side, which — a mechanic would work on one, a metric airplane in the morning, and an Imperial airplane in the afternoon. Flight crew would fly a metric airplane one flight and perhaps an Imperial airplane the next flight."[127]

There are admittedly dangerous aspects to operating a fleet of aircraft in which some use metric measurements and others use non-metric measurements. The danger is reduced, but not eliminated entirely, by introducing metric measurements into a fleet as each new aircraft type is purchased and brought into service. This is what Air Canada did with the introduction of the Boeing 767.

However, when they bought a new version of the L-1011-500, they considered it prudent to introduce the new aircraft in the old non-metric system to avoid using two different measurement systems on the same type of aircraft.[128]

The evidence then is clear that by following this method of metrication the aviation industry in Canada will remain largely non-metric for the foreseeable future.

In the meantime conversion to the metric system is proceeding in Canada. A new generation of children is being educated in the metric system and they are taught no other system of measurement. Very soon they will be ready to enter the work force. Thus, the next generation of pilots is likely to be trained in the metric system but the pilots will be required to operate non-metric aircraft. This is a situation which requires the most urgent attention by Air Canada, by Transport Canada and, since there are other airlines involved all flying non-metric aircraft, by the Government of Canada. In the interests of aviation safety a clear statement of policy on the issue of metrication is required.

2. Failure to Assign Responsibility for Fuel Load Calculations

One of the major contributory factors to the Gimli accident was the failure by Air Canada to assign clearly the responsibility for computing the fuel load in an abnormal situation. The corporation's failure clearly and specifically to assign this responsibility was accompanied by a failure to train anyone to perform this function. Air Canada failed to fill the gap left by the departure of the second officer.

Before the introduction of the 767 into the Air Canada fleet, aircraft of its size would normally have a three-man crew. The third man, either a pilot or a flight engineer, would be responsible for maintaining a fuel log to keep a check on the amount of fuel boarded and consumed. In abnormal situations he would supervise the taking on and measurement of the amount of fuel loaded. He would do the necessary conversions. In addition to this, his regular duties would include the supervision of all aspects of engine performance during flight. He would normally be seated behind the first officer, facing towards the side of the aircraft, where he would have his own panel containing all the necessary instruments relating to the aircraft systems which it was his duty to monitor. He was popularly known in the industry as "the oiler".

Three-man crews still exist in Air Canada, notably on the Boeing 727. The Boeing 767 was originally designed for a three-man crew. It is flown in Australia with a three-man crew. However, in the United States of America, President Reagan, during his first term, established a Commission to consider the feasibility of flying the aircraft with a two-man crew. The Commission reported that this could be done safely because of the electronic and computerized systems designed to aid the flight crew. The recommendations of the President's Commission were discussed with the pilots' associations in the United States and agreement was reached to introduce the Boeing 767 in that country as a two-man crew aircraft. Such recommendations were accepted in Canada and agreed to by the pilots' association in this country. In the process, Air Canada, as a corporate body, neglected to assign clearly and specifically the responsibility for calculating the fuel load in an abnormal situation.

It is worth repeating that it is only on very rare occasions that the fuel load has to be calculated manually. This procedure, as we have seen, involves using the drip sticks to check the amount of fuel in the tanks. The stick readings then have to be converted to a figure representing the weight of the fuel.

In the case of the 767, the sticks are calibrated in centimetres. The conversion to litres at the time of the Gimli accident was made by use of the tables in the drip manual. Conversion of the volume in litres to the weight in kilograms then had to be made. This calculation had to be done by the person or persons, whether flight crew or ground personnel, or both, to whom the responsibility was assigned by management.

It should be noted that calculating the fuel load by the use of the drip sticks was not intended as a substitute for operational gauges in the cockpit, but only as a confirmation of the readings. By the provisions of the MEL, an aircraft could be dispatched with one of its two wing tank fuel gauges in the cockpit inoperative. By the terms of the qualifying conditions, fuel quantity in the associated tank had to be determined by measuring stick, all the pumps in that tank had to be operative and fuel quantity information had to be available on the flight management computer.[129]

Before the introduction of the 767, there was one other aircraft in the Air Canada fleet with a two-man flight crew, the DC-9. It is still part of the fleet. If one of the gauges in that type of aircraft is inoperative and a drip is required, the normal practice is to fill up the tanks entirely. A drip is then taken by maintenance, to confirm that the tanks indeed are full.[130]

On those rare occasions when the wing tanks of the DC-9 are not filled, on short flights, a detailed procedure is set out in the Operating Manual. The procedure is basically to put the required amount of fuel into the tank with the serviceable gauge. This amount is then cross-fed into the other tank and the first tank again filled using the serviceable gauge. The flight crew are required to double check the drip stick readings and be satisfied that the check is valid and correct. The task of computing the fuel load appears to be that of ground personnel or the flight crew, although the manual is not clear.[131]

On three-man aircraft, the job of confirming the amount of fuel on board is shared between flight crew and maintenance. Maintenance personnel do the drip and supply the figures to the second officer or flight engineer, as the case may be, and he makes the appropriate calculations.[132]

Counsel for Air Canada, during the course of the hearings, made the admission that the company had failed to assign the task of calculating the fuel load of a 767 in an abnormal situation.[133]

There was no reference to flight crew involvement in abnormal fuelling procedures in the Aircraft Operating Manual for the 767. Captain Robert Coneen, Chief Pilot for the 767, Captain Walker, Chief Flying Instructor for the 767 and Captain Roger Miners, Director of Flight Technical, all of them senior members of Air Canada, were of the view that abnormal fuelling procedures were the responsibility of maintenance personnel because pilots were neither trained nor expected to do the work.[134]

Thus, those responsible for Flight Operations thought that the computation of fuel in an abnormal situation was a maintenance responsibility.

Maintenance personnel took the contrary view, which was expressed by Mr. Morawski, Senior Director of Aircraft Maintenance. In his evidence, referring to conversion of drip stick readings to weight, he stated:

> "There is no question about it in my mind that on a 767, there is a void there... If the question is: was it maintenance's responsibility to do the conversion? The answer is no. If you are asking me whose responsibility it was, my answer is I don't know."[135]

During the hearings, a good deal of time was devoted to trying to establish the precise meanings of (M) for maintenance and (O) for operations, which appear in the columns of the MEL. On the basis of this document and references in the job cards, in the Maintenance Manual and in the Minimum Equipment Deactivation Procedures, it was suggested that abnormal fuelling procedures were the responsibility of maintenance personnel.

Counsel for Air Canada, on the other hand, pointed to the fact that prior to the introduction of the 767, maintenance personnel had not been responsible for the computation of the fuel load on any aircraft in the Air Canada fleet. He concluded that, if they were to undertake this task on the 767, they would have to be informed of this fact and trained in the procedures. They were not so informed or trained. He also referred to the evidence of Mr. Laird Stovel, Senior Operations Engineer — Wide Body, of Maintenance and Engineering, Air Canada, and of Captain Walker, to show how the failure to assign clearly the responsibility for the task happened.

Mr. Stovel assumed responsibility for the Boeing 767 Aircraft Operating Manual in 1979. It was his job to adapt the Boeing manual for use by Air Canada. He was involved in the 767 introductory programme as a member of the engineering introductory group.[136]

During the introduction of the 767 into the Air Canada fleet, Captain Walker was concerned about the pilots' work load. He suggested specific changes to make the best use of the electronic flight deck. He wanted "to sweep away the clutter of papers and duties accumulated since the

DC-3".[137] One of Mr. Stovel's concerns was the issue of a fuel log on board the aircraft. Referring to a discussion with Captain Walker and Captain Miners, Mr. Stovel testified:

"Q. Could you tell me in substance what the nature of that discussion was?

A. The nature was that there was concern about the paperwork load that would exist in the cockpit if we had only two pilots. And there was a desire to keep that to an absolute minimum.

To be consistent with the standards that we had, the DC-9 did not have a fuel log book and it had two pilots only. So it was felt that that would be a consistent approach to do the 767 like the DC-9; in other words, not have a fuel log book.

The other airplanes that we have that have second officers, they have fuel log books where a record is kept of the fuel usage and all the bookkeeping exercise, you might say, that go with keeping track of that. And that was a job performed by the second officer.

Q. All right. But on the DC-9 there was not a fuel log book?

A. That's correct."[138]

Captain Walker was referred to the same discussion by Mr. Saul, Counsel for Air Canada in the following evidence:

"Q. ... Mr. Stovel said there was a discussion between himself, yourself and Captain Miners in which you had emphasized the need to reduce work load and advised him that the fuel procedures would be the same as the DC-9. And since the DC-9 didn't have a fuel log, there would be no fuel log on the '67; that was basically the discussion as he described it. Is that reasonably accurate?

A. The DC-9 procedures would be applied to the 767 in regard to the fuel operations."[139]

In the words of Mr. Saul, Counsel for Air Canada in his submission:

"Walker assumed that since pilots on the DC-9 were not involved in computing fuel load in an abnormal situation they would not be involved with that task on the Boeing 767. Stovel believed that since the Maintenance technicians were not responsible for computing fuel load on the DC-9 the task would be the pilots' responsibility."

This statement of what Mr. Stovel believed appears to be inconsistent with his evidence. In any event, it was agreed that the DC-9 procedures designed for two-man crews should be adopted. Unfortunately, as it turned out, Captain Walker and Mr. Stovel each drew a different conclusion from this decision.

Despite Air Canada's admission through its counsel that there had been a failure to assign the task of calculating the fuel load in an abnormal situation; despite the fact that no one was trained to perform this function; and despite the position of both maintenance and management witnesses that it was not their responsibility, a strong argument, based on the relevant documentation, can be made that this function was assigned to maintenance personnel prior to July 23, 1983.

Based on the MEL which refers maintenance personnel to the MEDP, and based on a reading of the relevant part of the MEDP, it would have been up to maintenance to do the following in the case of an inoperative fuel gauge:

"6.C. Measuring Stick Method.

(1) Determine pitch and lateral attitude of airplane by using inclinometers or plumb bob.

(2) Determine fuel quantity by referring to Fuel Measuring Stick Tables for Off Attitude Conditions (found on P61 Panel).

(3) Service tanks normally, except keep level in affected tank slightly lower than opposite tank. This can be accomplished by comparing fuel stick readings while tanks are being fuelled. When tank

with operative gauge reaches desired fuel quantity, slowly fuel affected tank until fuel stick readings between tanks agree within 0.1 inch.

(4) Measure fuel in affected tank using measuring sticks.

7. Placard affected fuel quantity indication FUEL IN TANK (____lbs)."[140]

The reference to lbs. is, of course, an error. It should have been kilograms.

Maintenance could not have placarded the fuel gauge as directed unless they had determined the weight.

It is a reasonable position to take, therefore, that the responsibility to calculate the fuel load in an abnormal situation was, in fact, assigned to maintenance personnel by the MEL and the MEDP. These documents appear to have assigned the task to maintenance personnel although the responsibility was not clearly spelled out. What is clear is that no one on the maintenance side understood this to be the case, nor were maintenance personnel trained to perform the function.

It should be noted as well that in all the other airlines whose evidence we took there was no doubt that it was a maintenance responsibility to calculate the fuel load in an abnormal situation. In fact, United Air Lines' maintenance personnel performed this function for Captain Richard Reid, a B-767 Captain with Air Canada, in San Francisco on July 14, 1983 when he arrived there with blank gauges. They provided him with the fuel weight in kilograms despite the fact that they normally work in non-metric measurements.

Mr. Lebeau was a member of the Accident Review Committee after Gimli. One of the recommendations made by the Committee, set out in a letter written by Mr. Lebeau and dated August 15, 1983, reads:

"1. Establish clear delineation of responsibility regarding fuel stick measurement, volume computation and mass (weight) calculations. This should be clearly identified in the appropriate Maintenance and Operations manuals (applicable to all aircraft types)."[141]

In evidence at the hearings he stated:

"... it became very evident to me that there was no clear cut delineation on assignment of responsibility as to who was to compute the fuel."[142]

The end result was that neither flight crew nor maintenance personnel were specifically assigned the task of manual computation of fuel on board the aircraft, nor was either group trained to do so.

3. Status of the MEL

One of the contributory causes of the accident which I have classified as a matter of corporate responsibility was the unclear status of the MEL within Air Canada. At the time of the Gimli accident and beyond it was not universally recognized by flight crew or maintenance personnel as a binding authority.

As indicated in Part II of this report, the MEL is the document which governs the legality of the dispatch of an aircraft with inoperative equipment. It details which equipment, under what conditions, may be serviceable, and the aircraft as a whole still be able to be dispatched.

In Canada, in the 1960's the MEL was only a guide for pilots. In Air Canada it was called the Minimum Equipment Guide. Its provisions were not obligatory or binding.

In 1970, with the introduction of the 747, the MEL within Air Canada became obligatory, as it had been in the United States since the 1960's.

In 1977, Transport Canada, as a result of discussions with the airline industry, recognized the need for an obligatory Minimum Equipment List. It was made obligatory by virtue of an air navigation order.

It appears from the evidence that there was an impression among Air Canada pilots that they could be authorized to deviate from the provisions of the MEL. It was their belief that they could receive relief from the restrictive provisions of the MEL by Maintenance Central. It was their belief that Maintenance Central could allow such relief because Maintenance Central had a more technical and expanded Minimum Equipment List called the Master Minimum Equipment List. I have already discussed Captain Pearson's evidence in this regard and concluded that he genuinely believed that somehow Maintenance Central had the authority to override the provisions of the MEL set out in the Aircraft Operating Manual. It was this belief that was one of the factors in leading Captain Pearson to the wrong conclusion that he was legal to depart from Montreal with blank fuel gauges.

Captain Weir in his evidence stated:

> "Well, we have an MEL on board the aircraft as part of the Aircraft Operating Manual, and it is referred to with reference numbers on flight plans, as it was in this case. However, our Operating Manual is not a technical manual in the sense as to the detailed description of parts of the aircraft, and the maintenance personnel, I am sure all pilots believe, have an expanded version of all Minimum Equipment Lists that are in our manual that would be referred to by the maintenance personnel. It would be in the same sense expanded as the components or functions on the aircraft that are covered in our Operating Manual."[143]

On the other hand, there were many Air Canada management witnesses who maintained in their evidence that it was clear policy within Air Canada that the MEL could not be circumvented. Mr. Morawski testified that there was no policy in the Maintenance Branch that encouraged the dispatch of an aircraft in violation of the MEL.[144]

Mr. Donald Brown, Manager of Maintenance Control, Air Canada, testified that:

> "... the MEL in use in Maintenance Control is the identical one to that which is carried on board the aircraft, that is contained in the AOM."[145]

Captain Charles Simpson, Vice-President of Flight Operations, Air Canada, reiterated the same point when he testified:

> "A. Yes. I think two points, Mr. Prober. There are not two MELs.
>
> Q. No.
>
> A. And Maintenance cannot grant relief to an airplane if Flight Operations do not want to accept it."[146]

Despite these protestations from senior level management people at Air Canada that the MEL on board the aircraft was absolute and could not be circumvented, there was obviously a problem within Air Canada because illegal relief was from time to time granted to pilots. Mr. Gordon Helm, Director of Operations Engineering, Air Canada, testified that there were a number of instances of which he was aware over the last several years where illegal relief was requested and obtained under the MEL. He estimated them to be two per month. He became aware of these instances of illegal relief by virtue of the so-called "morning summaries" which are provided to corporate headquarters daily at Air Canada.[147]

Even Captain Miners, Director of Flight Technical Operations, Air Canada, testified that he was aware of a few instances where the MEL was not understood or was misinterpreted.[148]

There was obviously a problem perceived by Air Canada because, as Mr. Helm pointed out, his department, Flight Operations Engineering known as "the policeman of the MEL", had to prepare a training program to deal with the problem. The so-called "road show" came into existence. A video tape presentation was developed which emphasizes the obligatory nature of the MEL. It is presented to Air Canada pilots on a regular basis. There is also evidence in the video presentation itself to the fact that illegal relief was granted on occasion. There is also reference to the Master MEL.[149]

Despite this video presentation, and in spite of the Gimli accident, there was an incident on September 28, 1983 which illustrates why some pilots continued to believe that there was relief obtainable from the obligatory provisions of the MEL. On that date, Captain J.H. Rasmussen reported an incident in relation to a Boeing 767, aircraft no. 602, during which he was advised by Maintenance Central that there was relief under the Master MEL for a particular problem. It is interesting to note that this was Flight 104, the same flight Captain Weir took on July 23, 1983 from Edmonton to Montreal. Captain Rasmussen refused to accept such relief which he knew to be illegal.

In his incident report, Captain Rasmussen stated:

"Mtce Central was called on the patch over YWG and we advised them of our problem and suggested that we proceed to YUL for a fix as the flt could not depart YOW with the current faults. Mtce Central declined and suggested we continue the flt to YOW as they had relief under MEL 49-94-1. They were informed there is no reference to 49-94-1 in our MEL and with the MEL item 49-11-1 the A/C would be grounded in YOW until a fix was made. We were then advised by Mtce that there was relief under the item 49-94-1 in the Master MEL. I stated that the only MEL we would use was the one on the aircraft and that the aircraft would remain in YOW until a fix was made."[150]

In the same report Captain Rasmussen raised the following questions:

"1. Why was reference made to the Master MEL?

2. Are we legal to operate with an MEL number quoted by Mtce which is not in our AOM?

3. Why is 49-94-1 not in our AOM MEL also?"[151]

It was fortunate that on this particular flight there were two experienced captains, Captain Rasmussen and Captain A.F.A. Alain. One of them was doing a routine check on the other. Thus, there was a captain assisted by a captain who was acting as a first officer.

Captain Rasmussen's incident report was answered in a memorandum from Captain Coneen, dated October 13, 1983. According to the memorandum, the questions raised in the incident report were answered in a letter by Mr. A.W. Sargent, General Superintendent, Aircraft — Line — Dorval, as follows:

"1. The reference to the Master MEL was related to the Dispatch Deviation Guide, a portion of the MMEL. This has been in use since introduction of the B767, but has now been withdrawn in favour of the Air Canada MEL and the appropriate sections of the Maintenance Manual.

2. No. The reference was eventually clarified as not applicable to Air Canada aircraft.

3. 49-44-1 is not applicable to Air Canada and should not be in our AOM MEL. It is still referenced against 49-11-1 on page 01-80-05."[152]

In regard to this incident Mr. Helm, under cross-examination by Mr. Beauchamp, Counsel for CALPA, testified that Maintenance Central had been provided with a copy of the Master MEL by one of the Boeing representatives, contrary to Air Canada policy and had used the Master MEL erroneously.[153]

Under further cross-examination by Mr. Blais, representative of the I.A.M., Mr. Helm pointed out that the copy of the Master MEL that was in Maintenance Central had now been destroyed.[154]

It is to be hoped that the steps already taken by Air Canada to correct the mistaken and potentially dangerous belief on the part of some flight crew that dispensation from the qualifying conditions of the MEL can be given by higher authority have by now eradicated the belief.

4. Training Programmes

Another contributory cause of the Gimli accident which is best classified as a corporate deficiency was the inadequate training given to pilots and maintenance personnel who were going to be involved with the Boeing 767 when it was introduced by Air Canada. Pilots were certainly not sufficiently trained to deal with abnormal fuelling situations nor were maintenance personnel. Mr. Morawski testified that maintenance personnel were not trained to perform the MEDP functions which are referred to in the MEL.[155]

Both flight crew and maintenance personnel seemed to be somewhat mesmerized by the complex, computerized characteristics of the 767. They did not appear to have sufficient background knowledge of these aspects of the aircraft. They did not seem to have received sufficient training about some of the critical aircraft systems, in particular, the fuelling system.

In order better to understand how this lack of training could have occurred it is essential to look at the "need-to-know" concept of training.

i) *Training of Flight Crew: The Need-to-Know Method*

The need-to-know method of training flight crew developed as a natural consequence of the increasing complexity of aircraft. In the early days, pilots were trained to know how the engine and other mechanical parts of the aircraft worked. Captain Walker, the Chief Flying Instructor for the 767 with Air Canada, testified:

"We taught pilots for many years as we taught maintenance people. In the mid to late '50's I was teaching that in Air Canada ground school and that was a common way of teaching pilots at that time."[156]

Captain Walker described the concept of need-to-know in the following words:

"The concept of need-to-know... is something that... evolved gradually over the past ten or fifteen years. I think probably our biggest step in that direction was the introduction of the 747... 1972 I think it was... ten, twelve years ago.

Until that time you taught the pilot how machines worked. You taught him how an engine worked, you taught him how various gadgets inside the aircraft worked.

... And then to a degree you let him work out, through whatever method he used, how he worked the machine. In other words, you taught him very carefully how a gearbox worked but you didn't teach him how to shift gears. He almost had to work that out himself. Or he worked that out in the company with his own flight instructor. And many pilots did things quite differently.

With the advent of flight simulators, we had our first look at how pilots might actually deal with an emergency or an abnormal situation. The results were sometimes quite startling because each pilot dealt with the situation very radically different in some ways than other pilots might have.

As a consequence of that — not just in this airline, across the industry — it was recognized that what you were really trying to teach people was how to perform particular tasks. So the concept — not just ours — it came out of Boeing; it came out of other airlines — of so-called specific behavioural objectives evolved in which you said, 'When the bell rings, I'd like you to press the green button and as a consequence of that a banana will drop out of the slot.' It's a little more complex than that we hope, but you had a specific behavioural objective which you wished the pilot to achieve and you taught him the steps to achieve that. The mechanism by which it occurred, the banana grove and so on and so forth, was less of his concern. Initially of course, you had him out plowing the fields and planting the banana trees using that as a system.

The buzzword — the phrase with the introduction of the 767 was a 'crew performance objective'. In other words, rather than an individual, you obviously had to deal with the crew as a much more complex thing than a man working individually. There you taught the crew. You decided what the objectives were, and you taught the crew to perform those objectives when faced with certain situations. And again, how the machine worked in the background, with the advent of the more complex aircraft, became more than it could reasonably be expected the pilot could acquire. The operation of the aircraft became his specialty."[157]

Captain Paul Woodburn, the Flight Manager Technical with British Airways and also a B-757 Captain, outlined what he described as a "gradual process of refinement of what has been termed necessary knowledge for pilots". He continued:

"... in the past, an engineering instructor used to give us perhaps a lot of chalk and talk, standing up telling us what he thought we ought to know, which was not terribly relevant for what we, with subsequent hindsight, thought we should have been taught.

Now, that process has led to a refinement of what is considered to be pilot knowledge, to the extent that in recent years anyway, we have gone over to a more automated form of training... and we train as a crew: a captain and a co-pilot on a 757. We provide basically a mock-up of the airplane environment in a small room, a small cubicle, and then where the cockpit windows are, we put up dual slide windows, et cetera, and basically you put the pilots then in an airplane environment. They can control, through their own controls, taped slide presentations, and they can basically, over the course of a couple of weeks or so, go through the entire technical systems of the airplane.

Now, we have done that on pretty well all of our more recent aircraft, changed over completely to that style of training. And then, of course, one goes on from that environment using fixed base simulators and then full flight simulators, and eventually to a limited amount of airplane training, and off we go, eventually, to a trained pilot."[158]

Captain Woodburn then described meetings hosted by the manufacturer, Boeing, which were concerned with trying to define crew performance objectives known as CPO's. He continued:

"Basically, in defining all the crew actions on the airplane, we then tried to define the minimum necessary knowledge to support that action...

... from the action and from the minimum necessary knowledge, grew the Boeing operating manuals."[159]

Captain Jack Jessop, Director of Safety Services, British Airways, intervened at this point to make the following comment:

"I think it is important at this stage to refer to the fact that the meetings got minimum necessary training. We ended up, obviously, company by company, with the optimum required training. That is the important thing — the optimum. In other words, it was not necessarily just the minimum, but it was the training that would produce the best; it would obviously be better than the minimum."[160]

During the training of 767 pilots, they are given a general description of the fuel system. They are told that the fuel gauges are operated by a fuel quantity processor. They are not required to know how the fuel processor works. This is borne out by the evidence of Captain Walker:

"Q. ... when Captain Pearson encountered an AFPAC which related to a deviation in terms of channels within a processor, that is, the internal workings of a processor, the need-to-know philosophy would not have assisted him and wouldn't require him to know what a channel was or how the processor worked; whether one channel could work without the other, or what a channel was necessarily?

A. We do not teach beyond the information which is supplied to us in the Aircraft Operating Manual. If a pilot — if an individual desires a greater depth of knowledge, we could provide that to him, but the depth of knowledge which is supplied in the Aircraft Operating Manual — and in very general terms, in this particular case, I think the Operating Manual merely says that there are two channels in the fuel quantity processor and doesn't describe what a channel is, or there's no details on this at all.

Q. ... And similarly on the 767 pilots are not required to recycle circuit breakers or manipulate circuit breakers, or deal with them in any particular way. That's not part of their function on a 767?

A. ... In general terms, the pilot on the 767 goes to the cockpit and resets all of the circuit breakers which are not specifically collared, and that in very general terms is the same thing as he would do in the other aircraft.

Q. But he's not trained to know — or need to know the circuitry and what system each circuit breaker related to, particularly?

A. Oh, no. Not at all."[161]

It is obvious that with aircraft as complex as they now are, the old training method simply would not work. It is equally obvious that the kind of training now required is of the type covered generally by the need-to-know method. The question is whether the content of the training based on that concept is sufficient, in the light of what happened in the Gimli accident. As pointed out in the Air Canada submission, the need-to-know philosophy of training places a greater emphasis than ever upon adherence to the Minimum Equipment List:

"In older aircraft on which the pilot received 'nuts and bolts training' his knowledge of that system allowed him a certain discretion in evaluating its failure upon the airworthiness of the aircraft. A pilot trained on a need-to-know basis has insufficient knowledge to exercise discretion with respect to the failure of a particular system and, accordingly, is obliged to adhere strictly to the provisions of the MEL."

The principle of strict adherence to the provisions of the MEL presupposes that those provisions are explicit and readily understandable. At the time of the Gimli accident, the provisions of the MEL were not all that clear in the all-important section dealing with fuel. The provisions of the MEL's used by British Airways and by Lufthansa very particularly specify the responsibilities of the flight crew and of maintenance personnel respectively when qualifying conditions are to be met in an abnormal situation before an aircraft can be dispatched.

There is a wider problem and that is to know just where to set the limits of the need-to-know training. In the particular context of the Gimli accident, it may well have assisted the flight crew if they had at least known that the processor had two channels and that the circuit breakers for those channels were located on the overhead panel in the cockpit.

There is a valuable discussion of the need-to-know method of training in the evidence taken at Egham, the headquarters of IFALPA. Discussing the Boeing need-to-know course, Captain Pat Farrell, a B-757 Captain and Pilot Instructor with British Airways said:

"Flight crew are only told as much about the airplane as they need to operate it. Having now experienced one of these courses, I have come to the conclusion that we are being told... enough to operate the airplane, but we are not being told enough about the airplane in order to make sensible decisions on a day-to-day basis in line operation. When things malfunction we do not have the background knowledge in which... always to make the correct decision, and we spend the first certainly two years of our time on an airplane learning how it really is put together."[162]

By way of example, Captain Farrell cited the fact that he had not been taught that there were two channels in the fuel processor. He thought that was a fault of the training, and that the need-to-know concept should be defined more broadly and should go into more depth about the airplane.

Captain Steve Last, Principal Vice-President of IFALPA and a B-757 Captain with British Airways, stated:

"I think the fundamental problem is nobody will dispute a basic statement that you only need to know what you need to know ...

The problem that we are faced with right now, and it is not by any means exclusive to Boeing or to any other individual manufacturer, is the total trend of the air transport system. I have heard exactly the same complaints about Airbus courses in the last month or so."[163]

He stated that the definition of what was needed was made by the manufacturer's engineers. They start from a basic assumption that everything they have done is totally correct, and that they have correctly forecast all failure modes. Problems arise when something which the engineer has not thought about occurs. Then, because the flight crew has only been given an absolute bare minimum of information in terms of training and in terms of in-flight information available from the instruments on the flight deck, they have no means of trying to find out what is happening. The background information made available by earlier training concepts is no longer there. It is learned during the course of normal line operations and, all too often, unfortunately, only as a result of an incident or an accident.

Captain Last gave an example of one such accident when an aircraft ran off the end of the runway at Boston in the United States and broke up. The accident occurred in 1983 and involved a Scandinavian Airlines DC-10. The airplane was travelling fast during the latter part of its approach to the runway. The flight crew was aware that it normally made a fast approach but they had no reason for concern because they had the auto throttle in. They had been taught in their training that the auto throttle would take care of the speed of approach because it was, as its name implies, automated.

What the crew, or indeed practically anyone else, did not know until this accident was that the auto throttle had not been designed to cope with wind-sheer. When the airplane ran into this condition the correct response would have been to back off the power. However, the longitudinal accelerometer in the auto throttle, which knew nothing about wind-sheer, was advancing the power the whole time. When the airplane touched down, it was going much too fast and the accident took place.

Captain Last continued:

"The guys who designed the system had never contemplated flying the airplane under those circumstances, which are in fact not that uncommon. So that is, say, an example of need-to-know being so closely defined that it does not in fact cope with the real world. It copes with the theoretical world that the person who envisaged it had in mind but that, unfortunately, is not what reality is."[164]

At the present time pilots learn by their operating experience and, if something goes wrong, information is distributed worldwide and they also learn that way. In the words of Captain Last:

"In general, the only way you get the information that should be passed on is by having an incident. That is the fundamental difference in philosophy. Now in order to get information distributed of this kind, it is necessary to have an incident and to hazard an airplane first of all. Previously the pattern was that more information was provided in advance so the incident did not occur. That really is about what it boils down to."[165]

Captain Pat Farrell, a 757 Captain with British Airways, stated:

"Now I am not trying to argue that pilots should have to pass an engineer's-type examination. There is obviously a level which is correct, and if the old level was too severe—we do not need to know how screw jacks work; we do at least need to know how many there are and what would happen if one did not work. That sort of level of information."[166]

It became increasingly clear from the evidence, particularly that taken at the IFALPA headquarters at Egham, that the problem with the need-to-know concept of training is that it involves more than just defining what the personnel concerned need to know in order to do their work confidently, efficiently and safely. Another important dimension is the economic factor.

Captain Last put it this way:

"You asked what the answer is, and I am afraid the answer is a rather unpalatable one to an awful lot of the industry. This situation is generated by one thing and one thing alone, and that is money. The fact of the matter is that the major manufacturers have no interest in being in the business of building airplanes other than to make money: the more they can sell the better off they are. And the easier they can sell them to operators, the better off they are. The operators are in the business of reducing their costs to the maximum possible extent. Training is a cost which does not show up as having any positive benefit on the balance sheets. It does not produce revenue unless you can sell your training to someone else, and you will sell it to someone else if you can sell a five-day course instead of an eight-day course.

So the whole thing is loaded in the direction of minimizing costs, which means minimizing information, minimizing time, et cetera, et cetera, and there is nobody on that side of the industry, either on the operators' side or the manufacturing side who is going to gain any direct benefit out of rectifying the situation. So whoever you are talking to, whether it be a management pilot or a manufacturer's pilot or whatever, his main concern, regardless of what he actually believes deep down—and a lot of them are saying informally that they do not agree with what is happening—but they are not in a position to do anything about it.

The only way, in my view, that you are going to do anything to rectify the situation is by involving your line pilots. And the line pilots have no real interest in artificially inflating training courses beyond that which is justified."[167]

Captain Farrell picked up the same theme in the following words:

"As Captain Last mentioned yesterday, there is an economic penalty for longer courses. And with deregulation in the States I am certain that the same emphasis is made on operators to reduce training costs, and this economy of operation is extending throughout the world. It is affecting British airlines as well, and any training manager that can show he can do a conversion course in 15 days instead of 22 days is on to a winner as far as his company is concerned, if there are no obvious safety implications."[168]

Captain Last, in his evidence, reiterated that the only answer was to allow the line pilots, through their pilots' associations, to participate more in the design and philosophy of training courses.

Captain Last also pointed to the fact that with the older aircraft and the older kind of pilot training, if something went wrong with the aircraft, the margin of safety did not drop drastically.

On the other hand, with modern complex airplanes ninety-nine per cent of the time there are no problems, but when problems do occur, the drop in the over-all level of safety that is experienced is much more severe. He continued:

> "The designs are being pushed closer and closer to the limits in many cases because they want to squeeze the last ounce of performance, weight payload, et cetera, out of it. The knowledge given to the crews to deal with the edges of the envelope is that much less... either it is all going fine and stays going fine for weeks on end and suddenly it all falls totally apart... the adjustment that has to be made from everything being wonderful to everything being absolutely terrible is much more severe than when the thing was, you know, a bit ropey all the time and it got a bit ropier, but you could handle it.
>
> And we have also—in order to achieve that, we have removed a crew member out of the whole system on the basis that none of the things around the edges would ever go wrong. But they do still go wrong.
>
> So we have increased the steepness if you like, of the gradient of problems that we encounter when things do go adrift."[169]

Captain Farrell pointed out that Air France is one of the companies which has recognized the problem with pilot training. In recent years they have come to an agreement with the pilots' union:

> "... that when a new pilot has been on the airplane for something like one month or two months, he goes back into the classroom and does an additional course which takes him into some of the technical background which is lacking in the modern need-to-know course."[170]

Pacific Western Airlines have their own course in addition to the Boeing course for flight crews. During the course they pay particular attention to the MEL. They also test the flight crews by having them deal with a snag and find the appropriate section of the MEL which covers it. They have recurrent training on the 737 every three or four months. Similarly, they had recurrent exams and recurrent training on the 767.[171]

It seems clear that with increasing deregulation in Canada and the possible sale of Air Canada to the private sector, there will be increasing competition in the airline industry in Canada in the struggle for profits and, indeed, for survival. It is all the more important, therefore, to ensure that no aspect of safety is sacrificed to the balance sheet.

ii) *Training of Maintenance Personnel*

Captain Farrell also brought up the fact that the need-to-know philosophy has had a detrimental effect on the training of line maintenance engineers. These are the equivalent in England of what are called maintenance technicians in Canada. In his words:

> "Now it worries me that not only are the pilots not being told, but the ground engineers are being told: 'Just interrogate the BITE; it will tell you which piece of equipment to pull and slot in a new one. You do not need to know how the system works'."[172]

In Captain Farrell's opinion, regulatory authorities, starting with the Federal Aviation Administration in the United States, are lowering their standards for certification through lack of knowledge and competence. He continued:

> "They are satisfied that when the manufacturer says, 'This is all the pilot needs to know', they are being convinced that this is reasonable. Now if you can convince the FAA of something, you convince the rest of the world, because of the exchange agreements made between various certificating authorities... if the FAA are prepared to accept that this need-to-know course is all the pilots need to know then the rest of the world accepts it.

And it seems to me, having experienced it, that it is going too far. The pilots are being told too little, perhaps even engineers are being told too little about the aircraft on which they are working."[173]

Referring to the Dispatch Deviations Manual, the British Airways' equivalent of the Minimum Equipment List, and referring to the introduction of a new aircraft into the fleet, Captain Farrell stated:

"With the need-to-know concept of pilot training, pilots have very little to go on; they have to rely on that manual. The engineers, as I pointed out earlier, also have initially very little technical knowledge on which to base their decisions.

Mr. Beauchamp: You are referring to the ground mechanics engineer in that context?

Captain Farrell: Ground mechanics, yes... there is also a problem of really understanding what is meant by the wording, because it is a new airplane, because the equipment is new, and so on."[174]

When Captain Simpson was asked whether one of the problems giving rise to the Gimli accident was an omission in alloting the manual calculation of the fuel weight conversion, he replied that there were procedures in place, including the MEL and conversion charts. He continued that in retrospect:

"... we realize that a more extensive training to both our flight crew and our maintenance crew might have prevented an event."[175]

Mr. Bourbeau, who had been employed with Air Canada for fourteen years as a maintenance technician, was an engine mechanic in the Royal Canadian Air Force for fifteen years prior to that date. In 1976, he became a Certified Aircraft Technician, Category 1 (CAT-1). He took the course on the Boeing 767, which he referred to as an eight-week course, as did Mr. Yaremko,[176] and received the endorsement in April 1983. He was trained mainly on the mechanical aspect of the aircraft, with a bit of training on the avionics aspect, enough to give him some insight into that aspect of the operation of the aircraft.[177] He stated that he was required to do refresher courses from time to time, but not as often as he sometimes wished.[178] Apart from that, he kept up to date with respect to changes in the maintenance of the aircraft by reading the service bulletins posted up from time to time.

Mr. Taylor, Supervisor of Component Analysis with the Aviation Safety Bureau of Transport Canada, worked in the Aircraft Analysis section involved in the investigation of mechanical problems. His early career was in the Royal Canadian Air Force from 1949 until 1981. He became an Engineering Officer and was responsible for the development of the Canadian Forces training standards for aircraft mechanical trades. In 1981, he joined Transport Canada. As a result of his investigations into the Gimli accident, he had some comments and a recommendation concerning the training of avionics technicians. Although the maintenance personnel assigned to work on the 767 had, in all cases, a background of training and experience on other aircraft, the main difference with the introduction of the 767 was the avionics systems. The ground maintenance personnel had to study what was, for most of them, a completely new area.

Mr. Taylor was quite impressed with the training package designed to train such personnel on the new generation of aircraft, but he was concerned that there seemed to be a very large quantity of material to be absorbed in a span of some nine weeks. It seemed to him that, dealing with equipment which is quite different from what they would have dealt with on other aircraft, a lot of the technicians would have difficulty assimilating that much new knowledge.[179] Mr. Taylor's concern was that there was a lack of follow-up on the graduates after they had completed the nine-week course during which they dealt with a considerable amount of significant and new information. Drawing on his experience in the Air Force, he recommended that Air Canada should investigate the feasibility of a validation process similar to the one in use by the military. He described such a process as essentially a follow-up of graduates done in a variety of ways, such as personal interviews with the graduates and with their supervisors, or even simply a questionnaire. In any event, the process involves an attempt to trace the performance of the graduates after graduation.[180]

It is worth noting that Pacific Western Airlines' mechanics receive Boeing training on Boeing aircraft initially, and are subject to recurrent training at regular intervals by P.W.A.[181]

Mr. Stewart was the Superintendent of the Investigation Audit Section of the Aviation Safety Bureau. His section was responsible for reviewing accident investigations by their regional offices.[182] He joined the Canadian Air Force in 1961 and trained as a pilot in 1971. He retired from the Air Force in 1982 and joined the Aviation Safety Bureau of Transport Canada in that year. He had had 24 years experience in aviation with 15 of those years as a pilot. During his last three years with the Canadian Air Force, he was employed in the directorate of Flight Safety in Ottawa, involved in the investigation of accidents. He was Chairman of the Operations Group investigating the accident in Gimli. The final report of his group was filed as Exhibit 122. That report contains recommendations in paragraph 4 at page 14. Among those recommendations are the following:

"1. Flight crews should be made more familiar with the implications of each MEL entry.

4. Air Canada training procedures should be reviewed to ensure that maintenance and flight crews have sufficient knowledge to completely understand the aircraft systems."

Mr. Stewart's recommendations were based in part on the finding that neither the flight crew nor maintenance personnel had the technical knowledge to realize that the lack of fuel quantity indications meant that the fuel processor was not working properly. In his view, had they known that, they would not have proceeded.[183]

His recommendation number 1 above was based on his investigations and, in particular, on an interview with Captain Walker. They spent some time discussing the philosophy of training and the extent to which a pilot should know about the black boxes, by which he meant systems such as the fuel processor. He felt that a starting point to improve the pilots' knowledge of the systems would be to use the MEL as a guide to training and to go into each MEL item in a little more detail. He found no indication that either the flight crew or maintenance personnel realized that the lack of fuel quantity indications was indicative of a more serious fault than one channel of the fuel processor being unserviceable.[184]

It is clear from the evidence that there is a problem with the implementation of the need-to-know philosophy of training. Whilst no one can quarrel with the concept, the application of the concept has resulted in both flight crews and maintenance personnel being taught less than they need to know about the new generation of aircraft. The Gimli accident itself illustrates the fact that there was a lack of knowledge on the part of flight crew and maintenance personnel alike which had serious consequences. The consequences could have been disastrous had it not been for the flying ability of Captain Pearson with valuable assistance from First Officer Quintal. Ironically, the avoidance of disaster was, to a considerable extent, due to Captain Pearson's knowledge of gliding. He applied such knowledge to the successful flying and landing of one of the most sophisticated commercial aircraft yet built.

In light of the evidence, it would seem unrealistic to expect the manufacturers to initiate a revision and possible extension of the training courses designed for the introduction of each new type of aircraft. It may also be unrealistic to expect commercial carriers to take the initiative, particularly with the move towards progressive deregulation and presumably fiercer competition. That, therefore, leaves Transport Canada, the regulatory authority.

In spite of what was said above about the rest of the world following the lead of the FAA, it is to be hoped that Transport Canada will recognize the need for an urgent review of the training of both flight crew and on-line maintenance personnel on the new generation of aircraft. They would also be well advised to involve line pilots, through their professional association, in such a review.

iii) *Training of Flight Attendants*

Mr. Stewart prepared a report entitled "Evacuation Group Report", marked as Exhibit 128, in which he made a number of recommendations relating to flight attendants. In his analysis of the evacuation of the aircraft, at page 3 of the report, he concluded in part:

> "The success of the evacuation was attributable to the low number of passengers on board and the absence of post-accident fire. Had there been a full load or had a fire developed following touchdown, it is possible a tragedy may have occurred."

He also stated:

> "A further consideration is that their lack of understanding of the aircraft's capability to glide, and perhaps land, raised the anxiety level of the cabin crew."

He concluded:

> "Although the evacuation was successful and the cabin crew reacted calmly to the emergency, there is evidence that Air Canada's evacuation procedures and training may not be adequate to deal with a 'worse' case evacuation."

On the basis of his findings, he made the following recommendations, among others:

> "2. Flight attendants should have sufficient knowledge of the aircraft to understand why emergency equipment should be used instead of normal aircraft systems.
>
> 3. Flight attendants should be exposed to and operate aircraft emergency equipment on the aircraft on which they are employed, so they will not be surprised or confused by the appearance of the equipment.
>
> 7. The feasibility of providing flight attendants with a threshold of knowledge which would allow them to understand the implications of major in-flight emergencies be evaluated."

In his evidence, Mr. Stewart referred to the fact that the flight attendants on the aircraft which made the emergency landing at Gimli, had previously been trained on the Boeing 747. The only training they had had for the 767 was by way of a film. It was his opinion that cabin crew employed on various aircraft types should be trained on each type.[185]

In short, therefore, whilst he regarded the performance of the flight attendants in that particular case as commendable, he found fault with their training. He pointed out that at least two flight attendants were not familiar with the fact that an aircraft could glide and were under the impression they were about to crash.[186] This impression was reinforced by what the in-charge flight attendant said to them after he had talked to the flight crew. He told them that they were going down. The initial impression was due to a lack of training, the further impression was due to inadequate communication.

5. Fuelling Procedures and the Wrong Conversion Factor

In terms of fuelling procedures for the 767, the evidence indicates the following:

i) there was a lack of training of the Air Canada personnel concerned as to how to compute the fuel load in an abnormal situation;

ii) there was no cross-check or double check built into normal fuelling procedures;

iii) there was no cross-check or double check built into abnormal fuelling procedures;

iv) there was no clear delineation of responsibility between flight crew and maintenance personnel;

v) there were no Air Canada ground personnel specifically trained for fuelling;

vi) there was no fuel log; and

vii) there was no second officer or oiler who was responsible for the fuel.

However, the most significant weakness in the fuelling procedures was the use of the wrong conversion factor in determining the fuel load of the metric 767 aircraft. It was wrong because it was called specific gravity when, in fact, it was not specific gravity. It was also the wrong factor because the number provided did not convert the volume of fuel to the correct weight measure, namely kilograms, used by the 767. It was and still is the correct factor for converting fuel volume in litres to fuel weight in pounds for all the non-metric aircraft which burn fuel in pounds. But it is still wrong to call it specific gravity.

The fuelling companies, Consolidated Aviation Fuelling and Services Ltd., and Shell Canada Ltd. must, in addition to Air Canada, bear responsibility for the use of the incorrect conversion factor.

The figure given by the fuelling companies was the same for all aircraft in the Air Canada fleet. What was not recognized was that not all aircraft used the same system of measurement. Some were metric and some were not. The figure given was a mixture of metric and Imperial. The figure given was the one for determining the weight of a given number of litres of fuel in pounds. It was typically around 1.77 meaning that one litre of fuel weighed 1.77 lbs.

Although this figure was called specific gravity, it was not. It was rather specific weight. Specific gravity is defined as the ratio of the density of any substance to the density of some other substance taken as a standard, water being the standard for liquids. It would necessarily have to be a number less than 1.

No witness was able to explain how the misuse of the term specific gravity originated and came to be so widely accepted in the aviation industry. Mr. John Muirhead, Maintenance Manager and Engineer, Consolidated Aviation Fuelling and Services of Toronto Ltd., even went so far as to testify that there was no such thing as specific gravity in the metric system.[187]

Both Mr. Douglas Selby, Resident Manager for CAFAS, Edmonton International Airport, and Mr. James Ferguson, Aviation Plant Superintendent for Shell Canada Ltd., Ottawa International Airport, testified that Air Canada requested that its crews be provided with the specific gravity figure. Mr. Ferguson pointed out that Air Canada never asked Shell to provide the weight in kilograms per litre.[188]

However, this does not absolve the fuelling companies from responsibility for the use and the perpetuation of the wrong conversion factor.

When Captain Pearson and First Officer Quintal requested the specific gravity of fuel for the day in Montreal and again in Ottawa they were given figures of 1.77 and 1.78 with no further qualification or description. If they had been given the correct specific gravity as defined in the Air Canada manuals, namely, a figure of about .8, they would have undoubtedly realized that they had insufficient fuel and that more fuel had to be boarded.

However, it is doubtful that many of the fuellers even knew that the 767's were metric and boarded fuel in kilograms. Mr. David Parsons, a fueller for Shell Canada in Ottawa, testified that he was unaware the 767 boarded fuel in kilograms.[189]

This is yet another indication of inadequate communication.

6. Inadequate Communication at the Corporate Level

One of the contributory causes of the Gimli accident which I have classified as both a human factor and a corporate deficiency is inadequate communication. It existed at both levels.

The evidence heard by the Inquiry not only revealed problems of communication between individuals who were on-line employees of Air Canada, as discussed above in the section on human factors and errors, but also revealed problems in communication which reached into the highest levels of Air Canada's corporate structure.

The evidence indicated a company which is too compartmentalized and somewhat bureaucratic in structure. This has seriously stifled effective communication. The persons from the management of the corporation who testified before me were highly qualified and dedicated individuals. However, the corporate structure within which they function creates too many hurdles which have to be overcome before a decision can finally be taken.

The evidence indicated a gulf in communication between the Maintenance and Flight Operations departments. This was particularly prevalent in the introductory phases of the Boeing 767. This deficiency applies to the training of both on-line pilots and maintenance personnel. It also applies to the preparation of the MEL. In addition, it appears that the changeover from a three-man crew to a two-man crew in the Boeing 767 cockpit was coupled with the failure within Air Canada to communicate what steps should be taken to fill the gap left by the departure of the second officer. The second officer would normally be responsible for ensuring that the aircraft had sufficient fuel.

There appears not only to be a problem in communication between the departments at the upper levels of the corporate structure but also a problem in communication between those upper levels of the corporate structure and the on-line pilots and maintenance personnel. This problem of communication was evident in some of the manuals which were tendered as exhibits at the Inquiry and particularly in the MEL. It was also evident in the failure by management to disseminate historical data with respect to the snags on aircraft 604 to the on-line maintenance personnel. There was virtually no communication about the previous incidents or problems with the fuel processor to those persons who would have benefited the most from that knowledge. Neither the on-line pilots nor the on-line maintenance personnel were made aware of the previous problems with the fuel processor.

There was also a lack of communication at the corporate level in making individual employees aware of their various duties. I have already discussed one aspect of the question above, under the heading "Training Programmes".

An associated problem with inadequate communication which became apparent at the hearings was difficulty among the employees working on the ramp in determining precisely what were their respective duties. Nor were other employees, such as the pilots, always aware of the duties of those employees.

Examples of these problems in communication are dealt with under the following headings:

i) Unclear Manuals;
ii) Preparation of the Boeing 767 MEL;
iii) Comments on the Boeing 767 MEL;
iv) Tracking and Communication of Historical Data on Snags;
v) Ramp Offices; and
vi) Morning Meetings.

i) *Unclear Manuals*

The testimony of some of the management engineers gives rise to concern about some of the manuals produced by Air Canada. Their evidence reveals both that the manuals are unclear and that they themselves have a basic lack of understanding of their own manuals and of the procedures set out in them.

Mr. Haigh, in discussing the Maintenance Manual and, in particular, the MEDP which forms part of it, testified that he did not agree that the Maintenance Manual specifically assigns certain tasks to maintenance. He said that the Maintenance Manual "sets out a menu of jobs or tasks that may be performed by Maintenance" but that it does not set up the organizational responsibility.[190]

If the Maintenance Manual, which is used exclusively by maintenance personnel, does not indicate what tasks are to be performed by maintenance then the question arises as to who is supposed to perform these tasks. Surely not someone who does not have access to the Maintenance Manual. It seems obvious that if a function is included in a Maintenance Manual then it should be performed by maintenance personnel. If this is not the case, then the function should be taken out of the Maintenance Manual.

The evidence of the Air Canada management engineers who were responsible for the preparation of the manuals for the 767 also demonstrated confusion over the meaning of the designations (M) and (O) found in the Minimum Equipment List developed for the aircraft.

Thus, Mr. Helm testified that the letter (M) in the Master MEL of the FAA indicated that satisfying the qualifying conditions beside it was the responsibility of maintenance personnel. Similarly, the letter (O) indicated that it was the responsibility of the flight crew to do whatever was necessary to meet the qualifying conditions set out beside that letter. However, when he came to deal with the meaning of the (M) and the (O) in the Air Canada customized MEL, he indicated that the letter (M) meant that the qualifying conditions could be accomplished by other than maintenance personnel.[191] Throughout the questioning of Mr. Helm as to the meaning of the letter (M) in the 767 MEL, he would not answer directly whether or not the letter indicated who was to perform the procedures set out following that letter. Nor would he say whether the letter (O) indicated who was to perform the procedures set out following it.

It should be noted that, in the definition section of the preamble to the MEL, in paragraph 3(e), the following explanation of the letter (M) is given:

> "A letter (M) will precede the qualifying conditions when "Minimum Equipment Deactivation Procedures" (MEDP) exist. The MEDP provides Maintenance with instructions for preparing the airplane for operation with inoperative equipment. Log Book entry information is also included. These procedures are contained in the Maintenance Manual Chapter 3-7-1 immediately following the MEL (Chapter 3-7-0)."

It goes on to provide with respect to the letter (O):

"A letter (O) will precede the qualifying conditions when Flight Crew Procedures exist (in addition to the ones normally available to the flight crew and flight attendants) for operation of the airplane with inoperative equipment. These procedures are contained in a section called MEL Procedures immediately following the MEL in the Operating Manual."[192]

For some unknown reason the Air Canada management engineers who were responsible for the manuals, including Messrs. Haigh, Helm and Stovel, were all reluctant to admit that the letter (M) meant that maintenance personnel had to perform certain specified functions or that the letter (O) meant that flight crew had to perform certain specified functions as indicated in the definitions of these letters.

At one point in his evidence, Mr. Helm went so far as to suggest that flight crew responsibilities might even be included in the provisions of the MEDP. When asked how flight crew would know about such responsibilities, he stated that reference to them would be in the Operating Manual. He went on to admit, however, that no such responsibilities were in the Operating Manual for the 767. Nor could he give any examples of where the content of the MEDP would be included in the Operating Manuals of other aircraft.[193]

Mr. Stovel, who had been responsible for the Boeing 767 Aircraft Operating Manual since the introduction of the aircraft into the Air Canada fleet, also testified that the letters (M) and (O) did not assign the particular tasks in the qualifying conditions. He said that the letters were simply representative of additional functions.

"Q. So the (M) and the (O) don't assign the particular task we find in the qualifying conditions?

A. No.

Q. They're just representative of additional functions?

A. That's correct."[194]

It is clear from the definitions of the two letters that there may well be additional functions in any given case. These will be contained, if required, in the Maintenance Manual, in the case of maintenance procedures, or in the Operating Manual, in the case of flight crew procedures. What Mr. Stovel would not admit, however, was that the letters specifically assigned the tasks to one or other of the two categories of personnel.

When asked about other aircraft in the Air Canada fleet, Mr. Stovel said that the letters (M) and (O) as found in the MEL's did in fact indicate an assignment of the task. In the same cross-examination he testified:

"Q. So in all the MEL's, where we see the (M) and the (O), in all the other aircraft, you're suggesting that is not an assignment of the task?

A. Certainly it is. The (M) and the (O) at the beginning of the item says that in addition to what you're going to read in the MEL, you have to look elsewhere to find a specific task that is addressed to either ground personnel or flight personnel. But I maintain that they are in addition."

To make matters worse, when again referring to the 767, Mr. Stovel testified:

"Q. All right, but how do we know then — they are in addition; the (M) and the (O) mean they're additional procedures. How would we know which tasks are — of all of these tasks in the MEL, how do we know who's to do them?

A. We don't."[195]

Thus the person responsible for the preparation of the 767 Operating Manual could not say who was to perform which tasks. He stated categorically that the letters (M) and (O) did not assign the tasks set out beside them to any particular group of employees. The question therefore arises as to the purpose of using the letters (M) and (O) and what they mean.

All these answers must, of course, be taken in the context of the position taken by Air Canada and the admission by its counsel that there had been a failure on the part of Air Canada to assign responsibility for calculating the fuel load on the 767.

When Mr. Stovel was asked whether he thought it would be an idea to specify in the MEL who was to do a particular function, he testified:

"That would be another way of doing it, yes. It could be done that way."[196]

It would seem that this is the only way to deal with the special procedures which are set out in the MEL. Indeed it is imperative that such procedures be specifically and clearly assigned in the MEL to those groups of personnel which are required to carry them out.

If these procedures are not specifically assigned then there may well be other incidents, or accidents, resulting from some person or group failing to perform necessary tasks prior to the dispatch of an aircraft when following abnormal procedures.

In fairness to Air Canada, it should be pointed out that one senior executive, Mr. Morawski, did testify that the letter (M) indicated a maintenance function. He also testified that he believed that the letter (M) indicated that maintenance personnel should also consult the MEDP. When questioned about the MEDP and what it meant he said that he could not explain the "entry" instruction to maintenance in the MEDP at page 73, paragraph 7, which stated:

"Placard affected fuel quantity indication FUEL IN TANK (____lbs)."

The reason why he could not explain paragraph 7 and its reference to weight was that to him fuel quantity meant volume not weight.[197]

In any case, the fuel gauges of the 767 read in kilograms not pounds. The reference to "lbs" in Exhibit 43, paragraph 7 is one example of a general problem with the manuals. Apart from other similar errors in them, they are remarkable for a general looseness of terminology in an industry which, by its very nature, demands precision.

Mr. Ferguson of Shell Canada Ltd., testified that the 81 Manual was confusing. This is the Air Canada Fuelling Manual used by fuellers. Mr. Ferguson testified that in some cases what was then referred to as specific gravity was given as .8 and in other cases as 8.0. He said that the same terminology was used for different figures.[198]

Mr. Ferguson testified that to update this manual he was supposed to receive the inserts himself so that he could scrutinize them and know what was going on. However, he complained that he was not receiving the inserts or transmittals, as they are called, and that one of the Air Canada people was inserting them in the Fuelling Manual for him. This had the unfortunate effect of leaving the fuellers in the position of not really knowing what the contents of the manual were.[199]

An additional problem of communication was that some of the Air Canada manuals said one thing whereas the relevant Air Canada form said another. For example, the 81 Manual described the specific gravity as .8 and the 500 Manual described, in chapter 10, p. 20.1, the specific gravity as typically a number like .76 for Jet B or .80 for Jet A fuel. However, at the time of the Gimli accident, specific gravity was invariably given as a number around 1.77 on the tender uplift sheet form 276, marked as Exhibits 8 and 92.

There was, therefore, a serious problem in written communication in the wording of the parts of some of the manuals.

ii) *Preparation of the Boeing 767 MEL*

The evidence indicates a serious lack of communication between Engineering and Flight Operations in the preparation of the MEL for the Boeing 767. Mr. Stovel was assigned the task of preparing the MEL but it appears that he had virtually no communication about it with that part of the corporate structure responsible for the operation of the aircraft on a day to day basis namely, Flight Operations. Captain Miners, Director of Flight Technical, testified that there was nobody specifically assigned from Flight Operations to help Mr. Stovel customize the MEL for the 767. This applied to the MEL in general and to abnormal fuelling procedures in particular.[200]

Captain Miners said that he was not aware of anybody in Flight Operations who specifically participated in the customization of the MEL items relating to the fuel gauges and the fuel processor. References to these items would almost certainly be taken verbatim from the FAA MMEL.[201]

Unfortunately, this gap in communication during the process of customizing the MEL resulted in conflicting views as to the involvement of the flight crew in fuelling in an abnormal situation.

Mr. Stovel, representing Engineering and in particular that Branch of Engineering responsible for the preparation of the MEL, came to the following conclusion, set out in his memorandum:

> "I expected the crew to be intimately involved in the refueling procedure (as they are on the DC-9) and arranged to have the Measuring Stick Tables installed as part of the On-Board Library so that the tables would be readily available to them as well as to Maintenance personnel."[202]

The memorandum is, of course, dated after the Gimli accident.

On the other hand Captain Walker, Captain Coneen, Captain Simpson and Captain Miners, all from the Flight Operations Division of Air Canada, came to the conclusion that the flight crew would not be involved in the computation of the fuel load. It came as a surprise to Captain Miners that Mr. Stovel believed that the flight crew would be intimately involved in fuel quantity computation in an abnormal situation.[203]

Mr. Ivor Thomas, the Fuel System expert from Boeing, testified that he was surprised to find the Drip Stick Manual in the cockpit of the aircraft when he attended the accident scene in Gimli.[204]

There was obviously a significant lack of communication which led to misunderstanding between Flight Operations and Maintenance and Engineering on the question of the involvement of the flight crew in the computation of the fuel load in an abnormal fuelling situation. This misunderstanding contributed to the Gimli accident.

iii) *Comments on the Boeing 767 MEL*

Communication by way of the 767 MEL was inadequate in the sense that, as customized for use in Air Canada, it was neither clear nor precise. It is of vital importance that the procedures specified in the MEL, and particularly those relating to dispatch of an aircraft in abnormal situations, be both clearly understandable and precise in the allocation of duties to be performed.

During the process of adapting the FAA's Master MEL to Air Canada's format revisions were made. These revisions reduced the clarity and precision of the FAA MMEL. In addition, there were and still are inconsistencies in the use of symbols in the 767 MEL of Air Canada.

It should be noted that these concerns about a lack of clarity and precision are equally applicable to the MEL for the 727 and the MEL for the DC-9, marked as Exhibits 151 and 181a) respectively. Furthermore, not only are there internal inconsistencies in the 767 MEL but there are also inconsistencies between the MEL for the 767 and the MEL for the DC-9. In the case of the DC-9 MEL there is no reference to the letters (M) and (O) which are so prevalent in the 767 MEL. There is obviously a need for a review of all the MEL's with a view to establishing standardization and consistency within them and between them.

A comparison of Air Canada's MEL with those of other carriers which operate the 767 such as Delta Air Lines, Trans World Airlines, United Air Lines and American Airlines, shows at a glance that they have MEL's which are much more clear and precise. All of these airlines have adapted the Master MEL of the FAA to their own format and in doing so have managed to produce lucid documents.[205]

Of particular concern in the Air Canada 767 MEL is the column entitled "A/C DISP MIN" and stands for "Aircraft Dispatch Minimum". This column specifies the minimum number of systems or components which are required for safe dispatch in an abnormal situation. It corresponds to the column in the Master Minimum Equipment List issued by the FAA entitled "Number required for dispatch". In the Master MEL and in the 767 MEL of each of the other airlines, the exact number of a particular component or system which is required for dispatch is set out, whether it is one (1), two (2), three (3), or zero (0). However, in Air Canada's MEL the numbers have in most cases been removed and replaced by arrows or dashes. In other cases the number has been left in. Air Canada could not explain why these changes had been made or what was the rationale behind the changes. In my view, the removal of the number which indicates how many pieces of equipment or components are required for dispatch is not only unnecessary but also confusing. It should be clearly stipulated how many units of a particular system must be operative before an aircraft can be legally dispatched.

There was even some confusion in the evidence as to what the designations (M) and (O) in the 767 MEL meant. In addition, there was the further problem that, in the case of some of the qualifying conditions set out in the MEL, there was no designation of either (M) or (O). It was and remains, therefore, in some cases difficult to determine who is to fulfil the particular qualifying conditions. There are, of course, cases in which it is obvious who should perform a particular task. Thus, when there is a restriction on the altitude at which the aircraft can be flown it is only the flight crew which can satisfy the qualifying conditions. In other cases it is evident that what has to be done must be done by ground personnel. In many cases, however, the nature of the task to be performed does not indicate who should do it. In those cases clarification and precision is required. This is a matter which calls for urgent attention.

iv) *Tracking and Communication of Historical Data on Snags*

The evidence revealed a problem in Air Canada in communicating historical information on snags, particularly intermittent snags, to on-line maintenance personnel and to flight crews. There was really no system by which on-line maintenance personnel could be easily alerted as to previous problems with respect to a particular piece of equipment on any given aircraft.

It is true that by referring to the log book and going back through its pages, it would theoretically be possible to determine whether there were earlier recorded snags in relation to the equipment. However, this procedure would be quite impractical and too time consuming in the context of the operation of a commercial airline. Furthermore, it would only be effective if the earlier pages were still there. The pages of the log book obviously cannot be allowed to accumulate indefinitely. Old pages are periodically removed.

This particular problem in communication was a factor in the Gimli accident because none of the maintenance personnel in either Edmonton on the night of July 22, 1983 or in Montreal on July 23, 1983, was aware of the previous difficulties with the fuel processor on the aircraft on July 5, 1983 in Edmonton and on July 14, 1983 in San Francisco. If they had been, it may well have assisted them in dealing with the problem of blank fuel gauges on the day of the accident, July 23, 1983. This was particularly the case in Montreal on that day. In Edmonton, during the previous night, Mr. Yaremko was able effectively to deal with the problem notwithstanding the fact that he failed to realize that he had encountered a similar problem on the same aircraft on July 5, 1983.

On July 5, 1983, when Mr. Yaremko was faced with the problem of blank fuel gauges on the aircraft, he was able to restore them to operation and dispatch the aircraft pursuant to MEL item 28-41-2.

In addition to making a note of the snag in the log book, Mr. Yaremko would have made a similar note on the job card. The information would then have been put into the computer and the down-line station informed by telex to warn those at the next destination of the problem on the aircraft. Mr. Yaremko testified that he believed that he had also telephoned Maintenance Central to inform them of the deviation so that it would be put on the flight plan.

On that day, Captain Cartmell or his first officer entered this snag as defect #269 before leaving Edmonton. The entry was answered in Toronto by maintenance personnel who did a fuel processor BITE test and found that the unit was within tolerance. The fuel processor was then reset.[206]

On July 14, 1983, the fuel gauges failed in the air when the aircraft was en route from Toronto to San Francisco. Captain Reid advised Toronto Dispatch that the fuel gauges had failed and that he was proceeding to San Francisco. Maintenance Central was advised of the problem and recommended that the fuel processor be changed. However, before a new processor could be obtained, the original processor was reseated and the gauges were restored to full operation. Reference to the problem and its rectification were entered in the Aircraft Journey Log Book.

In both of the above cases information about the problem with the fuel gauge processors would not have been readily accessible other than on the particular day. At any later date it could only have been found by checking back through the pages of the Aircraft Journey Log Book.

If the on-line maintenance personnel and flight crew had been alerted to these previous processor failures, they may have been more cautious in dealing with the blank fuel gauges caused by the defective processor on July 23, 1983.

v) *Ramp Offices*

The inspection of the Air Canada maintenance base at Dorval, which included one of the ramp offices, gave rise to concern about the communication of information by way of directives of various kinds, such as technical information telexes, transmittals, revisions and memorandums. It was noticed that it would be difficult for maintenance technicians to keep up to date with all the latest changes in procedure because the directives did not seem to be properly posted. Instead, many of them were lying around the office in no particular order. Furthermore, there were some directives which should have been destroyed by a particular date long since passed.

As Mr. Morawski testified, the Maintenance Department has the responsibility of ensuring that there is adequate communication between on-line maintenance personnel, ramp foremen and Maintenance Central. He said that on-line inspectors were employed in Toronto because of the sheer volume of work. These inspectors were to monitor and audit the maintenance systems, programmes and procedures to see that they were properly implemented.[207]

There is a need for such inspectors to audit all ramp offices to make certain that the information is being properly communicated to the on-line technicians.

vi) *Morning Meetings*

The inspection of the Air Canada Maintenance Base revealed an impressive procedure to monitor outstanding deviations in the Air Canada fleet. This procedure consists of holding morning meetings five days a week at Dorval commencing at 7:45 a.m. at which senior technical experts gather to discuss with Maintenance Control every outstanding deviation on all the aircraft in the fleet for that day at that time.

As Mr. Morawski testified, these meetings are attended by him, all his deputies, representatives from Engineering, from the Supply Branch and from Maintenance Control. They review the list of deviations such as Exhibit 93, and if a deviation has not been rectified, Maintenance Control has to explain why the deviation is still outstanding. At the same time Maintenance Control tells the meeting what plans are made for the deviation to be removed and how replacement parts are being obtained or whether parts are a problem. The meeting is also told where the work on the aircraft is going to be done. Mr. Morawski is then in a position to advise the Vice-President of his department about the above information later on in the morning.

The next review takes place routinely at 2 p.m. This review is, in effect, a system hook-up between the Manager of Maintenance Control, the General Superintendent of Line Maintenance and the District Maintenance Managers from all major stations from Halifax to Vancouver. One of the highlights of this review is the handling of deviations, and what arrangements are in place or are being put in place for the deviations to be removed at the first opportunity.[208]

The shortcoming of these meetings is that they do not take place on the weekends. The Gimli accident occurred on a Saturday. There had been no morning or afternoon meeting that day to review the outstanding deviations on the aircraft fleet and, in particular, on aircraft 604. If there had been a morning or afternoon review, such as described above, the deviation which affected the fuel gauges may well have been rectified prior to the aircraft taking off from Montreal.

Such morning and afternoon reviews should take place on Saturdays and Sundays and other holidays when Air Canada is still operating a busy or even busier schedule of flights. The people involved would not be the same people but that is no reason to abandon the procedure on weekends. Different experts could perform the same important function.

The problem of communication is not unique to Air Canada. One aid to better communication has been developed by British Airways.

Questioned on the subject of the problem of communication between flight crews and ground personnel, Captain Taylor referred to the publication put out by the British Airways Board Air Safety Review Committee in the following words:

"I think the response that I would make to that is that the Flight Safety Digest, the review, is important in being a bridge between the two disciplines as I see it and that the document is seen by the guy who gets his hands dirty in a snow storm working in terrible conditions on the ramp and the pilot. And provided that document tells it like it is, if it says that engineering, you know, the supervisor failed to carry out a check according to the work sheet and it says so without needing the name, that kind of honesty pays off. And if it says that the pilot was interviewed by his flight manager and acquainted with his responsibility to carry out a missed approach if the ground warning system tells him to do so, well then, that is good. So that both professionals can see that imperfection exists in both of them and it is treated equally as a lapse from the high standards by the organization.

I think the fact that that single document is seen by the ground engineer on the ramp and the pilot is a great aid to communication and understanding."[209]

An example of the review, the edition for July 1984, was marked as Exhibit 246-4. It lists in summary form other operators' incidents and accidents as well as those of British Airways. The type of aircraft, the operator and the date of the occurrence are included but not the names of the individuals involved. Copies of typical pages of the review relating to incidents in flight, and relating to ground handling, are included in this report as Appendix "D".

7. Spare Parts

The lack of spare parts for the Boeing 767 at Air Canada was a corporate deficiency which was a factor in the July 23 accident.

Air Canada ordered 12 Boeing 767 aircraft. At the time of the Gimli accident, it had received 4. For the entire fleet of 12 aircraft, Air Canada had decided to keep one spare processor in stock.

Mr. John Dickie, General Manager of Purchasing and Inventory for Air Canada, gave evidence that, as part of the purchase contract, Boeing was required to develop a spare parts plan in co-operation with Air Canada.[210]

In order to provide a spare parts plan, Boeing developed what they call a spare parts model. This was done by feeding statistics about the potential demand for spare parts into a computer which would then provide the required number of spare parts for each category. The critical number fed into the computer is called the reliability estimate. This is known as the MTBR which stands for the 'mean time between removal'. In simple terms, this figure represents the theoretical life expectancy of the particular part.[211]

The resulting recommendation in the case of the fuel processor was that Air Canada should purchase one spare. The recommendation was not automatically accepted by Air Canada, which made its own analysis.[212]

The independent analysis made by Air Canada indicated that one spare processor would be sufficient for their fleet of 12 aircraft. The problem is that, however good the information fed into the computer by Boeing and however valid the information used in the independent analysis made by Air Canada, the resulting figure, by the very nature of the process, could only be an estimate.

On the question of spares, Captain Jessop, Director of Safety Services with British Airways, had the following pithy comment:

"There is only one thing I will tell you about it. Whatever you do, and whatever planning you do, when you buy a new airplane and you decide on the spares, one thing you can be absolutely certain of: you are going to get it wrong."[213]

This was immediately followed by a comment by Mr. Ray Claydon, Fleet Maintenance Superintendent of British Airways:

> "Well, this is absolutely true, because any new airline going to a manufacturer to decide what level of spares they have, have only got the manufacturer's idea to go on, what they are expecting how the systems are going to behave."

An extra precaution taken by Air Canada was to make an arrangement with Pacific Western Airlines for each airline to be able to borrow spare parts from the other.[214] The agreement between the two airlines from the outset had been informal. However, by the time Mr. Dickie gave his evidence on May 3, 1984, a formal agreement had been drawn up and only required execution by the parties to make it binding.

On the basis of the Boeing recommendation and Air Canada's own analysis, one spare processor was ordered and supplied. However, Air Canada did not keep it in stock. It was sent to France on March 16, 1983 to a company called Aerospatiale in Toulouse for use in developing a computer repair programme.

There had been a history of processor replacement on the 767 aircraft in the Air Canada fleet. On February 14, 1983 the processor was removed from aircraft 602 and was replaced by the spare. The removed processor was repaired and returned to the stores department on March 2, 1983. On March 14 the processor was removed from aircraft 603 and replaced by the repaired part in stock. The removed processor was repaired and returned to the stores department on March 15, 1983.[215] It was sent to France the next day.

The first time they had a problem with an inoperative channel on aircraft 604 was on July 4, 1983. When the problem came to the attention of Mr. Joseph Acco, an engineer at the Air Canada Maintenance Base at Dorval, a few days later, he recommended that a spare processor be procured for this aircraft. At this time the spare was in France and Mr. Acco spoke to Mr. Bob Golding of Engineering about getting it back. Mr. Golding was the engineer responsible for the co-ordination of the automatic test equipment programme. Mr. Acco was subsequently told by Maintenance Central that the processor was working again.[216]

On July 14 a replacement processor was needed in San Francisco after the fuel gauges on aircraft 604 went blank en route from Toronto. On that occasion, United Air Lines loaned a processor to Air Canada. However, the original processor was repaired and the aircraft continued its flight without using the borrowed processor. It was at this time that Mr. Ron Clubb, Manager of the Rollable Repairable Section, Purchasing and Inventory, became concerned that the only spare owned by Air Canada was in France.

Mr. Clubb discussed the matter with Mr. Golding and a decision was made to recall the unit.[217] The spare was returned to Canada and arrived on July 13.[218] As it turned out, that spare itself was not working properly and it was sent to Honeywell for testing on July 18, 1983 and not returned until January 29, 1984.[219] Thus, a spare was not available for aircraft 604 when it was needed on July 22, and the best that Air Canada could do in the circumstances was to borrow one from Pacific Western Airlines, but that processor was not available until the evening of July 23 in Edmonton. It was not used because the aircraft did not reach Edmonton.

Even on the doubtful assumption that one spare processor was sufficient for a fleet of 12 aircraft or even for the 4 aircraft that Air Canada had at the time of the Gimli accident, such a spare should have been available; it should have been in Canada, not in France. That spare was itself defective and Air Canada was effectively without a spare from March 16, 1983 to January 29, 1984.

In my view, ordering only one spare in the first place was an error of judgement on the part of Air Canada. A further error of judgement was made when the only spare processor belonging to Air Canada was sent to France.

Air Canada has now improved the situation and since the Gimli accident has decided to carry two spare processors.

8. Flight Safety Organization

Another corporate deficiency was the lack of a sophisticated and well-developed safety organization within Air Canada. Captain Simpson, Vice-President of Flight Operations for Air Canada, gave evidence about the existing flight safety organization within Air Canada. In particular, he made the following comments:

> "A. If I had the vast resources of the Armed Forces, I would be delighted to build a Flight Safety Organization similar. The Canadian Armed Forces has fewer pilots than Air Canada. They have approximately 15 times as many safety officers.
>
> ... And they do have a different type of flying. They have a much higher accident rate, and they do have to concentrate on flight safety programs. The new Aviation Safety Board in Canada, which is only starting now— and which we're working very closely with Mr. Johnson on the organization, the new Inspector General— these things are only happening now in 1984 in a country where aviation has played such a dramatic part.
>
> Air Canada has supplied probably more expertise in heavy transport investigations than any other carrier in the country. I'm caught somewhere between a rock and a hard thing. I agree with what you are saying. I'd like to have a major safety organization. At the same time it has to be tempered with the resources available.
>
> Q. And so in that context then, when you were speaking this morning of a re-organization could— you expand on that a little bit, because you gave no details?
>
> A. I'd probably better not until I get the money from my boss. We are hoping to expand the organization, just with the recognition that we could do more things in safety. It's interesting that no airline in Canada has a safety organization developed to the degree that we have in Air Canada. In fact, a major audit of a major Canadian carrier recently revealed they didn't even have a safety officer—an unnamed carrier, but a major Canadian carrier."[220]

However well developed the flight safety organization in Air Canada, it was obviously inadequate in terms of resources or personnel to identify and deal with the various contributing factors that lead eventually to the Gimli accident.

What appears to be a model flight safety organization has been established by British Airways. The organization is known as the British Airways Board Air Safety Review Committee. Captain Laurie Taylor, Executive Secretary of IFALPA, described it as follows:

> "The British Airways air safety structure is unusual, perhaps, in that the Chairman and members of the Air Safety Review Committee are Board members of the airline, and the Chairman of the airline is the Chairman of that Review Committee.
>
> The other members of the Committee are Board members, plus one adviser, and the adviser is not a technical man. For British Airways' own purpose it so happens that his experience and background is security; he was in fact Chief of the Metropolitan police, Sir David McNee. The people who are entitled to attend meetings of that review committee are people from Engineering, the Chief Engineer, the Chief Pilot, the Operations Director — I may have left some out — but they may attend at their own choosing or they may be called to attend a particular session. And the Flight Safety Adviser is now I think Captain Jessop.

... He has a staff assigned to him. There are two—I do not know what the title is—they actually investigate instances of accidents and publish reports which eventually are given very wide circulation in the airline. Each pilot gets a copy of these periodic reports. They are quite frank. They will on occasion say that appropriate disciplinary action has been taken, but they do not name people, either pilots or mechanics. But the resources devoted to this are quite considerable.

The advantage of having it at Board level of course is so that people whose performance is being examined are not members of the team. If there has been a lapse of either pilotage or training or engineering the persons who are reviewing that performance are separate from the ones. It is in my opinion an unusual setup but an effective one. And of course having the Chairman of the airline as Chairman of the Committee means that the resources devoted to an examination and control of our safety are always adequate. You do not get a minor official trying to get an increased budget. You have the Chairman of the airline saying that this shall be done, and of course it is done."[221]

The composition of the British Airways Board Air Safety Review Committee is outlined in Exhibit 246-2. The permanent members consist of the Chairman and Deputy Chairman of British Airways, two members of the Board and an adviser to the Board. In attendance at their meetings are the Director of Safety Services, the Chief Air Safety Investigator and the Senior Air Safety Investigator who acts as secretary. Those persons who may either attend at their own request or that of the committee are the Director of Operations, the Director of Marketing, the Director of Engineering, the General Manager of Charters and the Chief Pilot.

Asked to state the advantages of having this particular structure, Captain Taylor continued:

"In general that the responsibility for the safety of the airline is at the very highest level of the airline and that the work of those people responsible, directly responsible for the safety, like the Director of Engineering, the Chief Pilot, et cetera, is studied by their peers and not by themselves, that is the major advantage."[222]

Captain Jessop, described his dual role as Director of Safety Services and also as a member of the Board Air Safety Review Committee in the following words:

"My role is fairly new, in the sense that I am a member of the Board, and I have executive authority as being Director of Safety Services, and I look after safety right across the airline worldwide in all aspects... obviously, that is ground safety, et cetera, as well. I will concentrate on the air safety side.

What we have in fact is an Air Safety Branch, which consists of six fully qualified air safety investigators. They are qualified and have done the accident investigation course, and they are quite experienced people. Primarily, they are qualified engineers in the past, but have concentrated on accident investigation. So, we have these six. They are broken up into looking after various types of airplanes... They investigate all incidents and accidents, everything.

... We then investigate, and we obviously have a liaison with the other departments, particularly with Engineering and with Flight Operations, and indeed with the Ground Operations, because they have a habit of damaging airplanes too. And we conduct an investigation... and then once a month we have a meeting of our Board Air Safety Review Committee...

You will see that the Chairman of that is in fact Lord King. So, it is our own Chairman who chairs that, and he has three outside board members and another adviser, Sir David McNee, and I attend, obviously, and present everything to him, with my Chief Air Safety Investigator, and another Air Safety Investigator who is the secretary, and we do require the heads of the various departments to attend on a regular basis.

For example, the meeting next week will be with the Engineering Director and the Operations Director. The following month, it will be the Chief Pilot, and thereafter, it will be people responsible for ground stations, the marketing trade.

We actually go through all the incidents we have experienced. We present them to him, and the objective really is to go through these incidents, and the whole objective, obviously, is that we should investigate everything, because until you investigate it, even though it is only a very short investigation, until you actually do an investigation, you do not know whether there is something significant behind that. The objective behind all of this is quite straightforward. It is obviously to identify trends and to prevent a recurrence, and that really is our role right throughout. We present this every month, as I say, and we present them in two ways. We present those investigations that are open. In other words, they are not yet complete; we are waiting for further information. And the other items are closed, which we are recommending, and the only people who can close an investigation is the Board Air Safety Review Committee. They are the only people that can close it. Nobody else can. We can recommend them closed, which we do. We give them a whole list, that we recommend these closed, and obviously to facilitate, we highlight those that we believe are the most important, that they should concentrate on, rather than they look through them, or talk about them. They read them all, but we highlight those that are important.

And we had and do have cases where one of the members will say, well, I do not understand why this happened, and they will refuse to close them. They want more information. So we will have to carry on until we have got the answers that they want.

Obviously, we work in very close relationship with our Department of Transport, Accident Investigation Branch, and if there is an accident, obviously under the law, either they or the state in which the accident happens will take charge of the investigation. But that does not eliminate us. We still do our own."[223]

Captain Jessop stressed that as an air safety branch they are totally independent of every other department in the airline and the procedure of reporting directly to the Board ensures their independence.[224] When asked how long the air safety system at British Airways had existed and whether it was satisfactory, Captain Jessop answered:

"It always has been like that. In other words, I think both British Airways and its predecessor companies have felt that the only way that you can actually prevent accidents is to investigate those incidents which eventually will become accidents, to ensure that you find the cause for it, and it may be a technical thing, a component; it could easily be a drill, and we have classic examples all the way through, maintenance procedure, anything where, on investigation, you discover that there are better ways of doing this and avoiding that incident in the future, and every one you avoid, you are reducing obviously, you must be reducing the possibility of a serious accident. That is the way we have approached it. Now, it is expensive, obviously, but we believe that this is the only way to go and we have always believed that.

... it is important that the decision to investigate and the decision to terminate an investigation really has to be totally independent of the people who are still responsible for the airworthiness and the procedures that go on. It has got to be totally independent."[225]

As pointed out by Mr. Beauchamp, Counsel for the Canadian Air Line Pilots Association, the flight safety organization in British Airways differs from the one in Air Canada in three fundamental respects:

1. The flight safety organization of British Airways, called Safety Services, is chaired by a pilot with line flying experience.
2. This person, the Director of Safety Services, reports directly to the Chairman of the Board Air Safety Review Committee who is also the Chairman of the Board of British Airways. In this way, matters affecting flight safety go right to the top of the company where such direct action as is necessary can be initiated.
3. The Safety Services organization is a completely independent body within the airline. Its only concern is corporate air safety and the prevention of accidents.

Human nature being what it is, accidents will never be completely eliminated from the aircraft industry or from any other field of human endeavor. Having said that, however, it is probably fair to say that the Gimli accident and the often bizarre circumstances which led up to it might well not have happened if a flight safety organization such as the one outlined above had existed within Air Canada.

9. Certification

The certification process of the 767 by the Airworthiness Branch of Transport Canada suffers from the same drawback which affects all national airworthiness authorities. They follow the lead of the Federal Aviation Administration in the United States and to a large extent depend on the manufacturer for much of the technical expertise. The evidence indicates that much of the Canadian certification process involves visits by the airworthiness personnel of Transport Canada to the manufacturer in Seattle, Washington, U.S.A. As Dr. Gerald Marsters, Director of Airworthiness at Transport Canada, testified, it is a familiarization process.[226]

The Canadian airworthiness authority, however, does on occasion have additional requirements for the certification of an aircraft. These are often based on accident history.[227]

The problem with certification was referred to by Captain Taylor.[228] He regarded it as a major deficiency in the present certification of airplanes by national airworthiness authorities. He expressed the view that such authorities are not competent to argue with the manufacturer. They usually take the Federal Airworthiness Regulations made by the regulatory body in the United States, the FAA, and apply them in their own national code. Captain Taylor stated that the FAA itself has been critized, even in the United States, for the fact that it very often does not use its own test pilots to certificate an airplane built on the west coast of the U.S.A., but rather delegates this authority and responsibility to the manufacturers' test pilots. He considered that a major deficiency.

This is a matter which requires the attention of Transport Canada.

D. Equipment Failures and Deficiencies

Foreword

At the outset of this discussion of equipment problems it should be emphasized that all the operators of the Boeing 767 whose evidence we took endorsed the 767 as a superb aircraft. They described it as a state of the art aircraft. There was no evidence that the two-man crew instead of a three-man crew was a threat to the safe operation of the aircraft although the issue was a matter of some controversy early on in the history of the 767.

The evidence was consistent in confirming that during the introductory phase of any new aircraft there is usually a high incidence of snags. In this regard the 767 was no exception. Of all the equipment problems the most significant was the one with the fuel processor.

Most of the carriers who operate the 767 and the 757, whose evidence the Inquiry heard, had all experienced problems with the Fuel Quantity Indication System. This is still a matter of some concern because, although Honeywell Inc. has taken steps to improve the fuel processor, the two newest aircraft in Air Canada's fleet have recently had problems with this system.

The two new 767's, aircraft 611 and 612, have had problems involving blank fuel gauges and hard faults with the fuel processor which governs the fuel gauges. Inquiry counsel received confirmation of this information from Air Canada as recently as March 1, 1985.[229] These problems have apparently been corrected.

There would have been no accident on July 23, 1983 at Gimli had the fuel processor on aircraft 604 not malfunctioned. The human errors would never have occurred had the fuel processor which operates the fuel gauges been functioning properly. Nor would the shortcomings of Air Canada, Transport Canada and the fuelling companies have been exposed.

This equipment breakdown was, in effect, the catalyst for all the other contributory causes of the accident both human and corporate. It was the equipment failure that called into play the safety nets which eventually broke down as described by counsel for Air Canada.

1. The Digital Fuel Gauge Processor

The processor, sometimes referred to in the evidence as the fuel processor or the fuel quantity processor, was mentioned in Part II of this report in reference to the discovery of blank fuel gauges in the cockpit of the aircraft on a routine service check on July 22, 1983. The fuel gauges are operated by this processor which is located immediately behind the cockpit underneath the floor of the cabin. The processor is one of many instruments stored vertically on shelves, in what is called the main electrical/electronics equipment centre. Schedule 1 of Appendix "B" contains a diagram of this equipment centre.

The processor has been described as the heart of the Fuel Quantity Indication System (FQIS) on the Boeing 767. It was built by Honeywell according to Boeing specifications. Schedule 2 of Appendix "B" contains a view of the front panel of the processor. The processor was taken out of the aircraft after the landing at Gimli and taken to Honeywell in Minneapolis for testing. Ms. Diane Rocheleau, a Mechanical Failure Analyst with the Aviation Safety Bureau of Transport Canada in

Ottawa, reported on the examination and testing of the unit. The FQIS and the function of the processor are thus described in paragraph 2.2 of her report:

"The FQIS is a digital, dual-channel system providing fuel quantity measurement, calculation, and indication. It consists of fuel tank units, compensators, densitometers, indicators, and a fuel quantity processor. The processor performs fuel quantity computation and fault isolation for the FQIS, controls the aircraft pressure fuelling and provides outputs to:

(a) the engine — indicating crew-alerting system (EICAS) for maintenance (sic);

(b) overhead display integrated indicator module for left and right main tanks, auxiliary tank and total fuel indications;

(c) the flight management computer (FMC) for calculated FQIS total fuel quantity;

(d) the load select fuel indicator at the wing fuelling station;

(e) the fuelling valve relays for automatic shut off;

(f) the 'LOW FUEL', 'FUEL CONFIG', signals for EICAS messages and 'FUEL CONFIG' light on the overhead display."[230]

It should be noted that the acronym EICAS referred to in paragraph 2.2a) of the above quotation from Ms. Rocheleau's report stands for Engine Indication and Crew Alerting System. She refers to it as being a system "for maintenance". It does in fact display information for use on the ground by maintenance personnel. It is also, as its title implies, a crew alerting system. It reduces crew workload by automatically monitoring engine performance and it alerts the crew to developing problems relating to the engines.

As pointed out in the submission on behalf of Air Canada, there were, at the outset, great expectations for the fuel processor. This is reflected in the following statement, an extract from a commentary on a Honeywell video presentation covering the FQIS:

"The processor unit computes fuel weight, controls fuelling valves during fuelling operations and performs a continuous built-in test and fault isolation of system components. The processor contains two redundant channels with the capability of switching to the opposite channel should the currently selected channel fail."[231]

Similarly, in a Boeing video presentation made by Mr. Thomas, a Computer Research Specialist in Propulsion Technology with Boeing and a Fuel System expert, it was said:

"The microprocessor has extensive fault detection, fault isolation, and built-in test capabilities for rapid system troubleshooting... The FQIS BITE is a valuable tool for troubleshooting the fuel quantity indicating system. BITE is a state-of-the-art system designed to reduce maintenance, time and expenses."[232]

The acronym BITE in the above quotation stands for Built-in Test Equipment.

Thus, the two main features of the processor were said to be firstly, the fact that it contained two channels, so that if one failed, the other could take over and continue to supply fuel quantity figures on the gauges in the cockpit; secondly, its ability to test itself and recognize faults within the system it operated.

The need for a reliable instrument which could assist both flight crew and ground crew and which would itself continue to operate in the event of a failure within its own mechanism was expressed by Mr. Gordon Handberg, Honeywell Program Manager for the Boeing 757 and 767 FQIS Program:

"For this airplane Boeing required a system with a high degree of failure monitoring capacity. I believe that their desire for that failure monitoring capacity in a built-in sense is prompted for two reasons: one is to better service the flight crew, to alert the flight crew to any problems that might occur in the hardware; and the second reason is to aid line maintenance people in identifying the source of any failures that might be in the hardware, so that they can better do their maintenance job.

The dual channel implementation that was chosen is quite well suited to that kind of a thing. Because there are two channels, each of which is doing the same job simultaneously, there is a built-in redundancy from which comparisons can be made and conclusions drawn as to whether or not a failure had occurred in either one. The logic being simply that if a failure has occurred in some component of either channel, why, comparison monitoring will automatically detect that and make available a signal to identify that that has happened.

The dual channel mechanization is also useful in terms of fault tolerance, we call it. That is the ability to sustain a fault, a failure, somewhere in the system and continue to operate."[233]

The features referred to above were emphasized in the Boeing FQIS training syllabus for maintenance technicians in Air Canada:

"*FQIS Processor Unit*

Design features

The processor unit features two independent channels and power supplies within a common aluminum container. Each power supply receives 28v dc airplane power from a different source. Each channel utilizes four different card assemblies, interconnected through a motherboard.

Channels

The processor unit contains two channels: channel 1 and channel 2, that are separate and redundant except for motherboard connections. Either channel may be powered by either power supply.

FQIS Fault Recovery

The FQIS is designed to retain quantity indication after most single faults. No single fault will cause the loss of more than one indication. This fault recovery will be assured by the following design features:

— a bad channel will cause automatic switchover to a good channel;

— a power loss causes switchover to the remaining power supply."[234]

As we now know, in spite of its protective design features, the processor was defective and it failed. The failure occurred in an inductor coil manufactured by Dale Electronics in Yankton, South Dakota, and supplied to Honeywell to be installed in the power supply circuitry of the fuel processor.[235]

The problem in the inductor coil was accurately described in a letter from Honeywell to Ms. Rocheleau:

"After the incident, the fuel processor was returned to Honeywell. Tests were conducted. It was determined that the failure was due to a 'cold solder' joint on the inductor between one coil wire end and its terminal post. The terminal post was pretinned and had sufficient solder adhering to it. The coil wire end was not pretinned and the adhesion was poor."[236]

Since there are two channels, there are two inductor coils in the processor. Only one of the inductor coils was defective. Thus, if the processor had worked as it was expected to do, the other channel should have taken over in accordance with the principle of built-in redundancy. The reason it did not automatically take over was due to a design error in the processor itself. What was expected of the system was confirmed by Mr. Handberg:

"Q. Now, the system as designed was expected to suffer a failure of this kind, a single fault — this would be described as a single failure, would it not?

A. Yes, it would.

Q. Okay. It was expected to suffer a failure of this kind without the total system failing?

A. That is correct."[237]

What should have happened was expressed by Mr. Handberg:

"A. — When one of the channels sustains a failure, it is recognized by that channel and by the other channel, because of the built-in testing capability; control is switched to the good channel and the pilot is never troubled by the knowledge even that that situation has existed.

Q. But maintenance personnel can find out that that situation exists by pressing the BITE check button or BIT check button —

A. Right."[238]

What in fact happened was described by Ms. Rocheleau:

"The processor malfunction was the result of the hardware failure in the channel 2 power supply. This failure resulted in a partial loss of this channel's 5 volts logic supply. The remaining logic power was insufficient to store detected system faults into channel 2 NVM. The loss of power also resulted in the channel switchover logic, defaulting to channel 2. The excitation card switchover logic was also affected."[239]

The acronym NVM stands for Non-Volatile Memory. That is where system faults normally detected by the processor are stored. There is one for each of the two processor channels.

When the separation between the post and the inductor coil occurred, the normal 5 volts D.C. logic supply in channel 2 dropped to 0.7 volts. Therefore, not only did channel 2 cease to operate with the drop in current, but neither did the switchover mechanism to the good channel, that is channel 1, work.[240]

The failure to switch from a defective channel to a good channel because of the drop in power supply was clearly a design failure. As a result, all functions of the processor were lost, including fuel quantity indication on the gauges in the cockpit. It should be noted that the failure did not happen all at once. The failure was intermittent.

No one knows precisely how or when the failure took place, but an explanation was offered by Mr. Handberg:

"... the only explanation that I am — that I can offer is that because of the heating that was taking place within the faulty component, that the component itself was probably deteriorating over time and as that deteriorated the connection inside the component was probably making and breaking, probably moving around as the potting compound was being melted away or whatever was happening in there.

There was considerable temperature stress probably going on during those several weeks actually that we know that there was something — that there were intermittent symptoms being exhibited."[241]

As far as we know, the processor failed three times, starting July 5, 1983. After each of the first two failures, it returned to normal operation.

Each time the fault occurred, the cockpit fuel gauges went blank. Furthermore, on such occasions, the fault rendered the BITE system unreliable. Normally, when the processor is interrogated, it displays faults by means of a code flashed on its screen. Each time a failure occurred, this system failed to work as planned. As Mr. Handberg put it:

> "Well, I think that in this failed condition channel two was just processing nonsensical data and it was doing funny things with that data, things that probably can never be explained because it was in a partially operating condition."[242]

The three recorded instances of processor failure, prior to the events in Montreal, are set out below:

i) *In Edmonton, July 5, 1983*

On the above date, Mr. Yaremko was doing a fuel quantity processor test. He wanted to compare the accuracy of one channel to the other by disabling one channel at a time. This is done by use of the circuit breakers in the cockpit. When the circuit breaker for the appropriate channel is pushed in, it is said to be activated because this action normally powers the channel. When the circuit breaker is pulled out, it is said to be deactivated because this action deprives the channel of power. When the processor is working properly, the other channel then takes over and fuel indication is provided on the gauges in the cockpit.

During the test, therefore, Mr. Yaremko disabled channel 1 and channel 2 remained powered. While channel 1 was disabled, and quite coincidentally, the fueller opened the fuel panel under the wing of the aircraft. At that moment all fuel indication was lost and Mr. Yaremko thought at that time that it was the action of the fueller which had caused the problem. Mr. Yaremko could not get any indication back while channel 2 was powered so he disabled channel 2 and repowered channel 1. This restored fuel indication and all cockpit gauges again worked. The aircraft was dispatched with only channel 1 operative and in compliance with the provisions of MEL item 28-41-2. Mr. Yaremko raised a deviation in order to alert all down-line stations as well as Maintenance Central of the failure of channel 2.[243] When the aircraft arrived in Toronto, a check of the processor showed it to be within tolerance. It was reset and appeared to be operating normally.[244]

ii) *In San Francisco, July 14, 1983*

En route to San Francisco from Toronto, the fuel gauges in the cockpit of the aircraft went blank and remained so until the aircraft landed in San Francisco.[245] Maintenance Central in Montreal was notified of the failure by an ACARS message sent during the flight.[246] ACARS stands for ARINC Communications Addressing and Reporting System. The acronym ARINC stands for Aeronautical Radio Incorporated.

In San Francisco, a change of processor was recommended but, before it could be obtained, the processor which had been taken out of the aircraft was reinstalled and both channels appeared to operate normally. The aircraft left for Toronto with its fuel gauges working.[247]

When the aircraft arrived in Toronto, a BITE test was performed on the processor.[248] Faults were found stored in the non-volatile memory, but the test showed no faults currently in the system. As a precaution, a new processor was ordered by Toronto maintenance. Before one could be produced, the aircraft was dispatched on the morning of July 15 with the processor and the fuel gauges working normally.[249]

iii) *In Edmonton, July 22, 1983*

On the night of July 22 Mr. Ev Doyle was doing the service check on the aircraft and attempted to do the processor check as required by the job card. When he looked at the fuel indicators, they were blank. He reported the problem to Mr. Yaremko. Because Mr. Doyle had to work on another aircraft, Mr. Yaremko took over the problem. He began the processor check and found that with the channel 1 circuit breaker in, that is, activated, and the channel 2 circuit breaker out, that is, deactivated, he got fuel indication. As long as the channel 2 circuit breaker was activated, the gauges remained blank. He remembered encountering the problem before, but did not realize it was the same aircraft. He then reset both circuit breakers and went down into the main electrical/electronics equipment centre of the aircraft to do the BITE test.[250] Channel 2 failed the test. The processor itself failed a reset test and Mr. Yaremko knew there was a problem. He phoned Maintenance Central and told them he needed another processor.[251] He was told that none was available. After unsuccessful efforts to make the processor operative, Mr. Yaremko went into the cockpit and deactivated the channel 2 circuit breaker by pulling it out. This restored fuel indication on the gauges in the cockpit. The aircraft was then dispatched under MEL item 28-41-2.

2. Cockpit Instruments

When the main electrical power supply was lost on the descent into Gimli, the flight crew were left with standby instruments from an earlier generation of aircraft: a magnetic compass, an artificial horizon, an airspeed indicator and an altimeter. These four instruments worked normally. Captain Pearson mentioned that they expected to be able to use the radio magnetic indicator, but it did not work.[252]

It is clear from Captain Pearson's evidence that the standby equipment was not adequate to the task. The crew had difficulty steering a heading because the standby magnetic compass was badly located in the cockpit. It was high up above the instrument panel, against the windshield, or glare shield as it is more properly called, and between the two pilots. It could not be read accurately by either the captain or the first officer because of parallax due to its location. Captain Pearson said that he had to lean over quite far to see it, but that it was impossible to use and he ended up referring to the top of the cloud layer. When the controller on the ground gave them heading changes, Captain Pearson judged the change by reference to the top of the cloud layer, rather than by referring to the compass.[253]

Another serious problem the flight crew had to contend with was the lack of an instrument to indicate their rate of descent, namely a vertical speed indicator to indicate the rate of descent in thousands of feet per minute.

With both engines out and no power to work the instruments which normally provide flight information to the flight crew, it is obvious that both the Captain and the First Officer were fully occupied in the task of trying to land the aircraft safely. In order to achieve a safe landing, however, they had to know how far they could glide to reach their selected landing. To know this, they had to know their altitude, their distance from the place of landing and their rate of descent. This information would give them their descent profile. All this and much other information would normally have been supplied by the flight management computer which was no longer working.

Without information from the FMC and without a stand-by vertical speed indicator, the flight crew had to rely on Ground Control in Winnipeg to provide them with range or distance. Thus, the flight crew frequently asked for their distance from Winnipeg. Supplied with this information, the First Officer tried to compute a descent profile. This he did in addition to going through check lists to determine all the necessary procedures in the emergency they faced. As described by Captain Pearson, First Officer Quintal had to remember the altitude of the aircraft at any given distance from Winnipeg. A short time afterwards he would again ask for the distance from Winnipeg and note the new altitude. By repeating this process, he could, in Captain Pearson's own words, "compute some sort of a profile for descent".[254]

3. The Landing Gear

A further problem First Officer Quintal had to contend with under these very trying circumstances was the lowering of the landing gear. This procedure had to be delayed until just before landing in order to maintain what is called a 'clean' aircraft. Lowering the landing gear produces drag and slows the aircraft down. For the purposes of the glide, such an effect was not required until immediately before the landing.

With the failure of both engines, there was no source of electricity to power the hydraulics which, in normal circumstances, cause the main landing gear and the nose gear to extend and lock into position. In such circumstances, it is necessary for the flight crew to refer to the Emergency and Abnormal Procedures Section of the Boeing 767 Aircraft Operating Manual, which section is known as the Quick Reference Handbook.[255]

As reported by First Officer Quintal, when the time came to lower the landing gear, he selected the gear lever in the down position and nothing happened. He therefore looked at the Quick Reference Handbook. He could find no reference to landing gear free fall either in the index to the section on landing gear or in the section itself.

Shortly before touchdown, First Officer Quintal selected the alternate gear extension switch to the down position. This had the effect of letting the gear wheels drop by their own weight. But only the main wheels locked in the down position. A warning light in the cockpit indicated that the nose wheel was not locked into position. First Officer Quintal then referred to the index of the section on hydraulics but found nothing about free fall. He started looking through the section itself, but ran out of time.

Because the nose wheel was not locked, as soon as it came in contact with the runway, it immediately collapsed and was forced back into the nose wheel housing. In the event, although this resulted in additional damage to the aircraft, it did have the effect of helping to slow the aircraft down.[256]

The procedure for alternate gear extension was in fact set out at the end of the section on hydraulics. Subsequently, in a letter to Captain Simpson, Vice-President, Flight Operations of Air Canada, First Officer Quintal suggested that, as a safety measure for the future, this procedure be included in what he called the landing chapter, or in the hydraulics chapter, but in any event be included in the appropriate index as well.[257] It seems that these so-called chapters should more properly be called sections. It would obviously have been helpful to the flight crew if there had been a more readily available reference to emergency procedures for lowering the landing gear.

4. Emergency Escape Chutes

With only 61 passengers on board, the aircraft was evacuated very quickly, immediately after it came to a stop. There was, however, a problem with the emergency escape chutes. Emergency exits are located at the front of the aircraft, over the wings and at the rear. At each of these stations there is one exit on each side of the aircraft. Thus, there are six emergency exits in all. At each exit, there is an inflatable rubber chute which, when inflated and deployed, becomes a slide.

When the aircraft came to a stop with the nose down, the front of the aircraft began to fill with smoke. This section of the aircraft was almost empty. Therefore, very few people used the front exits. Most of the passengers were in the back part of the aircraft. Mr. Desjardins, the in-charge flight attendant, said that there was congestion in the last three or four rows. The congestion was caused because of the steepness of the chutes at the rear of the aircraft. As can be seen from the photographs in Exhibit 120, with the nose down, the two chutes at the front of the aircraft sloped to the ground at a very gentle angle. By the same token, the chutes at the rear of the aircraft were very steep and did not touch the ground. One of them was two or three feet off the ground. From the inside of the aircraft, it looked so steep that people were afraid of sliding down. The effect of someone going down the chute would be to bring the end of the chute closer to the ground and closer to the body of the aircraft, thereby making the chute steeper.[258]

There was another problem with the overwing exits. The overwing window itself was quite heavy to handle. Beyond that, the flight attendants were under the impression that as soon as the overwing windows were opened, they would see a ramp and a chute on each wing. However, when the attendants opened the overwing exits, they could not see any ramps. Accordingly, they concluded that the ramp portion of the chute on each wing had not inflated. Because of this, some of the passengers were redirected towards the front and rear chutes. There was nothing in the flight attendants' manual to alert the flight attendants to the fact that the overwing ramp was not directly in front of the exit window.[259] During their training, they had been given the impression that it was.

If the aircraft had been full or had other problems developed such as fire or panic, disaster would undoubtedly have occurred as a result of the problems with the ramps and chutes.

5. Aircraft Seats

A passenger witness, Mr. Robert W. Howitt, reported a complaint by a passenger, Mr. Bryce Bell. The latter was in the process of getting ready to brace for the landing by holding on to the top of the seat in front of him. According to Mr. Bell, as he grasped the seat in front of him, it collapsed forward. Because there were few passengers on the aircraft, he was able to try a second and a third seat, each of which in turn collapsed forward. Finally, he found a fourth seat which did not.

Mr. Howitt concluded by saying:

> "Whether that's by design or whatever, that was his experience and he was very concerned that he didn't feel very safe in that situation with these seats going forward."[260]

The matter was not further pursued at the hearings. However, upon further enquiry it was learned that most of the seats in the passenger cabin of the 767, when subjected to a pressure of 25 lbs., more or less, do indeed fold forward if the requisite amount of pressure is applied, unless they are occupied by passengers. In such a case, the seat folds forward to some extent, but not entirely, because of the presence of the passenger. This is a design feature for safety reasons. Thus, most of the seats fold forward so that, on impact in a crash, the passenger to the rear of the seat will be less likely to be injured. The seats immediately behind the overwing emergency exits are designed not to fold forward so that they will not block the exits. Seats which may be used by flight attendants do not have what is called the "breakover" characteristic because of the more elaborate seat belts, or harnesses, which the regulatory agencies require for flight attendants.[261]

The Boeing 767 security card indicates that when a passenger assumes the crash position, with forearms folded and one hand on top of the seat in front of him, the seat folds forward to some extent.[262] From the diagram it can be seen that the seat in front is only prevented from completely folding forward because it is occupied by a passenger. In the diagram, there is no seat in front of this second passenger who has his head on his arms which are folded over his knees. This position presumably represents that of a passenger whose arms are too short to reach the top of the seat in front of him, or of one who is sitting immediately in front of the cabin bulkhead, or of one sitting behind an empty seat or a seat immediately behind an overwing emergency exit. It is impossible to tell from the card just what the diagrams mean.

In all such cases a passenger should probably be instructed to put his head on his arms folded across his knees as in the case of the passenger shown in the security card. There is no evidence that such instructions were given before the Gimli landing.

This is a complaint by a passenger who found himself repeatedly in a position of some difficulty at a time when the aircraft in which he was flying was about to make an emergency landing. Fortunately the aircraft was not carrying anything like a full load of passengers and no great harm came of what happened, although Mr. Bell must have been disconcerted and become increasingly anxious because of the experience. The complaint merits the attention of Air Canada.

6. Labelling of System Failures

The collar of soft tape which Mr. Yaremko used on the circuit breaker which he had pulled was not sufficiently resistant to prevent Mr. Ouellet from pushing the circuit breaker back in with the collar still around it. The same kind of tape was used to placard the fuel quantity gauges. It was attached to the panel above them and it contained the words "see log book". It would obviously be preferable to have a collar which would resist a normal attempt to push in a circuit breaker. It would also help if the tape used for placarding inoperative systems was somewhat more informative in its wording.

Some other airlines do have better systems.

As a collar, Aer Lingus uses a plastic material which is bright orange or bright red in colour. British Airways has traditionally used a metal tag so that the circuit breaker could not be pushed back in without taking off the collar. The latest collars are made of hard plastic. To placard a gauge, they used rounded yellow stickers with "inop" on them. Numbers can be placed on the stickers which refer to the technical log, in order to identify the defect for the benefit of the flight crew.[263] When fuel gauges are unserviceable in the cockpit, not only are they labelled as inoperative, but so are the gauges on the wing station, so that the fueller will know that the system is inoperative.[264]

Pacific Western Airlines uses a red plastic collar. For placarding, they use a day glow orange coloured sticker, which they stick on the defective instrument. In addition, they name the defective component. For example, in the case of a defect in the fuel quantity indicating system, they would note on the tape:

"Channel 1 unserviceable"[265]

American Airlines has the most sophisticated system of all. In their version of the MEL, they have a column entitled "Advance Notification To Dispatch Required". Whoever discovers a particular problem, and wishes to placard it, whether flight crew or ground personnel, they report the problem to maintenance which in turn reports the problem to MEL Control, at which point the placard is assigned a number, referred to as an authorization number. The number not only authorizes maintenance to placard the system but it is also a method of control of the problem.

The authorization number is accompanied by one of three initials, 'C', 'D', or 'M'. 'C' means that the aircraft can be flown, provided it conforms to the qualifying conditions in the MEL. A 'D' is