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

AVIATION OCCURRENCE REPORT

CONTROL DIFFICULTY - TAIL STRIKE

AIR CANADA
BOEING 747-433 COMBI C-GAGL
TORONTO/LESTER B. PEARSON INTERNATIONAL AIRPORT, ONTARIO
19 FEBRUARY 1996

REPORT NUMBER A96O0030

Canada

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Aviation Occurrence Report

Control Difficulty - Tail Strike

Air Canada
Boeing 747-433 Combi C-GAGL
Toronto/Lester B. Pearson International Airport, Ontario
19 February 1996

Report Number A96O0030

Synopsis

The Boeing 747-433 Combi aircraft, operating as Air Canada flight 899, was on a scheduled passenger/freight flight from Toronto/Lester B. Pearson International Airport, Ontario, to Vancouver International Airport, British Columbia. As the aircraft was taking off, the underside of the tail struck the runway, and, during the climb-out, considerable nose-down stabilizer trim was required to trim the aircraft for flight. The strike was undetected by any crew member, and the flight continued to destination, where damage to the aircraft was discovered.

The Board determined that the underside of the tail struck the runway on take-off because the first officer rotated the aircraft too steeply and at an aircraft speed below the calculated rotation speed; the early rotation was facilitated by the far aft centre of gravity and the incorrect stabilizer trim setting. Contributing to the incident were an error in a recently modified aircraft loading computer application, incomplete validation of the modifications to the computer application, and the inability of the aircraft loading system to detect a gross calculation error.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 History of the Flight

The aircraft was scheduled to depart Toronto/Lester B. Pearson International Airport at 0845 eastern standard time (EST)[1] on a scheduled, non-stop flight to Vancouver International Airport. The aircraft was a Combi, configured to carry passengers and large loads of freight. Its load consisted of 243 passengers and 31,257 kilograms (kg)[2] of freight.

The flight was delayed at the ramp 30 to 35 minutes while cargo was loaded. Push-back and taxi to runway 24 right were routine, and the aircraft was cleared for take-off at 0951 EST. The flight crew operated the aircraft in accordance with Air Canada standard operating procedures for taxi, pre-take-off, and the take-off roll. The captain monitored the take-off from the left seat with the first officer at the controls.

Flight data recorder (FDR) information showed that the nose of the aircraft started to pitch up slowly at about 120 knots indicated airspeed (KIAS)[3] without any elevator control movement. At about 134 KIAS, when the aircraft was about 5 degrees nose-up, there was a significant nose-up elevator movement, and the aircraft rotated more quickly, lifting off at 143 KIAS with a 13-degree nose-up attitude. Unbeknown to any crew member on board, the lower fuselage of the aircraft struck the runway during lift-off. Near full nose-down stabilizer trim was required to trim the aircraft on initial climb-out. Shortly after take-off, the flight crew advised company dispatch by radio that they believed, because of the way the aircraft was flying, that there was an error in the weight and balance of the aircraft.

When the aircraft was inspected at destination, it was discovered that the underside of the fuselage, in the tail area of the aircraft, had contacted the runway surface.

The incident occurred at latitude 43˚40’N, longitude 079˚37’W, at 0951 EST, during the hours of daylight.

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

2 See Glossary for all abbreviations and acronyms.

3 Units are consistent with official manuals, documents, reports and instructions used by or issued to crew.

1.2 *Injuries to Persons*

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	-	-	-	-
Minor/None	10	243	-	253
Total	10	243	-	253

1.3 *Damage to Aircraft*

Damage to the aircraft consisted of scraping and minor buckling of the bottom of the aircraft fuselage tail area from aircraft station 2658 to station 2742. This area comprises the auxiliary power unit (APU) access doors and the area slightly aft of the doors.

1.4 *Other Damage*

None.

1.5 *Personnel Information*

1.5.1 *General*

	Captain	First Officer
Age	58	49
Pilot Licence	ATPL	ATPL
Medical Expiry Date	01-July-96	01-July-96
Total Flying Hours	18,362	12,885
Hours on Type	1,085	23
Hours Last 90 Days	38	88
Hours on Type Last 90 Days	38	23
Hours on Duty Prior to Occurrence	2.3	2.3
Hours Off Duty Prior to Work Period	5 weeks	9.0

1.5.2 *Captain*

The captain was licensed and qualified in accordance with existing regulations. His licence was endorsed for the B747-200 in August 1991, and for the B747-400 in March 1992. His latest pilot proficiency and instrument check ride was completed on 27 January 1995. On his most recent pilot medical examination, 22 December 1995, he was assessed as fit, category I; his glasses must be available while flying. He was a qualified B747-400 company check pilot and was monitoring the first officer, who was undergoing company line indoctrination on the B747-400.

The captain arrived at the airport for duty about 0730 EST on the day of the occurrence. This was his first day of flight duty following five weeks off.

1.5.3 First Officer

The first officer commenced his company pilot ground school and flight simulator training for conversion to the B747-400 on 07 January 1996. He completed the simulator training and his pilot proficiency check ride on 09 February 1996. Prior to converting to the B747-400, he flew as a qualified first officer on the B767. His licence was endorsed for the B747-400 on 13 February 1996, and on his most recent pilot medical examination, 19 December 1995, he was assessed as fit, category I; his glasses must be available while flying. He was licensed and qualified in accordance with existing regulations.

The first officer completed a line indoctrination flight from Vancouver to Toronto on the day prior to the occurrence, arriving in Toronto at 2200 EST. He went directly from the airport to his hotel room and reportedly was in bed about an hour and a half after arriving in Toronto. On the day of the occurrence, the first officer arrived at the airport about one hour prior to the scheduled departure time for flight 899. The occurrence flight was his third of eight legs of line indoctrination training on the aircraft. It was his second take-off in the aircraft following his simulator training.

1.6 Aircraft Information

1.6.1 General

Manufacturer	Boeing Company
Type and Model	747-433 Combi
Year of Manufacture	1991
Serial Number	24998
Certificate of Airworthiness	January 1991
Total Airframe Time	17,115 hours
Engine Type (number of)	Pratt & Whitney PW 4056 (4)
Propeller/Rotor Type (number of)	Not applicable
Maximum Allowable Take-off Weight	394,600 kg
Fuel Type Used	Jet A

The flight crew did not report, nor did the investigation detect, any failure or malfunction of the aircraft systems or components that would have contributed to the occurrence.

1.6.2 Aircraft Description

The Boeing 747-433 Combi aircraft was configured to carry a mix of passengers and freight. Passengers only are carried on the upper deck of the aircraft from aft of the cockpit to the leading edge of the wing. Passengers and freight are carried on the main deck, passengers from the nose of the aircraft to beyond the trailing edge of the wing and freight from the rear of the main deck passenger area to the tail of the aircraft. Freight only is carried below the main deck area in hold areas forward of the wing leading edge to aft of the nose landing gear, and aft of the wing trailing edge to the rear of the aircraft.

1.6.3 Weight and Balance

The maximum operational take-off weight of this aircraft is 328,600 kg, and the operational centre of gravity (C of G) limit is from 10.8% to 32.5% mean aerodynamic chord (MAC).

A Toronto-based Air Canada certified station agent, assisted by a computer application called Automated Load Planning Air Canada (ALPAC), commenced planning the loading of flight 899 at 0645 EST. Load planning was routine and was completed by 0715 EST. Seven loaded cargo containers were placed in the aircraft main deck cargo area. Six of these containers exceeded the height of the cargo hold areas and could only be placed in the main deck cargo area of the aircraft. Total cargo weight in the main deck cargo area was 19,782 kg. The aircraft weight and balance information, computed by ALPAC, was given to the flight crew prior to the aircraft's departure.

A company load agent confirmed that the freight had been loaded on the aircraft in accordance with the ALPAC plan, and that the actual weight of the cargo was within acceptable tolerances of the ALPAC-computed weights used for the flight.

Company load agents carried out a manual weight and balance calculation for the occurrence flight when the flight crew notified dispatch after take-off that they believed there was a weight and balance problem with the aircraft load. The manual calculation quickly confirmed the ALPAC application error, and the company took immediate action to ensure that no further flights were dispatched using the modified ALPAC application. The take-off weight of 286,500 kg was confirmed; however, the C of G was 35% MAC, while that computed prior to take-off was 22.3% MAC. FDR data showed the aircraft take-off weight as 286,783 kg. The aircraft actual C of G, at take-off, was aft of the aft limit of 32.5% MAC.

At the same time as the flight crew was reporting its difficulty with Flight 899, load agents preparing another Boeing 747 aircraft for dispatch experienced problems with the modified ALPAC application and were using the manual method of weight and balance calculations to investigate the reason for the problem.

1.6.4 *Take-off Performance Data*

The weight and balance information passed to the flight crew from the load agent was entered in an on-board computer which computed the aircraft take-off speeds and stabilizer trim setting position for take-off. The computed take-off speeds were automatically displayed on the aircraft instrument panel for take-off. The take-off speeds were not stored parameters in the FDR. The FDR data showed the stabilizer trim set at 5.9 units for the take-off, which is within the aircraft stabilizer trim setting range for take-off. The computed take-off speeds for conditions that existed at the time of the occurrence were V_1[4] = 132 knots and V_R[5] = 144 knots.

A "de-rate one"[6] reduced engine power setting was used for the occurrence take-off, with 10 degrees of trailing edge flap extended.

1.6.5 *Take-off Roll Technique*

A characteristic of the Boeing 747 aircraft is that only light weight forces are exerted on the nose landing gear during the take-off run. The Air Canada Boeing 747-400 Aircraft Operating Manual, initial take-off procedure section, states that, for light weight and aft C of G conditions and for slippery runway conditions, the aircraft nosewheel should remain firmly in contact with the runway until just before V_R, when any column push force should be relaxed.

Take-off and initial climb performance depend on rotating the aircraft at the correct speed and rate to the target rotation attitude. Rotating the aircraft too early, too rapidly, or too steeply may cause the aft fuselage to contact the runway. Aft fuselage contact will occur at a 12.5-degree nose-up pitch attitude with the aircraft wheels on the runway and the landing gear struts extended.

The rate of rotation is related to the aircraft's acceleration; normally, the heavier the airplane, the slower the acceleration, and the slower the rotation rate. A 10-degree pitch attitude will normally be achieved in approximately three to five seconds with all engines operating, and lift-off will occur between 8.5 and 10 degrees nose-up attitude.

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4 V_1 is defined by Transport Canada as "critical engine failure recognition speed"; the Boeing 747-400 Airplane Flight Manual defines it as "take-off decision speed."

5 Rotation speed.

6 A reduced power setting used for take-off when maximum thrust is not required.

1.7 Meteorological Information

The weather at the time of the occurrence was as follows: scattered cloud based at 3,500 feet above ground level (agl), broken cloud at 5,000 feet agl, broken cloud at 10,000 feet agl, visibility 15 statute miles, wind from 150° magnetic at five knots, temperature -7°C, and dew point -13°C.

1.8 Aids to Navigation

None used.

1.9 Communications

Communication with air traffic control was routine and without difficulty. The flight crew contacted company dispatch by radio after take-off and reported the difficulty in controlling the aircraft on take-off.

1.10 Aerodrome Information

Runway 24 right is 10,500 feet long by 200 feet wide. The asphalt/concrete surface was bare and dry at the time of the occurrence.

1.11 Flight Recorders

The aircraft was equipped with an Allied Signal Universal Flight Data Recorder (FDR), model number 980-4100-AXUS. The FDR was removed from the aircraft when it arrived at destination in Vancouver, and was sent to the TSB Engineering Branch for analysis. Because the cockpit voice recorder (CVR) was continuously recording during the flight to Vancouver and the length of the recording loop is 30 minutes, no CVR data were available for the time of the occurrence.

On the occurrence take-off, engine power increased to and stabilized at 84% thrust. The pitch attitude of the aircraft gradually increased throughout the take-off roll without any control column movement from a zero (neutral) position. At about 120 KIAS, the pitch attitude and rate began to increase significantly without control column movement. There was slight control column forward movement as the aircraft accelerated through 132 KIAS, followed immediately by significant aft movement. As the aft control column movement peaked at 18 degrees aft, the aircraft pitch attitude increased to 13 degrees nose-up and the air/ground switch discrete toggled to air, indicating aircraft lift-off at 143 KIAS. A vertical acceleration spike of 1.13 g was recorded at the approximate time of lift-off. The aircraft pitch attitude continued to increase after lift-off, reaching approximately 18 degrees 13 seconds after lift-off. At this time, nose-down stabilizer trim movement from 5.9 units to 5.0 units was recorded, and the aircraft pitch attitude reduced to 16 degrees. About 16 seconds after lift-off, further nose-down stabilizer trim movements were recorded to 4.4 units, and the aircraft pitch attitude stabilized at 14 degrees nose-up for the climb.

FDR data from the previous take-off were analyzed and compared with data from the occurrence flight. The data from the previous take-off showed progressive forward control column movement throughout the take-off roll, peaking at minus 10 degrees prior to significant aft control column movement and the aircraft lifting off. After lift-off, only small movements of nose-down trim were recorded as the aircraft was established in the climb.

1.12 *Wreckage and Impact Information*

Not applicable.

1.13 *Medical Information*

There was no evidence that incapacitation or physiological factors affected the crew's performance.

1.14 *Additional Information*

1.14.1 *Cockpit Workload Management*

The company operations manual directs that the flight crew review the take-off speeds prior to take-off. On the take-off roll, the pilot flying (PF) advances the throttles and the pilot not flying (PNF) sets take-off power by 80 knots. The captain's hand remains on the throttles until V_1 speed is attained. If the captain detects any abnormality critical to aircraft safety before the aircraft attains V_1 speed, he assumes control of the aircraft and rejects the take-off. Company procedures for Boeing aircraft do not require that speeds be called out during the take-off roll; during this occurrence, there were no calls.

It is common practice in the aviation industry for the PNF to call out airspeeds as the aircraft accelerates on the take-off roll. Speeds called out on large aircraft are as follows: a speed well below V_1, confirming that the airspeed indicators are functioning and that take-off power is set and stabilized, V_1, and V_R. When the PNF calls V_R, the PF initiates rotation by smoothly moving the control column aft at a speed that will allow the aircraft to lift off at the correct speed and pitch angle.

1.14.2 *Pilot Training*

Although several take-offs were demonstrated to the first officer during his recent Boeing 747-400 simulator training, none was with the aircraft out of trim or out of balance. The only simulator training relating to an out-of-trim condition he could recall was carried out in conjunction with in-flight aircraft stabilizer problems.

1.14.3 *Station Agent Training*

Prior to beginning training to become a certified station agent, a candidate goes through a selection process of qualifying exams. The self-study exams cover basic ramp procedures, cargo procedures, and aircraft procedures. The candidate can also opt to take a self-study module on weight and balance for the DC-9 aircraft. Successful completion of the qualifying exams is followed by a six-week training course. The course covers basic ALPAC load training on narrow-bodied aircraft using both ALPAC and manual computations for weight and balance determination. The candidate is then examined on knowledge and theory and his or her ability to determine weight and balance using ALPAC and using a manual method. Candidates are examined and certified separately on each aircraft for which they prepare loads.

The certified station agent who handled the aircraft on the occurrence flight had more than 20 years of experience as a station agent.

1.14.4 Automated Load Planning - Air Canada (ALPAC)

ALPAC is a computer application, continuously under development by Air Canada, that assists certified load agents with the planning and positioning of cargo and baggage in all Air Canada aircraft. Some of the objectives of the application are to ensure that aircraft weight and balance limits are respected, dangerous goods are correctly loaded, pallets are positioned to allow unimpeded unloading at the destination, and the load is positioned to achieve the most fuel-efficient aircraft balance. The load agent enters into the computer particulars of each pallet; the application keeps a running total of the weights and calculates the moment change for the aircraft balance by applying a performance code which contains the arm for each pallet location.

For the B747-400 Combi aircraft, cargo is loaded onto pallets which are then loaded, as required, in the forward, aft, and bulk cargo holds below the main deck and in the main deck cargo area. Standard pallets are 88 inches by 125 inches (small pallet), and there is a new standard pallet that is 96 inches by 125 inches (large pallet). Air Canada uses the letter Q to designate a large pallet. Prior to 16 February 1996, the weight of the pallets was entered into the ALPAC application without indicating whether it was a small or large pallet. Air Canada found that when a large pallet was loaded in the aft hold of the B747-400 Combi aircraft, space was reduced and one less pallet could be loaded into the area. Therefore, for load planning purposes, Air Canada wanted the ALPAC application to be able to identify that a large pallet was in the aft hold. The computer company that maintains and develops the ALPAC application incorporated this modification at Air Canada's request, and tested the modified area of the application to confirm that it functioned properly before releasing it to Air Canada. Air Canada Engineering personnel also conducted a test to ascertain that the changed section of the application performed properly.

The ALPAC application was modified to further automate loading on the B747-433 Combi and Airbus A340 aircraft. This modification was believed to affect only the A340 aircraft and the cargo hold of the B747 Combi aircraft, and not the main deck cargo area of the B747 Combi aircraft. Consequently, testing of the modified application was not carried out for the main deck cargo area of the B747 Combi aircraft, nor was testing of the entire application carried out before the modified application was put into operational service. On 16 February 1996, the modified application was loaded on the main computer for use by the load agents. The modified application was not monitored for accuracy after it was put in operational use. The flight crew did not perform any manual weight and balance calculations prior to take-off, nor were any required by company procedures.

After the occurrence flight, it was discovered that when the smaller pallets were loaded into the main deck cargo area, ALPAC correctly calculated the weight and accounted for the moment changes. However, when large pallets were loaded in the main deck cargo area and their information entered into the computer, ALPAC properly added the weight to the total but did not account for any resulting moment changes. In order for the ALPAC application to account for the Q designator, changes were required to the performance codes for the pallet positions. No personnel from Air Canada or the computer maintenance company connected the initial application changes with the requirement to change the performance codes; therefore, these changes were not requested or made prior to the occurrence flight.

From 16 February 1996 until the occurrence flight, nine B747-433 Combi aircraft flights were inadvertently operated with incorrect C of G calculations as a result of the ALPAC calculations. The flight crews of these flights did not report any difficulty in controlling the aircraft.

2.0 Analysis

2.1 Introduction

Neither aircraft airworthiness nor environmental conditions contributed to the cause of the occurrence. Therefore, the analysis will concentrate on the company computer application in use that affected aircraft operational data, and flight crew handling of the aircraft during the take-off roll.

2.2 ALPAC Computer Application

The ALPAC computer application had been used by company load agents for several years without any reported errors in calculations used for aircraft operational data. Load agents were confident with the application and accepted aircraft operational data computed by the application without question. Since the ALPAC-computed C of G for the occurrence flight fell within the operational limits of the aircraft, the agent accepted it and dispatched the flight. He passed the weight and balance information to the flight crew and they accepted the calculations, routinely, as they had in the past.

In this instance, an experienced load agent, thoroughly familiar with the loading of aircraft, accepted a computer-generated C of G calculation that located the aircraft C of G near the centre of the flight envelope when the bulk of the freight, 63.3% of the total weight of the freight on board, was loaded in the very aft section of the aircraft. The actual C of G was beyond the aft limit of the flight envelope. The unquestioning acceptance by the load agent of computer-generated data demonstrates a degree of overconfidence that trained and experienced personnel have gained through the use of computers.

The ALPAC application in its entirety was not tested after the modification was completed, nor was it monitored after it was put in operation by the airline. In this instance, as with several previous flights, the ALPAC application correctly computed the weight of the aircraft but did not correctly compute the weight moment for the Q-designated pallets loaded on the main deck cargo area. The application is designed to display a computer screen warning to the load agent when aircraft operational limits are exceeded. In this instance, although the C of G was, in fact, aft of the rear limit, the computer data indicated that the C of G was positioned well within the limits; therefore, no warning was displayed. As well, there was no computer indication that the weight moment change was not being correctly computed when the load agent entered Q-pallet information.

2.3 Take-off Roll

Since the control column does not move without someone actually moving it, it was concluded that all control column movements, as recorded on the FDR, were inputs by the first officer. As the aircraft accelerated, the nose began to pitch up, gradually increasing with the control column in a near neutral position. The uncommanded nose pitch-up resulted from a combination of the aft C of G, the incorrect stabilizer trim setting (in that the stabilizer was trimmed for a nose-heavy aircraft although the aircraft was tail heavy), and the lack of control input by the first officer to keep the aircraft nosewheel firmly on the runway until rotation speed was attained.

The aft control column movement that started at 132 KIAS was considered to be the initiation of rotation by the first officer. The aircraft nosewheel was likely off the ground at this point, without any control input from the first officer. The uncommanded initiation of rotation likely influenced the first officer to continue rotation, even though the airspeed was about 11 knots below V_R. The aircraft lifted off below V_R with the nose pitched up 13 degrees, which caused the underside of the tail to strike the runway.

The captain, who was monitoring the first officer's take-off, did not take action to prevent the gradual, uncommanded increase in aircraft pitch attitude during the take-off roll, or to prevent early rotation of the aircraft. Once airborne, the captain told the first officer that the airspeed was low.

2.4 Silent Cockpit

Company policy for Boeing aircraft did not require the PNF to call out airspeeds on take-off, and none were called on this occurrence. Both pilots were accustomed to the silent cockpit take-off procedure. The first officer was not experienced on the B747-400 and may not have been accustomed to its characteristic lack of weight exerted on the nosewheel. The light weight on the nosewheel requires the pilot to make a conscious effort to keep the nosewheel firmly on the runway by applying forward control column movement (down elevator) until just before the aircraft reaches V_R.

The company's rationale for not calling out airspeeds is that it sees no requirement to call out normal information which is displayed to both flight crew. Any call made in this environment will therefore be addressing some abnormality. There are, however, some crew co-ordination and workload consequences arising from this procedure.

The PF must direct more of his attention to the airspeed indicator as V_1 and V_R are approached; he knows that the PNF will not be calling the speeds. This re-focusing of attention could be at the expense of time spent looking outside the cockpit or at other control and performance instruments.

As for co-ordination, a verbal call of V_R could help ensure that rotation takes place at V_R, and not before or after. The V_1 speed is less important in a normal take-off situation, but is critical for determining pilot reactions to an engine failure. The absence of a verbal V_1 call could create some confusion between the pilots should a power loss occur at an airspeed close to V_1.

3.0 Conclusions

3.1 Findings

1. The flight crew was certified, trained, and qualified for the flight in accordance with existing regulations.

2. The occurrence flight was the first officer's second at-the-controls take-off since completing his pilot conversion training on the B747-400.

3. The first officer did not apply sufficient down elevator input to keep the aircraft nosewheel firmly on the runway during the take-off roll.

4. There was an uncommanded nose pitch-up during the take-off roll.

5. Airspeeds were not called out by the PNF during the take-off roll, nor were they required to be by the company.

6. The first officer rotated the aircraft too steeply and at an aircraft speed below the calculated rotation speed, and, as a result, the underside of the tail struck the runway.

7. The captain, who was monitoring the first officer's take-off, did not take action to ensure that the aircraft nosewheel remained firmly on the ground until rotation speed was attained, or to prevent early rotation of the aircraft.

8. The aircraft stabilizer trim setting was incorrectly set because of an incorrectly computed aircraft take-off C of G.

9. The first officer's recent simulator training did not include an aircraft out-of-trim or out-of-balance take-off.

10. A recently modified computer application, ALPAC, used by load agents to plan loads and compute aircraft weight and balance, incorrectly computed the aircraft take-off C of G.

11. The ALPAC-computed aircraft take-off C of G was near the centre of the aircraft flight envelope, while the actual C of G was beyond the aft limit.

12. The ALPAC application produced a large error in the aircraft C of G calculation; however, there was no defence in place to detect such a critical error in the application itself, at the aircraft loading stage, or in the flight crew confirmations of load and trim setting.

13. The modified computer application was not adequately tested before it was released for operational use.

14. The modified computer application was not monitored effectively for accuracy after it was placed in operational use.

3.2 Causes

The underside of the tail struck the runway on take-off because the first officer rotated the aircraft too steeply and at an aircraft speed below the calculated rotation speed; the early rotation was facilitated by the far aft C of G and the incorrect stabilizer trim setting. Contributing to the incident were an error in a recently modified aircraft loading computer application, incomplete validation of the modifications to the computer application, and the inability of the aircraft loading system to detect a gross calculation error.

4.0 Safety Action

4.1 Action Taken

4.1.1 Operator Action - Calling of Speeds on Take-off

On 15 July 1996, the operator amended its Boeing 747-400 aircraft operations manual to introduce verbal calls at speeds of 100 knots, V_1, and V_R during the take-off roll. The change in procedures will be applicable to all Air Canada aircraft and will standardize the company fleet operation with the procedures previously accepted for the operation of Airbus aircraft in the company fleet.

4.1.2 Operator Action - Weight and Balance

Since the occurrence, Air Canada has taken action to enhance the quality assurance procedures for its load control software. Weight and Balance introduced a position of Operational Control Manager and Technical/Training/Development, effective 01 June 1996. More direct control will be taken for software changes, software change specifications will be clearly defined, a full impact assessment will be made to identify all components affected by the change, test databases have been updated, follow-on testing will be done in "live mode", and positive confirmation of testing will be achieved. Although its focus is currently on load control software, Air Canada indicated that it is taking a more comprehensive look at the testing environment and procedures for all critical systems. Training lesson plans are being rewritten to strengthen load agents' understanding of the relationship between the manual and ALPAC methods of determination of weight and balance.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 17 December 1996.

Appendix A - List of Supporting Reports

The following TSB Engineering Branch Report was completed:

LP 25/96 - FDR Analysis.

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

Appendix B - Glossary

ALPAC	Automated Load Planning Air Canada
agl	above ground level
APU	auxiliary power unit
ATPL	Airline Transport Pilot Licence
C of G	centre of gravity
CVR	cockpit voice recorder
EST	eastern standard time
FDR	flight data recorder
in	inches
kg	kilograms
KIAS	knots indicated airspeed
MAC	mean aerodynamic chord
PF	pilot flying
PNF	pilot not flying
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time
V_1	critical engine failure recognition speed, or take-off decision speed
V_R	rotation speed
°	degree(s)
'	minute(s)