Department of Transport and Regional Development

Bureau of Air Safety Investigation

INVESTIGATION REPORT

9403038

Boeing 747-312 VH-INH
Sydney (Kingsford-Smith) Airport
New South Wales
19 October 1994

BASI
Bureau of Air Safety Investigation

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The Civil Aviation Authority was replaced in July 1995 by Airservices Australia and the Civil Aviation Safety Authority. The Civil Aviation Safety Authority is the aviation safety regulator.

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INTRODUCTION

The main purpose for investigating air safety occurrences is to prevent aircraft accidents by establishing what happened, how it happened and why the occurrence took place. A further purpose is to determine what the occurrence reveals about the safety health of the aviation system. Such information is used to make recommendations aimed at reducing or eliminating the probability of a repetition of the same type of occurrence, and where possible, to increase the safety of the aviation system.

To produce effective recommendations, the information collected and the conclusions reached must be analysed in a way that reveals the relationships between the individuals involved in the occurrence and the design and characteristics of the systems within which those individuals operate.

This investigation was conducted with reference to the general principles of the analytical model outlined in International Civil Aviation Organisation circulars 247-AN/148 and 240-AN/144.

Accordingly, common elements in any occurrence are considered to be:

- organisational failures arising from managerial policies and actions within one or more organisations (these may lie dormant for a considerable time);
- local factors, including such things as environmental conditions, equipment deficiencies and inadequate procedures;
- active failures having a direct adverse effect (generally associated with operational personnel); and
- inadequate or absent defences and consequent failures to identify and protect against technical and human failures arising from the three previous elements.

Experience has shown that occurrences are rarely the result of a single failure but are more likely to be due to a combination of a number of factors, any one of which by itself being insufficient to cause a breakdown of the safety system. Such factors often lie hidden within the system for a considerable time before the occurrence and can be described as latent failures. However, when combined with local events and human failures, the resulting sequence of factors may be sufficient to result in a safety hazard. Should the safety defences be inadequate, a safety occurrence is inevitable.

An insight into the safety health of any organisation can be gained by an examination of its safety history and of the environment within which it operates. A series of apparently unrelated safety events may be regarded as tokens of an underlying systemic failure of the overall safety system.

SYNOPSIS

The flight was an international regular public transport operation between Sydney, Australia and Osaka, Japan on 19 October 1994. The technical crew consisted of a very experienced (B747) pilot in command who was also acting as a training pilot, an experienced co-pilot who had not yet completed his line training on the B747, and an experienced but newly B747-rated flight engineer who was on his first revenue flight as a qualified B747 flight engineer.

Approximately one hour after departure the crew shut down the number one engine because of an oil leak. They returned the aircraft to Sydney where the approach proceeded normally until the landing gear was selected. With selection of the landing gear and selection of the flap beyond a setting of flaps 20, the landing gear warning horn began to sound because the nose landing gear had not extended. The flight crew unsuccessfully attempted to establish the reason for the warning. Believing the gear to be down, the crew elected to complete the landing, with the result that the aircraft was landed with the nose gear retracted. There was no fire and the pilot in command decided not to initiate an emergency evacuation.

The investigation found that the oil loss was caused by the failure of a threaded insert used to retain the engine angle gearbox housing cover. The cover came loose, allowing oil to escape. An opportunity to action service bulletin SB JT9D-7R4-72-410, which would have prevented the oil leak had not been taken. Although the same engine is used on a number of aircraft approved for extended range operations over water, the manufacturer had not made the incorporation of this service bulletin mandatory. The owners of an aircraft can elect not to action a manufacturer's recommendation to incorporate a service bulletin.

An unexplained reduction in air-driven hydraulic pump output caused slower than expected operation of the number one hydraulic system. The system may still have been capable of extending all the landing gear, given adequate time. However, the aircraft landed before the system could complete the landing gear extension.

The flight crew had the opportunity to recognise and correct the landing gear problem prior to landing. The pilot in command attempted to determine the actual landing gear situation from the flight engineer. Although the flight engineer's panel indicated the nose gear was not down and locked, the flight engineer did not recognise this and subsequent communication and co-ordination between the flight crew failed to detect this error.

During the latter part of the flight, the crew did not adequately manage the operation of the aircraft. The crew's performance reflected a lack of effective crew resource management, the crew's lack of knowledge about some of the company's procedures for B747 operations, the flight engineer's and the co-pilot's lack of experience in the B747 and perceived pressure.

A review of events associated with the introduction of the B747 indicated that organisational factors involving both Ansett and the Civil Aviation Authority led to a situation where there was increased potential for an accident of this nature to occur. These factors included deficiencies in the planning and implementation of the introduction program for the new aircraft, particularly with respect to manuals, procedures and line training. In addition, all regulatory requirements were not observed, nor were they enforced.

The flight crew's performance combined with the organisational factors to breach defences that had been put in place to ensure the safety of regular public transport operations in high capacity aircraft.

A number of recommendations were made as a result of the investigation.

Ansett Australia has advised the Bureau that it has taken a number of significant actions in response to this occurrence. Details of the actions taken can be found in Section 4 of this report.

1. FACTUAL INFORMATION

1.1 History of the flight

At 1007 on 19 October 1994, VH-INH departed Sydney bound for Osaka's Kansai Airport. The aircraft, a B747-312, was being operated by Ansett International Limited as Flight AN 881, on a regular public transport flight.

Almost an hour after departing Sydney, and whilst cruising at Flight Level 310, the crew noticed that the oil quantity in number one engine was decreasing. The engine had a recent history of high oil consumption. The crew continued to monitor the oil quantity and referred to the appropriate procedure in the operations manual. They also conferred with company operations and engineering personnel on the ground in Sydney and Brisbane. When the oil quantity decreased to zero and the oil pressure indicator began fluctuating, the pilot in command called for the engine to be shut down, in accordance with the procedure in the Quick Reference Handbook for 'inflight engine failure and shutdown'.

The engine was secured at about 1110 and, after discussions with ground-based personnel, the aircraft was turned back towards Sydney and descended to Flight Level 270. In preparation for landing, the crew obtained approval to jettison fuel en route to Sydney, aiming for a landing weight of 285,000 kilograms and leaving sufficient fuel for several hours operations.

The co-pilot was the handling pilot for the planned flight to Osaka and the pilot in command decided that the co-pilot should continue to fly the aircraft for the return to Sydney, bearing in mind the training aspects of the flight.

Whilst the aircraft was en route to Sydney, plans were being made for alternative travel arrangements for passengers. One option being considered by Ansett management was the transfer of crew and passengers to an available aircraft for a continuation of the flight to Osaka. This was the option conveyed to the flight crew. The flight engineer was used as the co-ordinator between the ground-based operations personnel and both flight and cabin crew members. This co-ordination involved establishing the status of catering supplies, discussing the timings involved with the new schedule and discussing the possible extension of the crew duty day to 15.5 hours. In addition to these tasks, which were performed between approximately 1148 and 1155, the flight engineer was completing entries on various aircraft forms and logs, monitoring fuel jettison progress, balancing fuel and making other preparations for landing as the aircraft headed towards Sydney.

The weather conditions expected at Sydney for arrival required an instrument approach. The aircraft commenced a descent for Sydney at 1200 and Air Traffic Control allocated it a LETTI-1 standard arrival route.

Whilst in the descent, the crew briefed for a flaps-30, three-engine approach and landing. They had previously discussed whether some of the hydraulic services would be slower than normal due to the loss of the number one engine and agreed that early selection of flap and landing gear would be desirable. The crew tracked for a runway 16 instrument landing system approach.

The flaps were progressively extended as the aircraft slowed. The crew noted that the inboard trailing edge flaps extended at a markedly slower rate than the outboard trailing edge flaps and the flight engineer commented that the number one hydraulic system pressure had reduced to 1,000 pounds per square inch. The evidence from the cockpit voice recording showed that neither pilot acknowledged this comment or exhibited any signs of having heard it. In later

interviews, the flight engineer added that he had observed the number one air-driven hydraulic pump 'run' light illuminate intermittently throughout the return to Sydney. This would be expected with the number one engine shut down and the air-driven pump selected to AUTO.

The aircraft levelled off at the initial approach altitude of 3,000 feet for a short time before reaching the West Pymble locator. There was then a further short discussion between the pilot in command and the flight engineer about the likely slow movement of flap and landing gear due to the engine being shut down. The landing checklist was partially completed as the aircraft intercepted the localiser, and was stopped with the next item being 'gear lever'. Flaps 20 was selected as the aircraft approached glide slope interception.

The aircraft commenced final descent from 3,000 feet at 1217. The approach continued to 2,000 feet, with the inboard trailing edge flaps slowly travelling towards flaps 20. Fifty seconds after commencing the approach, as the aircraft approached 2,000 feet above mean sea level, the co-pilot called for landing gear extension. The pilot in command made the gear selection and after a further 50 seconds, with the concurrence of the co-pilot, selected flaps 25. At this point the aircraft was descending through about 1,200 feet above mean sea level and the flight data recording indicated an airspeed of 197 knots.

As the flap selector handle was moved out of the 'flaps 20' detent, the landing gear warning horn sounded. The initial action of the pilot in command, in response to the warning horn, was to say that he believed the horn had sounded because the gear was 'still running'. He then checked if the number one engine thrust lever was the cause (due to it being at idle setting without the landing gear being down and locked). As the warning horn continued to sound, he asked the flight engineer to check the state of the landing gear on the flight engineer panel and moved the flap selector back to the 'flaps 20' detent. He believed that this action would redirect hydraulic flow to the landing gear.

Analysis of the cockpit voice recorder indicated that the flight engineer's reply to the pilot in command's question was less distinct, or more distant, than previous flight engineer comments. His response of 'four—four greens' was without any tonal inflection that may have indicated a problem. Almost simultaneously with the completion of this comment, air traffic control issued a take-off clearance to another aircraft. The pilot in command later indicated that after the flight engineer's reply, he believed that all of the landing gear was locked down.

The co-pilot acknowledged the landing clearance issued by Air Traffic Control as the aircraft passed 670 feet above ground level and as the pilot in command confirmed that the landing gear selector was 'down and in'. At about the same time the flight engineer volunteered the information that they had 'four greens'. The pilot in command repeated the 'four-green' call and selected flaps 25. The landing gear warning horn immediately sounded again as the flap selector lever was moved out of the 'flaps 20' detent.

As the aircraft passed 500 feet above mean sea level the co-pilot called '500 feet'. This was not acknowledged by the pilot in command but almost simultaneously he asked the flight engineer if all green lights were ON on both primary and secondary indicating systems. The flight engineer responded that they were. The pilot in command commented that he was perplexed by the still-illuminated red gear warning light on the pilots' centre instrument panel. Seven seconds later the flight engineer said that the flaps were still running. The pilot in command's response indicated he was still concerned about the landing gear warning horn.

In the latter part of the approach the aircraft was observed from the control tower to exit the cloud base. Light rain was falling on the airport at the time. As the aircraft continued its approach, very strong condensation vortices were evident. The attention of observers, some of whom were able to communicate with Air Traffic Services, was initially directed at these

vortices rather than at the position of the landing gear. The visibility in the area of the aircraft was approximately 2,500 metres, but was fluctuating with the passing showers.

At 1220, as the aircraft descended through 170 feet above mean sea level, the pilot in command selected flaps 30 and quietly commented 'flaps 30 green light'. The pilot later indicated that this comment meant that he had selected the briefed flap position and that this completed checklist actions. At the time of the comment the inboard flaps were approaching the flaps 25 position and the outboard flaps were probably load limiting to the flaps 25 position, due to the airspeed still being 183 knots (26 knots above nominated threshold speed).

The Air Traffic Control surface movement controller observed that the approaching B747 did not have its nosewheel extended. He alerted the aerodrome controller, who transmitted the information to the aircraft. The warning was given after the mainwheels were on the ground and as the nose was being lowered. The initial reaction of the two pilots to the Air Traffic Control alert was to initiate a go-around, but there was quick recognition by the flight engineer followed immediately by the pilots that this was not possible, because reverse thrust had been selected. Ten seconds later the nose was gently lowered onto the runway.

Figure 1. The aircraft on the runway with its nose-gear retracted.

The control tower team leader activated the crash alarm as the nose contacted the runway and the Rescue and Fire Fighting Service dispatched crews in response.

Whilst the aircraft was still moving along the runway, the pilot in command used the public address system to advise the occupants of the cabin to remain seated. As he was completing this and shortly before the aircraft stopped, the flight engineer called for the engine fire handles to be pulled. Seven seconds later, the flight engineer indicated to the pilots that there should have been five lights on his panel and not the four that he had reported.

The fire services directed foam at the point of contact (see figure 10) between the aircraft and the runway as there appeared to be smoke and steam emanating from this area. Radio

communications were established between the pilot in command and the fire chief and it was confirmed that there would not be an evacuation of the aircraft occupants.

The fire crews entered the aircraft through a front door at 1237 and ensured that there was no internal fire. Shortly afterwards, external stairs and buses arrived at the scene and the occupants were disembarked.

1.2 Injuries to persons

	Crew	Passengers	Other	Total
Fatal	-	-	-	0
Serious	-	-	-	0
Minor/none	21	253	-	274
TOTAL	21	253	0	274

1.3 Damage to aircraft

The aircraft sustained substantial abrasive damage to the forward fuselage undersurface.

1.4 Other damage

There was no damage to other property or objects.

1.5 Personnel information

1.5.1 Pilot in command

Pilot in command	Male, aged 58 years	
Highest licence	Airline transport pilot licence	
Medical certificate	Class one, valid to 30 April 1995	
Medical restriction	Vision correction required (glasses were worn)	
Instrument rating	Multi-engine command, valid to 17 September 1995	
Flying experience	Total hours	Last 90 days
	21,500	74
B747, various models	7,500	74
Previous types (last 20 years)	B707, L-1011, MD-500D	
Last proficiency check	17 September 1994	

The pilot in command had retired from Cathay Pacific Airways in October 1991 after 30 years of service, the last 15 of which had been as a senior check captain on B707, L-1011 and B747 aircraft. He had been a training and checking pilot for 21 years. Ansett had recruited him through an outside aircraft crewing agency for an initial three-month period as a line training pilot for their new international B747 operations.

For the 18 months prior to being employed by Ansett, the pilot in command was contracted to Mandarin Airlines as a training pilot operating a B747SP. This contract expired on 31 August 1994. Whilst completing his contract commitments with Mandarin Airlines, the pilot in command attended Ansett's B747 lecture series, which covered topics such as emergency procedures, flight planning and weight and balance. These lectures were attended by all contract and Ansett technical crew members. In addition, the contract crew members attended a two-hour session covering general administrative matters such as pay procedures and the issue of uniforms. The pilot in command was issued with some procedural notes and some of Ansett's manuals during this period and the remainder were issued to him on 16 September 1994.

On 17 August 1994, the pilot in command completed the first of three simulator exercises in a Qantas B747-200/300 simulator. This exercise was conducted over four hours with him acting as co-pilot for the first two hours and as pilot in command for the remainder. The exercise firstly exposed the pilot to both Qantas and Ansett operating procedures and then assessed his general handling ability.

On 17 September 1994, the pilot in command was tested in a simulator for a command instrument rating by an approved testing officer from Qantas. He passed the test, which concentrated on command instrument rating requirements and tolerances, but was not assessed on performance with respect to Ansett's operating policies or procedures. However, a comment was made by the testing officer that the pilot in command was unaware of Ansett's method of performing phase one (immediate) responses to emergency situations.

Two days later, on 19 September 1994, the pilot in command flew his third exercise in a simulator. This exercise assessed his ability as a training pilot in the right seat and simulated operations in the Hong Kong aviation environment. The pilot performed phase-one procedures according to Ansett's methods during this exercise. Ansett's acting director of flight operations, who was not B747-qualified, observed this third simulator exercise, to assess the training ability of the pilot.

The pilot in command's first flight as a crew member in one of Ansett's B747 aircraft was his line check on 23 September 1994. He passed the check and then flew seven sectors as a co-pilot. Four sectors were with the Ansett fleet manager for the B747, who was newly cleared to the line, and the other three were with contract pilots. On 9 and 11 October 1994, he flew as pilot in command with a contract pilot acting as co-pilot. The 19 October 1994 flight was the pilot in command's first in a training capacity with a pilot from Ansett who had not been cleared to the line.

The pilot in command spent the 72 hours prior to the accident at home and with his family. His sleep patterns were normal and he was not involved in strenuous physical activities. There were no stressors likely to preoccupy him. He was happy to be flying from his home base in an aircraft type with which he was familiar and which he enjoyed flying.

The pilot in command said that when he started with Ansett, he did not know 'the Ansett way of doing things'. Evidence from B747 crew members and from flight operations management indicated that contract crew members were expected to learn the procedures by reading manuals (which were being amended progressively), undergoing simulator training and learning from the Ansett employees with whom they flew. He felt that the procedures being used by the crews caused some confusion on the flight deck during the trips that he had flown.

The pilot in command was aware that the co-pilot had completed his line training but needed a refamiliarisation flight before a line check, due to a short period of illness.

1.5.2 Co-pilot

Co-pilot	Male, aged 35	
Highest licence	Second class airline transport pilot licence	
Medical certificate	Class one, valid to 24 January 1995	
Medical restriction	None	
Instrument rating	Multi-engine command, valid to 31 August 1995	
Flying experience	Total hours	Last 90 days
	7,100	80
On type	80	80
Previous types (last 13 years)	L-188, F.27, BAe 146, B727	
Last proficiency check	31 August 1994	

The co-pilot was an experienced B727 co-pilot when he applied for upgrade to the B747 aircraft in response to Ansett's call for expressions of interest for transfer. He was advised on Thursday, 30 June 1994 that his application had been successful and he was told to report to the Qantas Jet Base in Sydney the following Monday to commence a training course. He was also asked to complete his rostered flying for the weekend before starting the training.

Qantas' philosophy of training was different to that of Ansett. Ansett's training philosophy emphasised learning throughout the simulator and endorsement training program with a proficiency check at the end of the program, whereas the Qantas method required crews to complete each simulator training session to a minimum standard before the next session could be commenced. Qantas then had a final check at the end of the simulator program. The co-pilot said that he found that he had to work very hard to keep up with training expectations. He indicated that the variety and extent of Ansett initiated amendments to manuals and procedures added to his difficulties.

On 23 August 1994, the co-pilot passed his final simulator check, which incorporated his multi-engine command instrument rating renewal. The simulator session included a requirement to act as co-pilot in support of another trainee undergoing a final check. Six days later, he completed 40 minutes of circuit flying in one of Qantas' aircraft to complete that part of the endorsement process.

The co-pilot said that he had received minimal briefings or exposure to the overseas operational environment prior to commencing B747 line training, which was conducted during revenue flights to both Hong Kong and Osaka. However, he had obtained some international experience during operations in the South Pacific while seconded by Ansett to another operator in 1988-89. The expectation of management was that the co-pilot would be trained by the contract training pilots during the line-flying phase of his training.

He was issued with an Ansett route manual for overseas operations but said that he did not receive the amendment covering operations into Hong Kong and Osaka until after the accident. Ansett said that the amendment was issued on 4 August 1994.

When interviewed, the co-pilot said that having to teach Ansett's methods of operations to his training pilot whilst also learning his own duties in a new aircraft and a new operating environment made his line training very difficult.

After 80 hours under training, the co-pilot was programmed for his line check, but was prevented from attempting it due to an illness which precluded him from flying for two weeks.

When he recovered from the illness, the co-pilot was rostered to fly to Osaka on a consolidation flight on 19 October 1994. It was expected that he would be rostered for a line check shortly afterwards.

In the 72-hour period before the flight the co-pilot relaxed and studied for the flight.

1.5.3 Flight engineer

Flight engineer	Male, aged 49	
Highest licence	Flight engineer licence	
Medical certificate	Class one	
Medical restriction	Vision correction required (glasses were worn)	
Flying experience	Total hours	Last 90 days
	8,650	118
On type	118	118
Previous types (last 22 years)	L-188, B767	
Last proficiency check	14 October 1994	

The flight engineer commenced duties as a L-188 (Lockheed Electra) flight engineer in November 1972 and 18 months later was promoted to training flight engineer for L-188 aircraft. In August 1981, he was approved as a check flight engineer on L-188 aircraft. He completed an endorsement onto B767 aircraft in August 1983 and became a training flight engineer on this aircraft at the end of 1990. In October 1992 the Civil Aviation Authority approved the flight engineer to act as a check flight engineer on B767 aircraft. He applied for promotion to the B747 program and received approval of his application two days before the training course started in Sydney on 4 July 1994.

During the endorsement training conducted by Qantas, the flight engineer was required to use manuals and procedures from two organisations (Qantas and Singapore Airlines/Boeing) which had operational philosophies different to those of Ansett. The procedures that the flight engineer was expected to use were also being modified as his course progressed. He participated in four extra simulator exercises due to other crew members requiring repeat simulator sessions. Qantas provided eight different flight engineer instructors during his 15 simulator exercises and the flight engineer said that each appeared to have slight variations in their interpretation of procedures to be used. He said that he did not sleep well throughout the ground-school phase of his training. The flight engineer said that these factors contributed to him finding the ground and simulator training the most difficult and stressful of his flying career. He failed his final simulator endorsement check but passed a further check the next day.

At the end of the training of the first group of Ansett pilots and engineers, the number of flight engineer instructors for each trainee was discussed by Ansett with Qantas. Qantas explained that they normally used a number of different instructors for each trainee as it was considered to be beneficial to the student.

During the line training trip prior to the flight engineer's first rostered line check, the Civil Aviation Authority flight engineer inspector travelled on the flight deck as part of his surveillance duties. As a result of his observations during that flight, the inspector informally commented to the training flight engineer that the flight engineer would need more training before he could be considered ready for a line check. The inspector made this informal comment as an experienced check flight engineer. The training flight engineer did not document or report the comment to flight operations management as he attributed the

observed poor performance to nervousness and considered that the flight engineer's performance on the second sector had improved to a standard satisfactory for a line check. The training flight engineer, who was flying with the flight engineer for the first time, knew nothing of the flight engineer's background, had previously acted as a trainer only on B707 aircraft and had not trained at all for more than 20 years.

After a total of seven sectors and 56 hours of line training, with three different contract training flight engineers, the flight engineer commenced a line check. His performance on the first of three check sectors was unsatisfactory, with the check report indicating poor panel skills. On the takeoff for the second sector the pilot in command had to reject the takeoff. The contract training and checking flight engineer assessed the flight engineer's performance during this rejected takeoff as unsatisfactory. After the completion of the second sector the check flight engineer debriefed the flight engineer and then converted the final sector of the check into a training sector. He recommended that more training be completed before another check flight was scheduled. He later indicated during interview that the flight engineer's performance was below what he expected and below the standard he had experienced during his previous 15 years as a checking flight engineer.

The flight engineer passed a second line check on 14 October 1994, after a further two sectors and 18 hours of training. He said that he found the flight training phase to be as stressful, confusing and high-pressured as the ground-school phase had been.

The flight engineer said that Ansett's normal operations section of the operations manual was issued to him at about the time that he completed and passed the line-check flight.

After he had passed his line check he was programmed for his first unsupervised flight to Osaka on 19 October 1994. In the 72 hours prior to the flight, he did not engage in any strenuous physical activities. He centred most of his activities in this period around his home and family and spent the previous night studying various aspects of B747 operations, including a number of emergency procedures. The flight engineer reported that he did not sleep well and that he woke early on the morning of the flight.

The flight engineer said that the B747 was the 'first old fashioned aircraft that he had flown which had a side-facing flight engineer panel'. He said that the workload on this aircraft was more intense than he had previously experienced.

The investigation team spoke to most of the contract flight engineers who were associated with the flight engineer during his flight training program. They described him as a keen and conscientious but nervous person who acquired necessary skills and knowledge through a slow and methodical learning process. His principal trainer assessed him as lacking in confidence and appearing demoralised after the first line-check failure. The only observation included on the four weekly reports raised to cover the 15 training and checking sectors flown by the flight engineer in the six weeks before the accident flight, was that he was conscientious.

1.5.4 Cabin crew

The flight attendants commenced employment with Ansett International between 26 June 1994 and 1 August 1994. All completed the eight-day induction course on safety training in July or August 1994. Four of the flight attendants had previously been employed as flight attendants, but only the cabin manager had come from the operator's domestic operations. All flight attendants were tested at the end of their induction course for proficiency in procedures specified in Civil Aviation Order 20.11.12 and appendix IV to Civil Aviation Order 20.11. These procedures were taught, practised and tested in the operator's moving base B737 simulator or by utilising equipment in Singapore Airlines' B747 aircraft, as they passed through Melbourne. All training was conducted in accordance with Ansett International Limited's emergency procedures manual.

1.6 Aircraft information

1.6.1 Aircraft

Manufacturer	Boeing Aircraft Company
Model	747-312
Serial number	23026
Registration	VH-INH
Country and date of manufacture	United States, 15 April 1983
Certificate of airworthiness	CAN/10034
Issued	2 September 1994
Certificate of registration	CAN/10034/01
Issued	31 August 1994
Total airframe hours	51,372
Engines	4 X Pratt and Whitney JT9D-7R4G2
Engine type	Turbofan
Last major inspection	Heavy maintenance visit Singapore, May 1992
Last inspection	Check 3A, Sydney New South Wales, 3 October 1994
Hours since last inspection	144
Cycles since last inspection	21
Total airframe cycles	9,414

1.6.2 Aircraft history

The aircraft was new when entered onto the register of civil aircraft of the Republic of Singapore as 9V-SKA on 29 April 1983. It operated under that registry with Singapore Airlines until 31 August 1994 when it was deregistered.

The aircraft was leased to Ansett International Limited and was entered onto the register of Australian civil aircraft on 31 August 1994 as VH-INH. It flew 456 hours during 70 flights with Ansett prior to the accident.

The aircraft did not have any record of previous accident or incident damage.

1.6.3 Significant particulars—number one engine

Manufacturer	Pratt and Whitney
Type	JT9D-7R4G2
Serial number	P715157
Date of manufacture	17 October 1985
Total operating hours	32,944
Total cycles	6,327
Last shop visit	Singapore, 10 February 1994
Hours since last shop visit	2,678
Cycles since last shop visit	539
Date installed VH-INH	22 August 1994
Hours since installation	456
Cycles since installation	70
Last maintenance check	Check 3A, Sydney New South Wales, 3 October 1994
Hours since last check	144
Cycles since last check	21

1.6.4 Engine history

After the engine was released from its 10 February 1994 shop visit, it was installed onto Singapore Airlines' B747-312, registered N123KJ. It operated on this aircraft until removed for fitting to the accident aircraft on 22 August 1994. During the transfer between the two aircraft the engine had a 'stagger check' which was essentially a visual inspection. No oil leaks were recorded.

On 12 September 1994 engineering reports began recording higher than normal oil consumption by the engine. By 17 October 1994, the consumption had increased to 0.61 United States quarts per hour, which approximated the maximum allowed in the B747 maintenance manual, but was less than the ramp maintenance manual upper limit of 1.0 United States quarts per hour.

1.6.5 Significant particulars—angle gearbox housing

Part number	791673
Serial number	MH1245
Hours since new	39,385
Cycles since new	7,161
Last reconditioning	Singapore, 10 February 1994
Installed on engine P715157	Singapore, 10 February 1994
Hours since installation	2,678
Cycles since installation	539

1.6.6 Angle gearbox history

The angle gearbox housing was reconditioned prior to installation onto engine P715157 in February 1994. There was no record of any work being completed in relation to the angle gearbox housing cover Part Number 788874 nor to the inserts Part Number 788870.

The cover was installed after the gearbox assembly was fitted to the engine prior to the engine being installed onto aircraft N123KJ in February 1994. There is no record of the cover being disturbed since that installation; it was not required to be disturbed during the engine's installation on the accident aircraft in August 1994.

1.6.7 Significant particulars—nose landing gear door actuator and number one air-driven hydraulic pump

	nose landing gear door actuator	number one air-driven hydraulic pump
Part number	60B00230-4	350880-7
Serial number	0916	MX489416
Hours since new and installed	51372	51372
Cycles since new and installed	9414	9414
Date of installation	15 April 1983	15 April 1983

1.6.8 Nose landing gear door actuator history

There was no history of this part having been removed or repaired since installation at the aircraft manufacturer's factory.

1.6.9 Air-driven hydraulic pump history

For the period 31 August 1994 to 19 October 1994, there were three maintenance log entries reporting problems with the number one air-driven hydraulic pump system. These were dated 21 September, 26 September and 10 October. None of the problems could be replicated by engineering staff, despite extensive testing for fault rectification. The system was considered serviceable and no further problems were noted before the accident.

1.6.10 Weight and balance

Maximum permissible landing weight	285,762 kilograms
Total indicated fuel remaining after occurrence	71,920 kilograms
Aircraft zero fuel weight	215,448 kilograms
Calculated landing weight	287,368 kilograms
Overweight by	1,606 kilograms (0.56 per cent)

The aircraft weight at landing was calculated by determining the fuel remaining in each tank after the occurrence and adding the total to the zero fuel weight printed on the loadsheet for the planned flight.

The centre of gravity position was calculated to be 21.9 per cent mean aerodynamic chord which was within the centre of gravity envelope.

The aircraft landing weight was not considered to be a factor in this accident.

1.7 Meteorological information

The automatic terminal information service current at the time of the approach and landing indicated a visibility of 4,000 metres, reduced to 2,500 metres to the east in rain, with three octas of cloud at 350 feet, 3 octas at 500 feet and 3 octas at 1,000 feet. Twenty minutes before the aircraft landed, the trend-type special meteorological conditions forecast indicated a reduction in visibility to 3,000 metres, rain showers, 4 octas of stratus cloud at 500 feet and 6 octas of stratus cloud at 800 feet. Gradual improvement was expected after 1300.

Figure 2. Looking back along runway 16 towards the approach path.

The crew reported that they had the runway in sight from about 1,000 feet during the approach, but the aircraft was flying through rain which was sufficiently heavy to require the co-pilot to have his wipers selected. There was light rain falling as the aircraft touched down.

1.8 Aids to navigation

The navigation aids at Sydney Airport were monitored by Air Traffic Control and were serviceable on the day of the accident. They were not considered to be a factor in the accident.

1.9 Communications

Radio communication was not considered to be a factor in the accident.

1.10 Aerodrome information

Sydney (Kingsford-Smith) International Airport was equipped with two sealed runways, 16/34 which was 3,962 metres long, and 07/25 which was 2,529 metres long. The aircraft landed on runway 16. Full air traffic services were in operation.

1.11 Flight recorders

1.11.1 Digital flight data recorder

The aircraft was equipped with a Lockheed Aircraft Services Model 209 digital flight data acquisition and recording unit which recorded 20 parameters.

After the accident, the flight data recorder was removed from the aircraft and the data was successfully recovered. It was noted that the pitch parameter was unserviceable, but its unavailability did not hinder the data analysis.

See insert in the rear cover of this report for a graphical presentation of relevant flight data recorder parameters.

1.11.2 Cockpit voice recorder

The aircraft was fitted with a Fairchild A100 cockpit voice recorder.

Parts of the record of communication from the cockpit voice recorder are reproduced on the flight data recorder graphical presentation insert, because of the pertinence of those parts to the analysis of this accident. This is not a complete transcript of all comments during that period; only those comments pertinent to the analysis of the final approach have been included.

During replay of the cockpit voice recorder, it was discovered that the flight engineer's radio transmissions were recorded on the same channel as the pilot in command audio. The normal channel distribution is one for the recording of audio associated with each flight-deck crew position and one for audio detected by the cockpit area microphone. The aircraft was delivered to Ansett with this incorrect channel recording sequencing and the reason for the fault was not determined.

Due to the incorrect channel allocation, some of the replayed cockpit voice recorder data was indistinct or barely audible, and instances of simultaneous communications occurred. Channel isolation, and manipulation and enhancement of the audio signal contributed to the recovery of all but a few words in the final minutes of the recording.

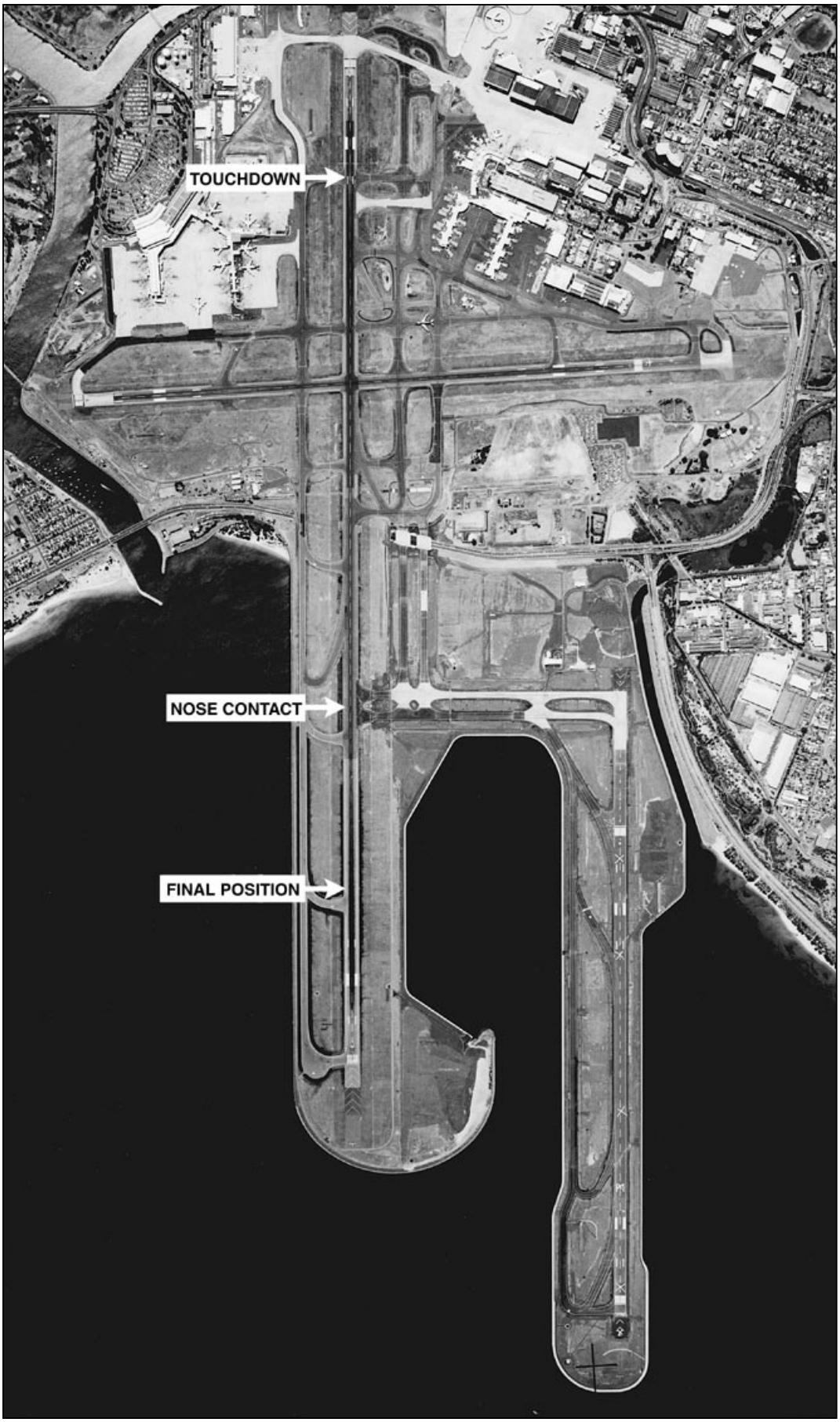

Figure 3. Photograph of Sydney Airport indicating the approximate touch-down, nose contact and stop points on R/W 16.

1.12 Wreckage and impact information

1.12.1 Accident site description

The aircraft touched down approximately 540 metres from the threshold of runway 16 (now 16R), abeam taxiway F (see figure 3). It came to a halt in the centre of the runway with its nose approximately 50 metres north of the entrance to taxiway A5. A scrape mark on the runway indicated that the fuselage first contacted the runway surface adjacent to the island between taxiways B10 and B11 (see below). The scrape mark continued for 810 metres to the point where the aircraft stopped. The total distance from the initial touchdown of the aircraft to the point where it stopped was approximately 2,770 metres.

Figure 4. Commencement of scrape mark.

The damage to the aircraft was confined to abrasive wear and distortion of fuselage skin, stringers and frames in a 3.8-metre section under the front of the aircraft, including the rear 0.5 metres of the nose-gear door. Some of the skin was worn away completely, allowing steam and 'hot smells' to infiltrate to the forward cabin via the forward avionics bay. Several antennae were damaged or broken off during the sliding contact of the fuselage undersurface with the runway.

An inspection of the cockpit revealed that the aircraft had been secured by the flight crew after the accident and that all aircraft systems had been shut down. Electrical power was

subsequently supplied by external units and an examination of the landing gear indication system showed that:

- all lights on both the pilot and flight engineer stations were serviceable;
- the red gear light on the pilots' centre instrument panel was illuminated; and
- with both primary and alternate selections on the flight engineer annunciator panel, the four wing and body-gear green lights illuminated but the fifth, nose-gear light did not illuminate.

1.12.2 Technical examination of nose landing gear system

1.12.2.1 Landing gear extension tests

Engineers raised the nose of the aircraft and released the nosewheel manually. With the nose landing gear down and locked, the aircraft was towed away and jacked for testing of the gear retraction/extension capabilities. The tests were repeated a number of times and all parts of the system functioned normally. The number one and number four hydraulic systems were powered by the number one and number four air driven pumps through the use of an external pneumatic unit for the tests, as both systems are used in landing gear and trailing edge flap operations (see diagram at figure 5 for details of the hydraulic system). The external pneumatic unit is a ground start unit supplying normal operating air pressure to the common manifold.

Apart from minor discrepancies directly attributable to damage in the nosewheel area, normal cockpit indications on both the pilot and flight engineer panels were observed during the landing gear extension and retraction tests. In particular:

- With the air-driven hydraulic pumps selected to 'AUTO', the hydraulic system pressures exhibited normal values during operation of the landing gear and flap systems.
- When 'gear down' was selected, extension time was normal and all green down and locked indications appeared on the pilots' and flight engineer's panels, using both the primary and alternate systems. This did not occur on the accident flight.
- With the gear up or extending, and the flaps selected beyond flaps 20, the landing gear warning horn came on and could not be silenced.
- When the gear was selected down while the flap was still running, the flap extension continued and the gear extended normally. This did not occur on the accident flight.

1.12.2.2 System description

(a) Nose landing gear

Landing gear extension or retraction is initiated by moving the selector handle on the centre instrument panel. This action moves a selector valve which directs number one system hydraulic pressure to the appropriate body and nose landing gear actuators.

On the nose landing gear side, the pressure passes through the gear operated sequence valve to the 'unlock' port of the door actuator. The nose landing gear door, the door-operated sequencing valve, the gear-operated sequencing valve and the nose landing gear lock actuator are all mechanically interconnected. This means that unless the door opens and repositions the pilot valve within the door operated sequencing valve, which in turn introduces hydraulic pressure to the nose landing gear lock actuator, the nose landing gear unlocking and extension cycle cannot commence.

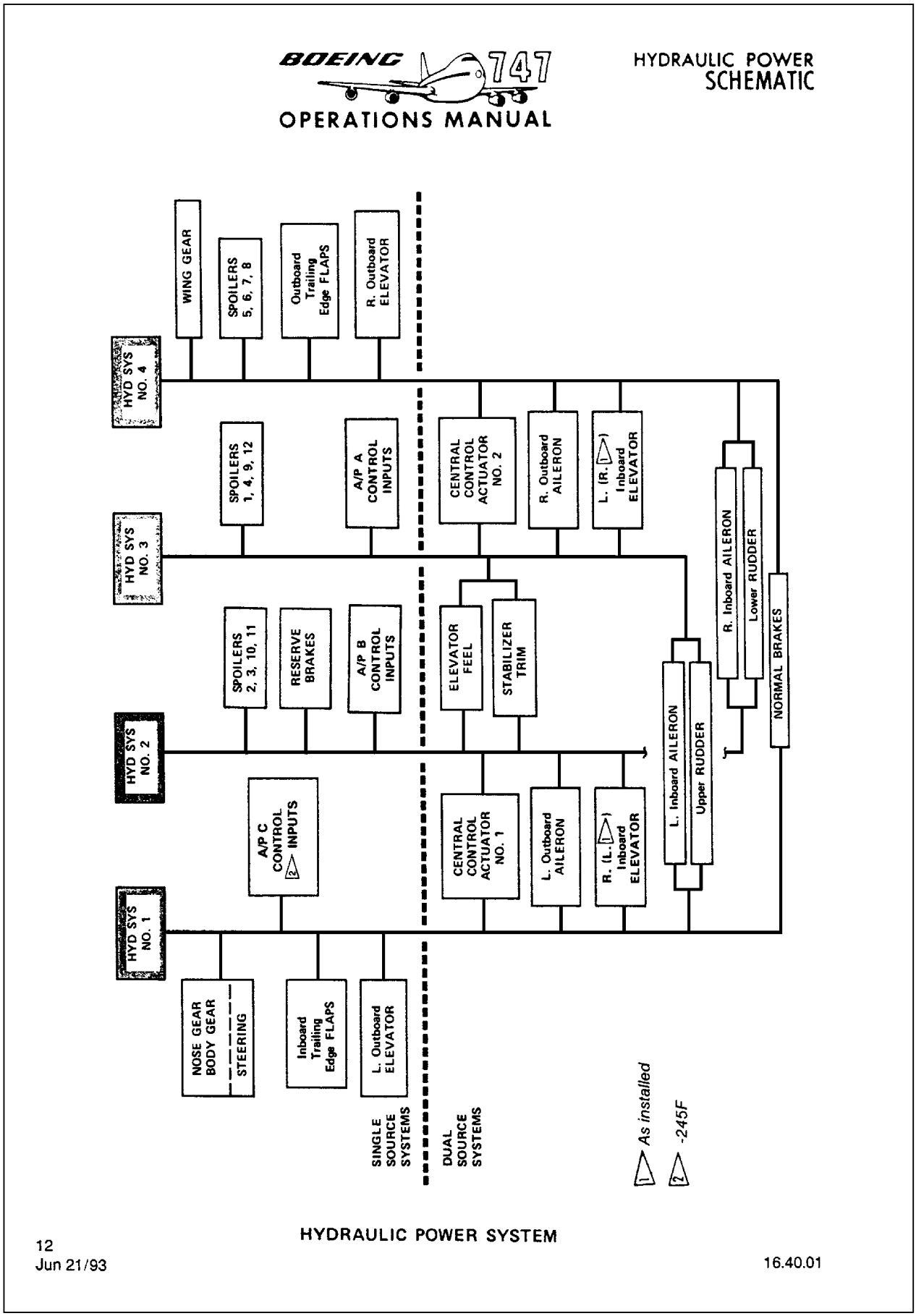

Figure 5. Schematic of the hydraulic services and their power sources on the B747-312.

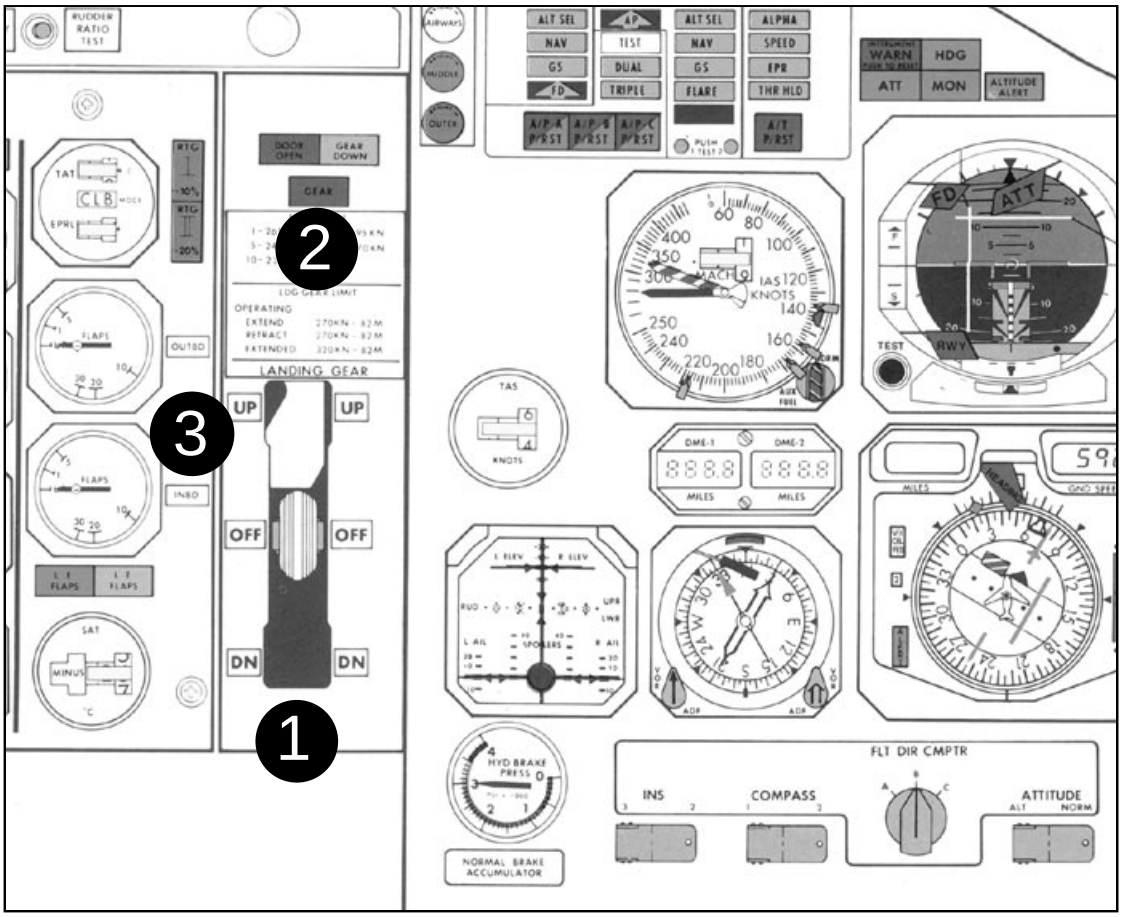

Figure 6. Portions of centre and co-pilot instrument panels with landing gear selector handle (1); red gear unsafe light (2); and inboard flap indicator (3) marked.

The nose landing gear door actuator is fitted with an internal lock which can be either hydraulically or mechanically unlocked. The hydraulic activation of the lock is used in normal operations and the mechanical unlocking is used during alternate (non-normal) gear extension procedures.

The nominal landing gear extension time is 19 seconds.

(b) Hydraulic system

The number one hydraulic system is the single source of hydraulic power for the body and nose landing gear extension and for operation of the inboard trailing edge flap. Hydraulic power for the system can be provided either by the engine-driven hydraulic pump, the air-driven hydraulic pump or both pumps together. The engine-driven pump and the air-driven pump are two identical, variable displacement pumps capable of delivering approximately 32 gallons per minute at 3,000 pounds per square inch. The engine-driven pump is the primary source. The air-driven pump, driven by air from the common pneumatic manifold, is the secondary source activated when the flow demand on the engine-driven pump exceeds its maximum capacity.

The air-driven pump operating mode depends on the position of the air-driven pump switch on the flight engineer's panel. With the switch in the 'OFF' position, the pump will not run. With the switch in the 'CONTINUOUS' position the pump will run continuously whenever airflow from the pneumatic manifold is available, regardless of the engine-driven pump's output pressure. With the switch set to the 'AUTO' position, the pump will start automatically and operate on system demand to maintain the system pressure above 2,600 pounds per square inch.

The operations manual's normal procedures require the air-driven pump selection switch to be placed in the 'AUTO' position after the engine start. The engine failure and shutdown procedure does not require the switch position to be altered. The flight engineer said that he had selected the number one air-driven pump to 'AUTO' after start.

Data provided by Boeing indicated that at an aircraft speed of approximately 210 knots (speed at which the landing gear extension was initiated), the engine-driven pump driven by a windmilling engine would still be capable of providing approximately 11–12 gallons per minute of hydraulic flow at the system pressure of 3,000 pounds per square inch. The flow would be reduced to approximately 6–7 gallons per minute of useful flow, when allowance is made for Boeing's estimation of the system's internal leakage rate. With the air-driven pump switch in either the 'AUTO' or 'CONTINUOUS' position, the air-driven pump would have been capable of delivering an additional 32 gallons per minute. This would have combined to provide approximately 38–39 gallons per minute of useful flow at around 3,000 pounds per square inch.

Although the normal hydraulic system static pressure is 3,000 pounds per square inch, operation of the landing gear and flaps reduces the system pressure below this level. Boeing designed the gear unlocking systems such that the main landing gear normally unlocks at pressures around 1,000 pounds per square inch and the nose landing gear usually above 1,500 pounds per square inch.

1.12.2.3 Component testing

(a) Nose landing gear actuator

All components in the nose landing gear extension and retraction system which could have contributed to the non-extension of that landing gear were removed and forwarded to their respective manufacturers in the United States for compliance testing against appropriate specifications.

All components, except for the nose landing gear door actuator, fully satisfied the compliance test requirements and their strip examinations failed to find any fault.

The nose landing gear door actuator was tested to establish the pressure and torque needed to unlock the internal lock. The range of pressures stipulated by Boeing testing procedures are from a minimum of 350 pounds per square inch with no simulated air loads on the door to an upper limit of 1,650 pounds per square inch with the maximum simulated air load. The maximum allowed unlock torque is 175 pound inches.

When the pressure was applied under test procedure conditions, that is, the test pressure was applied instantaneously, the unlock pressures needed to unlock the actuator ranged between 700 pounds per square inch and 1,750 pounds per square inch.

During further tests, which were not conducted according to the manufacturer's test specifications, it was noted that when the pressure was progressively raised to the test levels, the unlock pressure ranged from 1,200 pounds per square inch to 2,500 pounds per square inch. On two occasions, the pressure was raised to 3,000 pounds per square inch without the actuator unlocking. Dismantling of the actuator did not disclose any reason why it had failed to unlock.

The torque required to unlock the actuator ranged from 125 pound inches to 250 pound inches.

Other testing and strip examination of the actuator did not reveal any further deviations from specifications or any defects.

(b) Air-driven hydraulic pump

The air-driven hydraulic pump and its drive were extensively tested by their respective manufacturers in the United States for compliance against specification.

Both were found to be well within the specification limits in all parameters tested. No defects were found that could have contributed to the accident. No internal faults were found during a detailed strip examination of the air-driven pump.

1.12.2.4 Other system tests

The number one hydraulic system module from the flight engineer panel was removed for examination of the air-driven pump switch control circuitry. Proximity switches from the landing gear legs were also removed for functional inspection. These examinations found no faults which may have affected normal operation of the switches.

A leakage and blockage check was performed on the number one hydraulic system. No faults were found.

Hydraulic fluid was sampled from a number of sources within the number one hydraulic system. These were found to conform to specifications. No particles which would have restricted normal flow were found in the system filters.

No defects were reported or found in the pneumatic manifold which could have prevented the air-driven pump from operating normally. The duct is a common duct with air normally supplied from all four engines. During the approach to Sydney, the remaining three engines were supplying the duct and only two of the three airconditioning and pressurisation packs were being operated.

1.12.3 Engine oil leak

1.12.3.1 Oil consumption history

Two days after the aircraft entered service with Ansett, reports commenced regarding higher than normal oil consumption. The B747 ramp maintenance manual, which would normally be used as a reference on the flight line, states a normal oil consumption range of between 0.5 United States pints and 1.0 United States quarts per hour. However, the B747 maintenance manual is more stringent and specifies a maximum of 0.6 United States quarts per hour.

A week after the aircraft had entered service, Ansett's engineers assessed the oil consumption as being 0.45 United States quarts per hour, and this had increased to 0.61 United States quarts per hour two days before the accident flight. Ansett Engineering consulted both the owner and the engine manufacturer in an effort to identify and rectify the cause of the excessive oil consumption, but the source was not found.

During the day prior to the accident, the aircraft had flown 20 hours and the engine required the addition of 13 United States quarts of oil. Pratt and Whitney's representative inspected the engine and recommended that Ansett should monitor the consumption for several more days before deciding on an engine change. In the hour after takeoff, on the accident flight, the engine had lost approximately seven United States gallons of oil before being shut down.

1.12.3.2 Engine testing and inspection

The number one engine was removed from the aircraft and transported to Singapore Airlines' maintenance facility for inspection and testing. During testing, a substantial oil leak was observed emanating from the base of the fan exit case at the cover assembly.

The cover was removed and the angle gearbox housing cover was found to be partially detached, allowing overboard spillage of engine oil (see below).

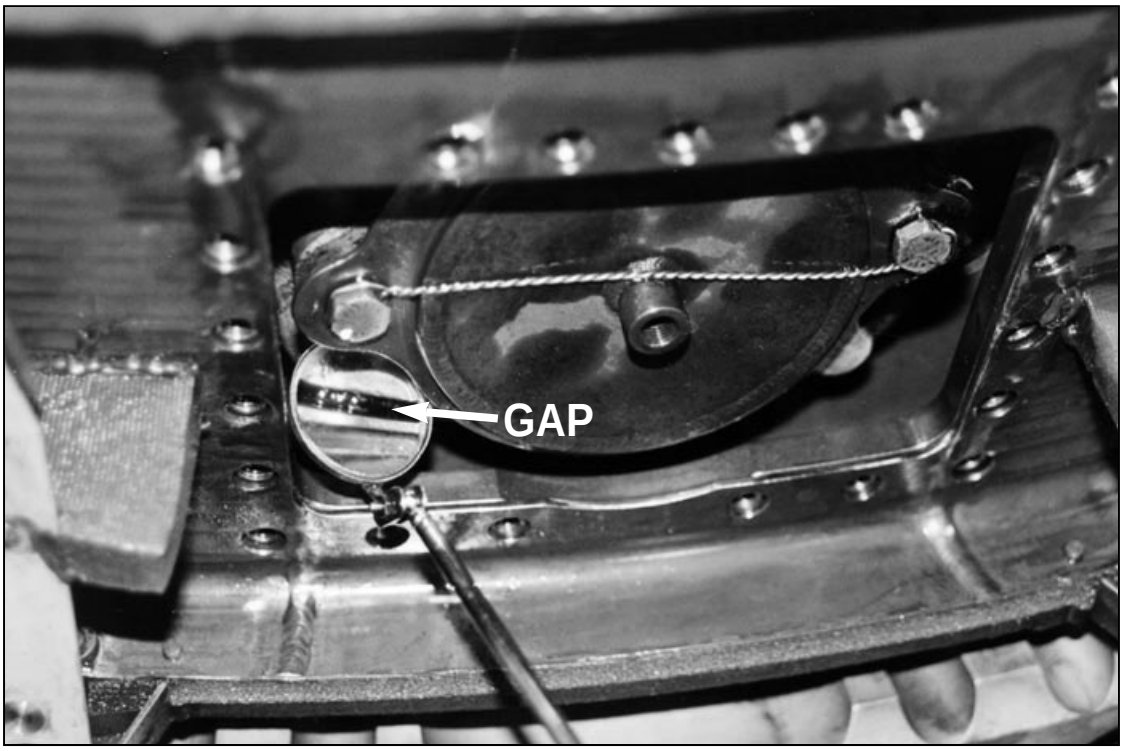

Figure 7. Partially detached angle gearbox housing cover.

The angle gearbox housing cover is secured to the angle gearbox casing by two bolts which attach to the casing by screwing into steel-threaded inserts, which in turn are screwed into holes in the casing. The left steel-threaded insert was loose in the casing but remained bolted to the cover. The right insert was secured within the casing, with the cover retaining bolt in place. Both bolts were lockwired together and had not rotated.

During installation each insert is locked in place by a pin which is located in an angled hole drilled into the gearbox casing. When the cover was removed from the casing, it was evident that the internal thread in the gearbox casing, that would have retained the left insert, had been destroyed (see figure 8).

A replacement gearbox was fitted and the engine retested. This test recorded an oil consumption of 0.125 pints per hour, which was consistent with other engines in service.

1.12.3.3 Access cover assembly inspection

The nature and extent of the wear of those areas of the access cover assembly which had been in contact with the locking wire indicated that the cover had been subject to vibrational loads during operation.

The threaded left insert had been tightened against the angle gearbox housing cover. Examination of the cover showed definite imprints consistent with the impressions of the heads of both inserts. The right insert was found to be flush with the case. The failed insert had been installed either proud of, flush with, or at an inadequate distance below the casing surface.

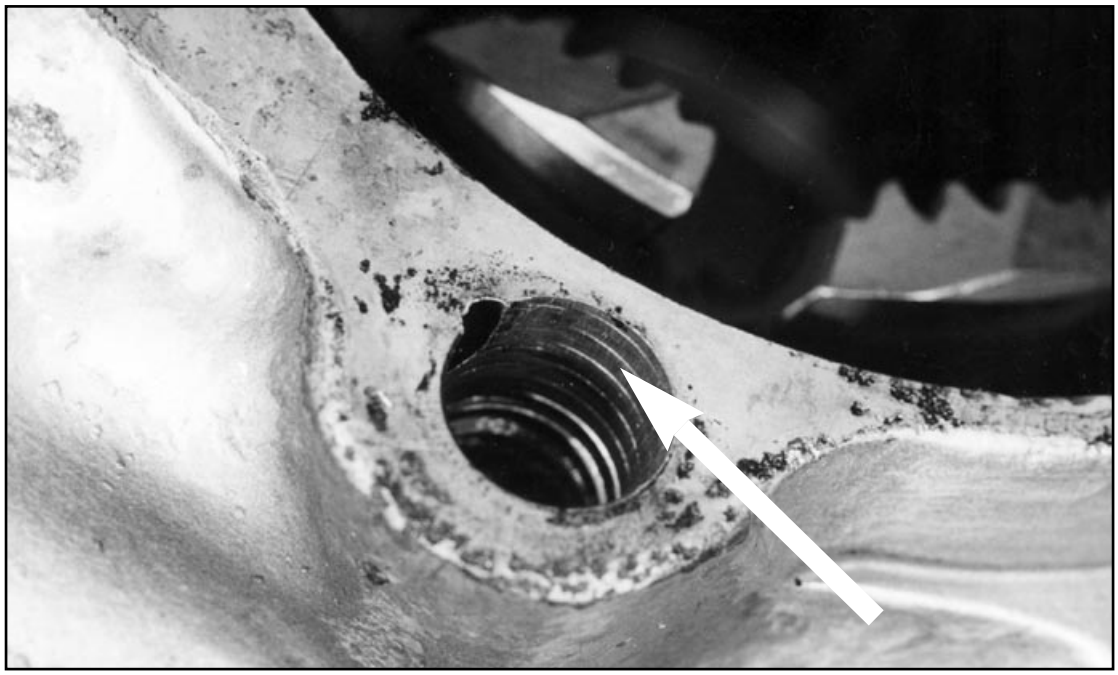

Figure 8. The metal threaded insert had milled out the internal threads of the gearbox casing.

The left insert exhibited signs of wear associated with vibratory loading. This was extensive in the region of contact between the locking pin and the thread insert. Extensive wear had also occurred as a result of movement between the flanks of the external thread of the insert and the internal thread of the gearbox casing.

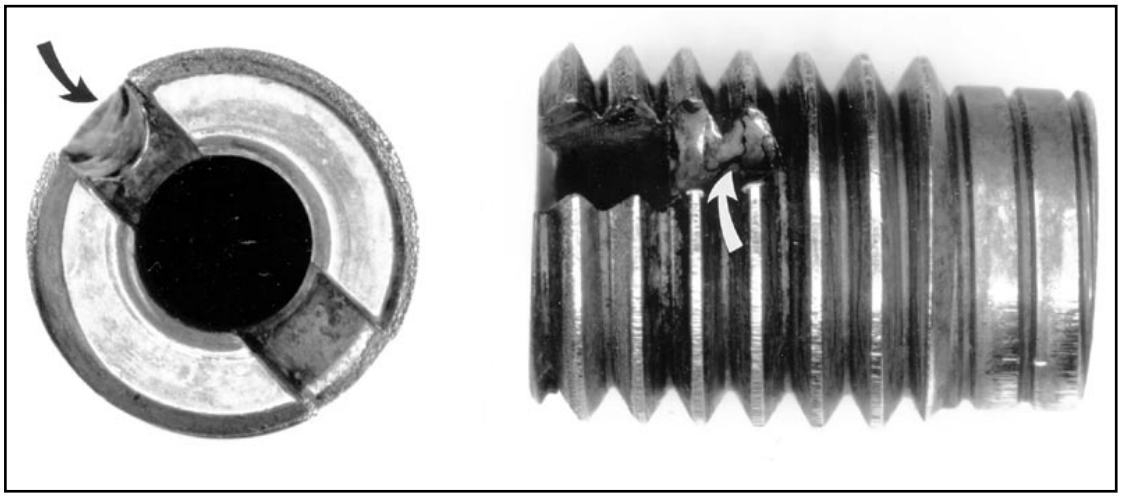

Figure 9. The detached thread insert showing the extent of wear created by relative movement between the locking pin and the insert. Magnification 4.3X.

1.12.3.4 Wear in threaded inserts

When a bolt is tightened into a threaded insert, the degree of preload will depend on whether the top of the insert is proud of or below the casing surface. If the top of the insert is proud, the bolt will tighten the cover to the insert and no preload will be placed on the insert/casing thread interface. This condition would allow any vibration of the cover to be transferred to the insert/casing thread interface. A similar situation may arise if the top of the insert is not a sufficient distance below the casing surface to allow for stretch when the bolt is tightened. If the insert is far enough below the surface, the bolt will tighten the cover

to the casing and preload the bolt/insert thread interface as well as the insert/casing thread interface, thus creating a frictional force which resists movement between the threads.

1.12.3.5 Installation of angle gearbox threaded inserts

The procedures that relate to the installation of the steel inserts are contained in the manufacturer's engine assembly drawings and engine manuals, and in an early service bulletin.

The manufacturer's original design philosophy was to obtain preload on the insert threads by bottoming the insert in the casing. However, this was not always achieved because manufacturing tolerances, and the need to align the insert with the retaining screw slots in the housing, precluded consistent bottoming of the insert. Two changes made by the manufacturer in an endeavour to achieve insert preload were:

- The insert length was changed.
- The assembly drawing was changed to include a requirement to have the insert flush with or below the surface of the casing. Bottoming of the insert was not a drawing requirement.

Both the Pratt and Whitney engine manual and Service Bulletin JT9D-7R4-72-307 stipulate that the inserts are to be installed flush with or below the surface of the angle gearbox casing. The service bulletin was issued to introduce an improved insert and had a compliance of category seven (to be accomplished when the supply of superseded parts has been depleted).

1.12.3.6 History of angle gearbox casing cover oil leaks

Between 1983 and 1985 Japan Air Lines experienced 11 angle gearbox casing cover oil leaks, three of which resulted in an in-flight engine shutdown. In late 1985, Japan Air Lines engineers designed and implemented a modification to the attachment of the angle gearbox housing cover and by 1988 had reduced their rate of cover oil leaks to zero.

In April 1990 Pratt and Whitney issued Service Bulletin JT9D-7R4-72-410 which introduced a modification to the fan exit case cover. The modification ensured angle gearbox cover security in the event that the cover bolt loosened. This modification was similar to that incorporated by Japan Air Lines. The compliance period for incorporation of the service bulletin was category six (to be accomplished when the sub-assembly is disassembled sufficiently to afford access to the affected part). This modification was not incorporated into the accident engine although there had been an opportunity to do so during the shop visit in Singapore in February 1994.

1.12.3.7 Extended range operations

Similar angle gearboxes are fitted to engines of twin-engine aircraft which have been approved for extended range operations. Aircraft included in this category are the B767, A300 and A310. In Australia, the B767 is the only extended range operations approved aircraft type with this angle gearbox on its engines.

The lack of immediate mandatory requirements for the incorporation of service bulletin SB 72-410 and the lack of a requirement to fit inserts at an appropriate depth below the angle gearbox casing surface to ensure adequate preload, exposes these extended range operations aircraft to the possibility of a similar oil-leak scenario.

1.13 Medical information

No injuries were sustained by the crew or passengers during the landing or during the disembarkation.

There was no evidence to suggest that the flight crew suffered from any condition which may have contributed to the occurrence.

1.14 Fire

The Rescue and Fire Fighting Service crew noted what appeared to be smoke emanating from the contact point between the fuselage and the runway and applied foam to the area (see below). No evidence of fire was found when the aircraft was recovered. However, the aircraft had come to a halt on a wet runway after sliding for more than 810 metres and sustaining substantial friction damage. Consequently, what the rescue crew observed was probably steam.

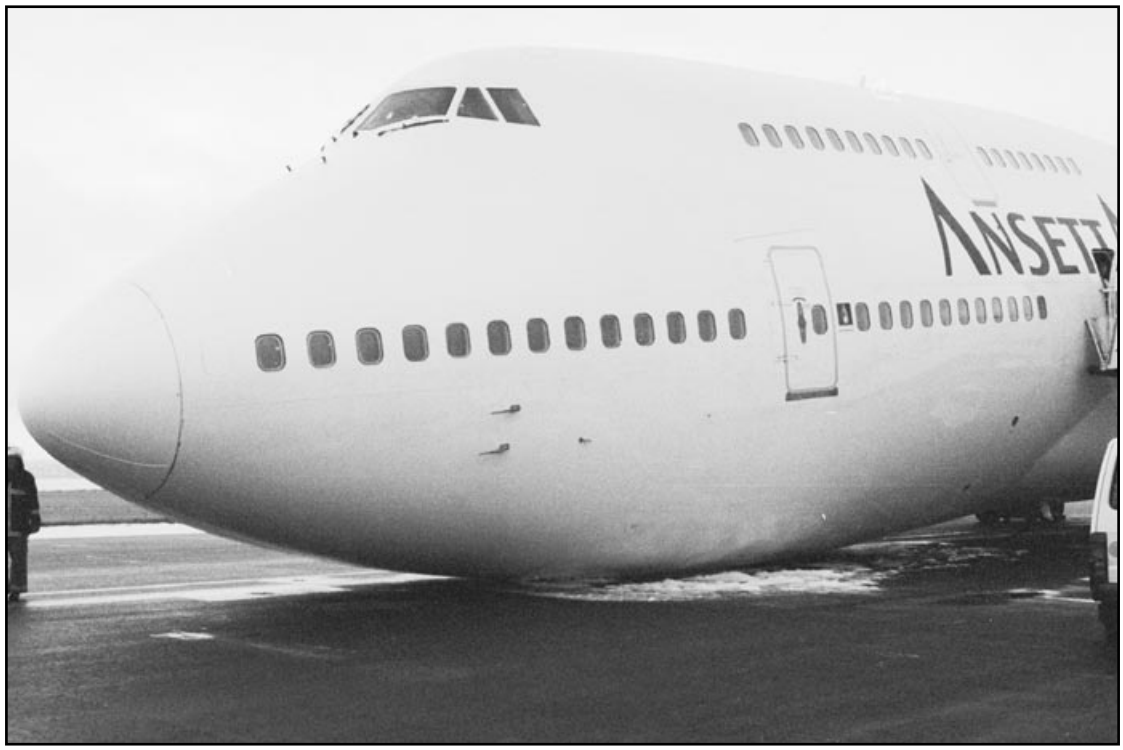

Figure 10. Foam was directed at the point of contact between the runway and fuselage.

1.15 Survival aspects

1.15.1 General

This was a survivable accident.

The pilot in command elected not to initiate evacuation procedures as he was concerned that the added height of the rear escape slides might contribute to passenger injuries if they disembarked by this method. Information supplied by Boeing indicated that the angle of descent of the slides increased by 17 degrees with the aircraft in the accident configuration as opposed to normal, level attitude. Under Ansett International Limited's operational procedures the pilot in command has the option whether or not to order evacuation. The decision not to evacuate was in accordance with those procedures.

1.15.2 Emergency services response

The emergency services response to the accident was satisfactory.

Entry to the aircraft cabin by the fire services was delayed due to the aircraft's flight crew not acting on the request of the fire chief to open an access door. The flight crew was concentrating on other tasks concerned with passenger disembarkation.

1.16 Tests and research

1.16.1 Hydraulic system performance

One of the parameters recorded on the flight data recorder was the position of the inboard flaps. Analysis of the performance of the number one hydraulic system was possible by examining the speed of movement of the inboard flaps. Data on the flight data recorder from the flight preceding the accident flight indicated normal extension times when compared with data supplied by Boeing. Recorded data from the accident flight indicated extension during this flight was slower by a factor of ten.

During the aircraft's test flight, after it had been repaired, three simulated approaches were flown in configurations similar to those during the accident flight. The sequences were performed at between 15,000 feet and 19,000 feet, due to weather, and the number one engine was shut down prior to the first simulation. For the first sequence the air-driven hydraulic pump operating switch was selected to the 'AUTO' position, for the second it was selected to the 'CONTINUOUS' position, and for the final sequence it was selected to the 'OFF' position.

Measurements taken on the flight deck during the test flight indicated that the extension time for the complete landing gear with the air-driven pump running and the number one engine-driven pump windmilling was 22 seconds. This was approximately three seconds slower than nominal extension time. The landing gear was significantly slower in its extension cycle during the third sequence with the air-driven pump selected 'OFF', as was the inboard flap movement. During this sequence the hydraulic pressure fluctuated between 300 and 500 pounds per square inch whilst both the flap and gear were in transit.

The recorded data from the test flight indicated that the flap extension times with the air-driven pump selected to the 'AUTO' and 'CONTINUOUS' positions were comparable with the figures provided by Boeing. Extension time with the pump switch in the 'OFF' position was approximately ten times slower. However, it was marginally faster than that recorded during the accident flight.

The data from the flight preceding the accident flight, the accident flight and the three simulated approaches from the test flight were integrated into one graph, which is shown in figure 11.

1.16.2 Landing gear annunciator panel

In the early 1990s, an experienced B747 flight engineer from another airline misinterpreted the landing gear annunciator lights during an exercise in a B747 simulator. As a result, the flight engineer did not recognise that the nosewheel light was not illuminated and the simulator was landed with the nose gear retracted.

The investigation team discovered that some of the B747 fleet from an Asian airline had fine lines bordering critical groups of instruments on the pilots' and the flight engineers' panels. In particular, there were fine lines added to the flight engineers' landing gear annunciator panels apparently so as to better define the five lights as a unit. Inquiries were unable to determine why the airline took such steps.

A depiction of the flight engineers' annunciator panel is illustrated in figure 12.

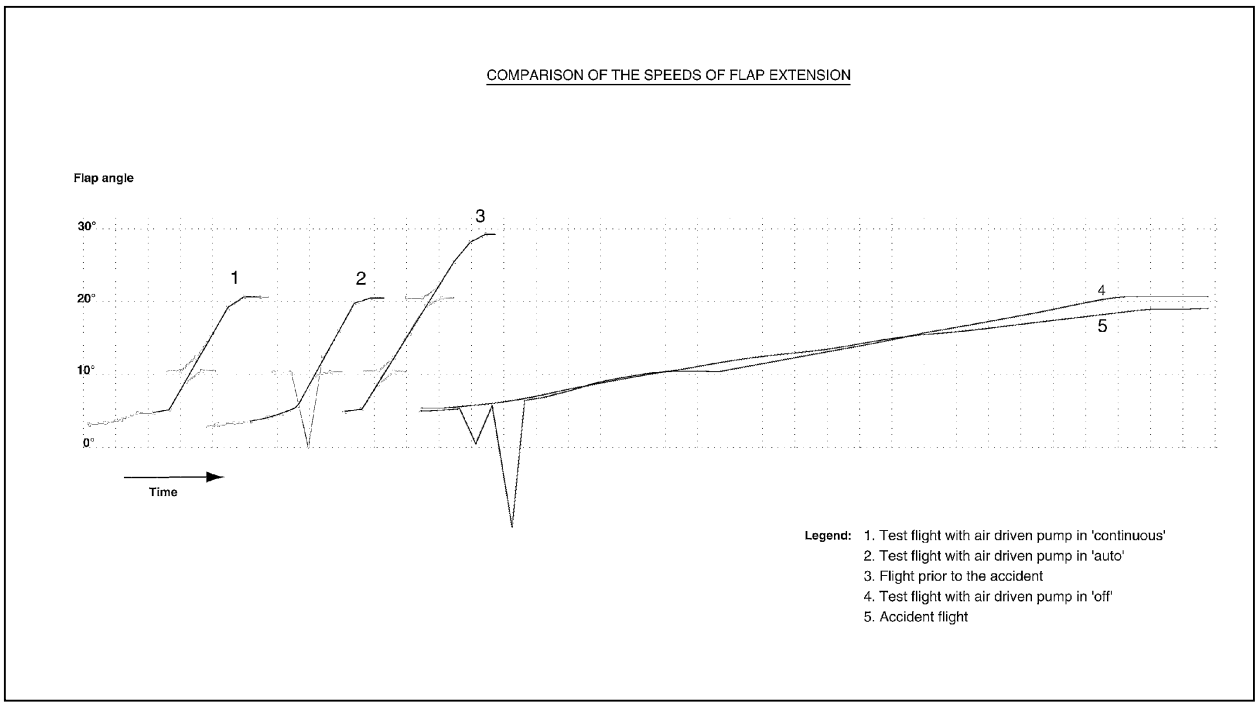

Figure 11. Reproduction of the combined flight data recording output for the accident and the test flights. The principle area of focus is flap movement.

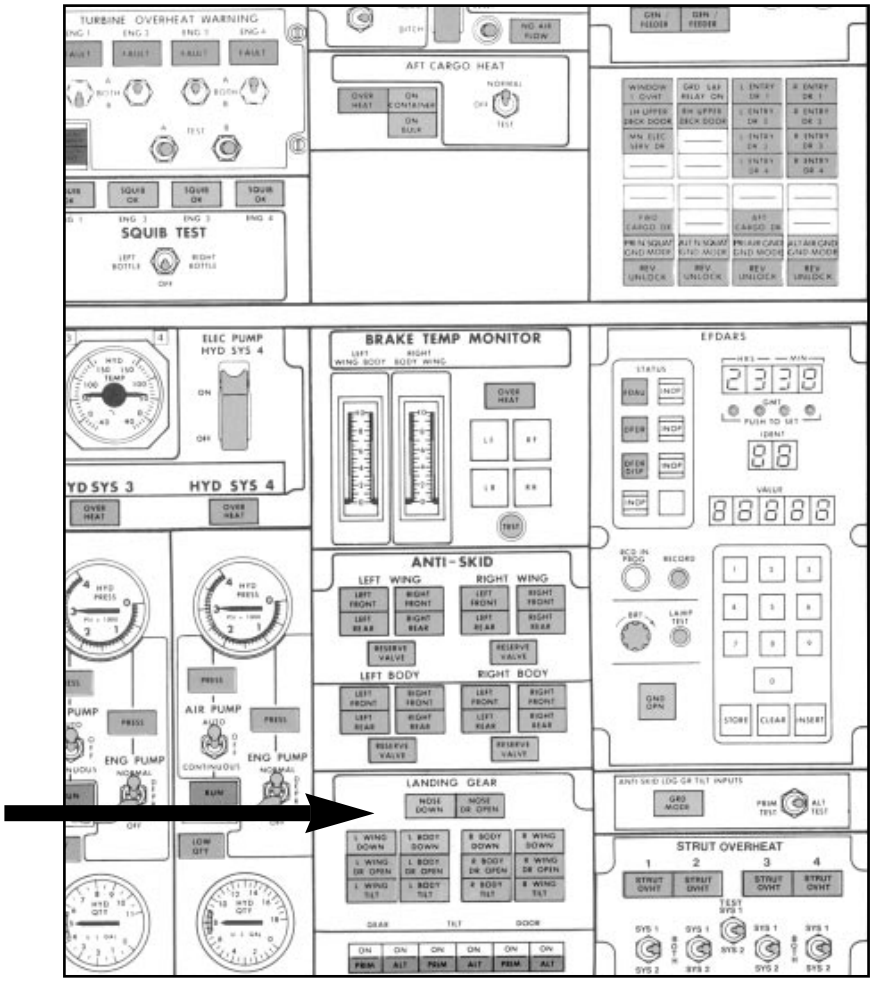

Figure 12. Portion of the lower flight engineer panel. The landing gear annunciator panel is indicated.

1.17 Organisational and management information

1.17.1 History of B747 introduction by Ansett

1.17.1.1 Traffic rights

The International Air Services Commission issued Determination 9308 on 9 August 1993, allocating new seat capacity and route entitlement between Australia and Osaka to Ansett. This right to operate was to be utilised by 1 November 1994 or within 30 days of the opening of Kansai (Osaka) Airport, whichever was later. At that stage Kansai was expected to be opened between July and October 1994.

In its applications to the International Air Services Commission, Ansett indicated that it intended to operate B747 and B767 aircraft on the Japan route.

In late 1993, the expected opening date for Kansai Airport was confirmed as 4 September 1994.

On 30 March 1994, Ansett's board of directors decided that they would exercise the route rights to Japan and commence operations from 4 September 1994 using B747 aircraft. Ansett published its commercial schedules in mid-June, based on an inaugural flight to Osaka on 4 September 1994.

1.17.1.2 Project development

After commencing international operations to Bali in mid-1993, Ansett, using its domestic resources, established a project team outside the domestic organisation to run the international operation and oversee the securing of other route capacity rights. This project team co-ordinated the application and approvals for the Japan and Hong Kong rights and then conducted a feasibility study and prepared a business plan of the various options. A report was presented to the managing director/chief executive officer, who took it to the board for approval. The board made its decision to exercise its route rights to Japan and Hong Kong after this report was submitted.

The project manager allocated tasks to various departments within the domestic operation and established lines of co-ordination between himself and those departments. It was the responsibility of these departments to provide the appropriate service to the international operation as requested by the project manager. The flight operations department was responsible for having trained staff available to operate the aircraft on revenue flights commencing with the inaugural Osaka flight on 4 September 1994. Flight Operations was also responsible for securing the appropriate air operators certificates for the new operation. One of the prime tasks of the engineering department was to have an Australian-registered aircraft available for the first flight. Other departments had responsibilities in their own areas of expertise.

Each department was responsible for the development and implementation of a plan to achieve the target start date. The project manager did not involve himself in the management of individual department plans nor did he conduct regular meetings of departmental project leaders as a group to monitor and communicate the project's progress. No formal project management process such as critical path analysis was used by the project manager; however, he set macro milestones which each department was required to meet. The manager relied on individual meetings with department project managers to monitor overall progress and accepted their advice that the milestones were being achieved and that the target date could be met.

Decisions regarding the progress of the operation were made at various levels within the organisation from individual department project leaders through to the managing director and

the board. The managing director initially met with the project team at infrequent intervals but eventually met daily with the project manager. The managing director said that he took a 'hands on' involvement with the B747 introduction. Moreover, when the project manager left the organisation in July 1994, the managing director became far more involved as he had more knowledge of the project than the replacement project manager. He maintained this higher level of involvement until the new project manager was ready to take control.

The managing director and other Ansett senior management advised the investigation that although the first B747 aircraft was due to commence international revenue-earning operations on 4 September 1994, they were prepared to delay the startup date or use a B767 aircraft as an interim measure if strong arguments for delay were presented to them. They said that they had not received any requests to delay the start of the B747 operation.

1.17.1.3 Flight operations project management

Ansett's director of flight operations and chief pilot said that he was aware in the latter part of 1993 of the probability of Ansett commencing international flights to Japan coincident with the opening of Kansai Airport. In March 1994, he initiated discussions with a number of organisations to find an appropriate B747 training package for the flight-deck crews. These initial discussions were generalised, as the aircraft type had not been finalised within the company, and both the B747 and the B767 were still under active consideration.

After the board decision was made, the director of flight operations had a flow chart created for use as a training course plan for the first three groups of flight-deck personnel. The flow chart consisted of proposed start and finish dates for component segments of the crews' training. The director of flight operations formed a development team of four management pilots and two flight engineers to be the project team from the flight operations department. The director of flight operations was the leader of this development team, which was programmed to be the first group to be endorsed onto the new aircraft type. (Henceforth, this report will refer to the director of flight operations as the development team leader.)

The development team leader's original expectation was that the flight crew would be completely trained by one organisation using that organisation's aircraft for line training (route flying training aspects). He decided that Qantas would be the most suitable organisation to meet Ansett's training needs. However, the industrial association covering Qantas pilots withdrew its co-operation from the involvement of its members in line training Ansett's staff, causing the development team leader to make alternative arrangements for line training.

He originally envisaged that some contract crews would be needed to help with crewing during the initial period of the operation. His flow chart indicated that these contract crew members would be employed from 4 September 1994 and would not be used after mid-January 1995. There were no allowances on the chart for training or indoctrination of the contract crew members. After the withdrawal of the industrial association covering Qantas pilots, he modified his plan so that contract crew would be used for line training and checking and negotiated a contract for ground and simulator training with Qantas.

The Ansett board announced on 2 May 1994 that it had entered into a leasing arrangement with Singapore Airlines for the supply of two B747 aircraft.

Two days after the aircraft lease arrangements were publicised, Qantas withdrew its offer to provide ground and simulator training and stated that its decision was not negotiable because Qantas had offered training only in conjunction with the lease of Qantas B747 aircraft. In response, the development team leader reopened discussions with other training organisations

and delayed the training commencement date for the development team from 23 May 1994 to 20 June 1994. A consequence of the delay was that the development team could no longer be line-trained before the arrival of the first B747 aircraft. The development team leader's flow chart was modified by compressing the training course plan for the three Ansett crews and making allowance for line training to be conducted for all Ansett crews after the international revenue flights commenced. However, it was not modified to include any extra time for the contract crew members to be checked or trained, nor did it allow for earlier hiring of these people for indoctrination processes. The chart still indicated that the contract crews would only be required until mid-January, 1995. The development team leader advised the project manager that the target date was still achievable, despite the delay.

On 18 May 1994, some of the development team met with representatives from the Civil Aviation Authority as part of the air operators certificate variation procedure. The development team leader advised the Civil Aviation Authority representatives that he intended to operate the B747 in accordance with Ansett's operating philosophies. The Boeing operations manual as supplied to Singapore Airlines would be used as the basis of operations, but would be amended to reflect Ansett's philosophies. The agreement between the two groups was that the flight/operating/training/route manuals would be amended and submitted to the Civil Aviation Authority for review and approval 30 days before commencement of operations. The development team leader expected that the development team would direct the amendments whilst undergoing training and that the second course should have the amended version of the operations manual available for its training course. It was recognised that any contract crews employed would need to be familiarised with Ansett philosophies.

The managing directors of Qantas and Ansett met at the end of May and as a result of that meeting, the development team leader recommenced negotiations with Qantas for the supply of training. A contract for the provision of ground and simulator training by Qantas was finalised by 9 June 1994.

Qantas recommended to the development team leader a training course used for its own flight crew which had been approved by the Civil Aviation Authority. Although the training staff recommended that Qantas procedures be used throughout the crews' B747 training, Ansett required that, where possible, its own operating practices be integrated into the procedures taught by Qantas. This requirement resulted in the need for Ansett to conduct training in addition to the Qantas training, covering such topics as flight planning and weight and balance, before the Ansett crews could be endorsed and progress to line training. This concept was agreed upon and a contract similar to the one prepared a month earlier was signed. It was agreed that the development team would review and modify the program as it progressed and that Qantas would not teach operational policy matters to the trainees.

The development team leader delegated his director of flight operations and chief pilot duties to another management pilot before commencing the first training course with the rest of the team on 20 June 1994. He also delegated responsibilities for employment and training of contract crews, for acquisition, distribution and approvals of various manuals, and for related administrative functions, to Ansett's flight operations department.

The pilots for the two courses following the development team's course were chosen on the basis of seniority, merit and experience. Although there were other non-management pilots employed by Ansett who had some previous experience on B747 aircraft and in international operations, their applications were delayed until later courses.

The development team leader, the manager of flight engineering and the acting chief pilot / director of flight operations all advised that the flight engineers for the first two courses were chosen on a seniority basis due to an industrial agreement with the flight engineer's industrial

association. However, the manager of flight engineering did agree that he was able to depart slightly from the strict order of seniority when choosing the flight engineers, and also stated that those flight engineers on the first two courses would have been chosen if merit had been the only criterion.

1.17.1.4 Flight operations ground and simulator training

Training for the development team commenced on 20 June 1994 and the second training course commenced on 4 July 1994. The program used was essentially aligned to the syllabus used by Qantas for its own crews with allowances for additional exposure to the international environment during simulator scenarios.

Some problems arose because of differences in operating and training philosophies and practices of the two airlines. One of the main differences centred on the manner in which the flight engineer was integrated into the crew. Thirteen Ansett operational pilots and flight engineers interviewed, including the development team leader, indicated that Ansett's culture tended to exclude flight engineers from operational aspects of flights. Ten of those interviewees specifically related this to Ansett's B767 operations. However, Ansett's flight operations management advised the investigation that they viewed the flight engineer as a specialist systems operator. Qantas viewed the flight engineer on the B747 as an integral member of the flight-deck team, particularly as an extra resource for monitoring and procedural backup.

As the basis for their training protocols, Qantas staff used their own and Boeing operating manuals as designed for the Singapore Airlines aircraft. Qantas advised the investigators that training and checking was not conducted totally in accordance with Qantas policy and procedures. However, both the training and checking complied with Civil Aviation Authority operating requirements and tolerances as stipulated in the Authority's orders and was in accordance with Boeing's general operating philosophies and procedures. Qantas did not assess the trainees with respect to specific Ansett operating policies and procedures.

The development team made modifications to operating techniques and procedures as required to align them with Ansett's operating philosophies. Many of the modifications appeared to some Qantas staff and some members of Ansett's second training course to be disorganised, unnecessary and confusing. The disorganised approach to modifications of procedures is evidenced by 'flaps' being omitted from a modified 'landing checklist'. A further example is that during the second course, unsigned, unattributed sheets of paper containing amendments to operational procedures were distributed to trainees during the night by members of the development team. In the absence of accompanying instructions, some trainees assumed that these procedures were to be used from the next day and/or in their next simulator session.

Many of Ansett's crew members found the intensity of training and the unusual hours utilised by Qantas difficult to work with, as the program was significantly different to Ansett's own training regimen. The difficulty of the course was exacerbated by the variety of manuals and procedures used during this ground phase of training. Some of the crews received and used Ansett manuals based on the Boeing manuals issued for Singapore Airlines aircraft. Some of the crews were issued with the normal operations section of the Qantas operations manual so that they could understand and effectively operate the Qantas simulator. This simulator was configured with different engines to the Ansett aircraft. The third source of procedures used were those based on the Ansett philosophy of aircraft operations, such as which pilot taxies the aircraft, which pilot manipulates the landing gear selector, how the radios are utilised and so on. One pilot reported that he knew three different checklists for the aircraft, which caused him some confusion.

An added source of difficulty for many of the Ansett crews was that they were dealing with new concepts associated with an international environment which was different to the familiar, Australian, domestic aviation environment.

Some of the Ansett flight personnel, found the ground and simulator training to be stressful, and some did not adapt. Three pilots from the first three courses did not complete the program and there was an unusually high proportion of repeat simulator sessions and failures in simulator 'final checks' compared with results normally achieved by Qantas crews. Of the eight flight engineers and 13 remaining pilots on the first three courses, 6 pilots and 2 flight engineers (including the flight engineer from VH-INH) failed their first simulator 'final check'.

Ansett was required by the Civil Aviation Authority to provide some additional training to complete the ground phase of training. This training was to cover differences between the configuration of Qantas aircraft and that of their own leased aircraft. One of the differences was the fact that the leased aircraft were fitted with Pratt and Whitney engines rather than the Rolls Royce engines of Qantas aircraft (the pilots needed to know about Rolls Royce operations to fly Qantas aircraft for their one-hour base check). The added training also needed to cover Ansett's philosophies on performance, weight and balance and fuel management. Ansett arranged for its own training officers to instruct on some of these aspects and the Ansett crews did receive exposure to some of the engines and systems 'differences' through their simulator training with Qantas. However, Ansett did not conduct a formal course on 'differences' for the contract crews and produced a two-page, unsigned list of 'cockpit' panel 'differences' for the Ansett crews.

Qantas training staff considered that the crews who completed the syllabus and passed the final check in the simulator had achieved an acceptable standard. However, Qantas emphasised that the trainees had not been checked to Qantas procedural standards.

1.17.1.5 Contract flight crew

Ansett sought experienced contract pilots and flight engineers from a homogeneous background to ensure common cockpit culture and to help with crewing during the introduction of the B747. Ansett preferred that these contract crew members had been previously employed by Qantas. This plan was modified after the delay in the start of development team training, to also require contract crew members to possess a combination of training and checking skills and qualifications. The company eventually employed three pilots and two co-pilots from other airlines in addition to those previously employed by Qantas, due to market availability. However, all of the contract flight engineers had been employed by Qantas within the previous five years but needed varying amounts of training and checking to regain currency in B747 operations.

The contract pilots all possessed training or training and checking experience and were all employed by Ansett at least in a training capacity. Two were employed and later approved by the Civil Aviation Authority as check pilots. The contract co-pilots employed were experienced in B747 operations.

Two flight engineers were employed and approved for checking duties and a proportion of the rest were employed in line training roles. However, one flight engineer said that he did not realise that he was employed in a training role until he met his trainee when reporting for duty for his first rostered flight.

The acting director of flight operations / acting chief pilot organised for the contract crew members to attend the Ansett training lectures on topics such as performance, flight planning, and weight and balance. A simulator program was prepared for each individual based on his recent experience and on the Australian licences and ratings he held. Essentially, the pilots were

given a B747 refresher program which introduced some of Ansett's operating techniques and included an instrument rating test.

No briefing sessions were delivered on operating philosophies, training philosophies, management expectations of the contract crews, training standards, thresholds to be met for checking purposes, or any other similar topic relevant to the roles for which the contract crews were employed. Nor were any crew resource management training sessions held for the contract crews, although there was material related to crew resource management in various parts of the general operations manual. All three of the flight engineer trainers interviewed advised that they reverted to standards from previous employment to gauge the acceptability of trainees' performances.

All but one of the contract flight crew members interviewed were issued with an incomplete set of manuals at the start of their employment. Some contract crew members operated with manuals or checklists acquired during previous employment and several taught procedures used in other companies. Senior management from Ansett's flight operations department advised that this practice was neither approved nor brought to its attention prior to the accident.

Ansett flight operations department management expected the contract crew members to learn appropriate procedures by reading the various manuals, by undergoing simulator training, and by learning from the Ansett employees with whom they flew. Some of the contract crew members reported that they found this difficult due to deficiencies in the manuals or because of the poor distribution of the manuals and added that they saw evidence of others experiencing the same difficulties.

Although an Ansett management pilot observed the ability of contract pilots in command in the right seat in a training role, there was no appraisal made of the training ability of contracted training flight engineers, other than by informal reference to their previous employers. The first two courses of trainees comprised experienced Ansett check flight engineers and none of these reported any deficiency or difficulty with their line training flight engineers.

The Civil Aviation Authority flight engineer inspector reported that he had expressed concerns to the development team leader and the manager flight engineering that there was a need to train some of the training flight engineers. The development team leader advised the investigators that he had no recollection of the conversation. The manager flight engineering's recollection was that the inspector had spoken to him about the two check flight engineers to say that they were satisfactory but that he had not observed all the proposed training flight engineers. The manager flight engineering had replied that the training of training flight engineers was a company responsibility, not the Civil Aviation Authority's. The company did not conduct any training for the training flight engineers.

Ansett's flight line training form/syllabus for pilots was an adaptation of forms used in the domestic operation and was available from the commencement of line training flights. However, the form was not received by all contract pilots until several weeks after they commenced training duties. The syllabus retained items which were more relevant to domestic operations.

The flight engineer line training form/syllabus was written specifically for the B747 operation by a contract flight engineer. It was not finalised until almost a month after the first revenue flight. The distribution of the form was not uniform, nor was it achieved in a timely manner. One check flight engineer obtained a copy himself shortly after publication, but did not receive a distributed copy until two months after the accident.

Ansett's operational management did not readily accept advice from the contract crew members and when changes were agreed to, management was invariably slow to implement them. The development team leader tended not to adopt or even acknowledge constructive suggestions from the contract crew members who were experienced in operating the aircraft and were knowledgeable of the international environment. These aspects were unfamiliar to most of Ansett's crews. The development team leader viewed the contract personnel as short-term and one of his team was reported to have said that Ansett's crews should be checked to the line quickly so that the contractors could be dispensed with. There was some involvement of contract crew members in flight engineer syllabus development and in a few other areas, but it was minimal.

1.17.1.6 Manuals

Part of the duties of the development team for the aircraft introduction was to acquire, amend and have approved manuals relevant to flight-deck operations. The original plan was for the development team to complete the training course and amend the operations and other manuals used by the flight crews, to reflect the company philosophies. This was to be completed before the second training course commenced.

The plan for manual production was not formalised on the training flow chart and after the development team leader relinquished his chief pilot and director flight operations duties to a replacement, the monitoring of the manuals' amendment, approvals and distribution was not managed by any single person. Some of the flight crew and training staff interviewed considered that the resultant distribution of manuals and amendments to flight crews was haphazard and ineffective.

Contract flight crew and the Ansett crews used manuals from a variety of sources, depending on which were issued to them and which they had to obtain themselves.

Ansett's version of volume one, section four ('Normal Operations') of the B747 operations manual was not distributed to all cockpit crew members before they commenced flying and some did not receive it until several weeks after flying started. There were complaints that many of the company's B747-specific procedures were not written in this section. Of particular relevance to this accident is that there was no definition or description of the concept of a 'stabilised approach'.

The General Operations Procedures Manual forms part of Ansett's generic operations manual and contains the operating ethos of the company and how management expects its aircraft to be operated. It also describes how general procedures are to be applied to specific aircraft types or to types of operations. This manual did not have a section pertaining to international operations nor did it have amendments to show how general procedures should be adapted to the B747 operations. It also did not contain a 'stabilised approach' definition or description.

1.17.1.7 Line training

Line training of Ansett's crews was performed by the contract personnel without established standards and without syllabuses uniformly available for reference. Individual trainees and crews reacted differently to the apparent variety of procedures being taught, varying from confusion to pragmatic acceptance. Some trainee pilots stated at interview that they were instructing the contract trainers on company procedures whilst trying to apply and consolidate new skills in international and B747 operations. Trainees were required to adjust procedures to those preferred by the individual trainer, which may have been different to those taught in the simulator or to those required by Ansett. Ansett management advised that prior to the accident, it was not aware that some of the contract crew members were using their own or

their previous employers' procedures. However, the check flight engineers said that they had been advised by the manager flight engineering to use standards from their previous employment at Qantas.

Ansett's crew members were scheduled for check flights when they exceeded the minimum experience levels required by the Civil Aviation Authority. For the development team pilots, the minimum level was six sectors of line training and for the rest of the pilots, the level was ten sectors. All flight engineers were required to complete the minimum training stipulated in the Civil Aviation Orders, which was six sectors of normal route flying. There was little evidence of ongoing evaluation of completed line training forms in an attempt to structure training to individual requirements. The flight engineer on the accident flight was programmed for a check flight after seven sectors and 56 hours of line training. He failed the first two sectors of the three-sector check flight. The remaining sector (totalling one hour and 37 minutes) was used by the check flight engineer as additional training. A further two-sector, 18-hour training flight was completed, followed by a second check flight with a different check flight engineer.

Minimal effort was made by the responsible flight engineer manager to analyse why the flight engineer failed the sector or what, if any, underlying factors contributed to the 'fail' performance. There was also no remedial program developed to ensure that identified weaknesses such as panel skills were addressed in the flight engineer's subsequent training.

The check flight engineer on the second check flight did not see the documentation of the flight engineer's previously failed flight but he advised the investigation team that his normal checking procedure covered those areas identified during the failed check as weaknesses. Prior to this second check flight, the manager flight engineering briefed the check engineer that if the flight engineer did not achieve a satisfactory standard, the flight was to be converted to a training flight. The check flight engineer considered the flight engineer's performance on the check flight as satisfactory for a pass assessment.

The recent flight experience of the flight engineer was as a flight engineer on B767 aircraft. Ansett selected B767 aircraft with a flight engineer's position due to industrial agreements and was the world's only operator of B767 aircraft with three-man crews. Two senior management pilots said that the flight engineer on the B767 did not have a participatory role on the flight deck and that the flight engineer role was not a demanding one. Eight other experienced crew members who were interviewed made similar comments. It was a generally held view of these interviewees that the culture in Ansett was such that the B767 flight engineer was not integrated into flight crew operations, as is required on the B747-300.

1.17.2 Regulatory aspects

The Civil Aviation Authority was the organisation responsible at the time of the accident for setting the safety standards and enforcing the Civil Aviation Act, its regulations and orders. To assist Civil Aviation Authority staff and operators to meet the regulatory requirements and complete certification for a new type of aircraft and/or a new type of regular public transport service, a manual of air operator certification was available.

Ansett Transport Industries Limited was the holder of an air operators certificate for domestic operations and for international operations between Australia and the Indonesian terminal port of Den Pasar. As part of the process of establishing the B747 service to Osaka, Ansett lodged with the Civil Aviation Authority, on 16 May 1994, a pre-application statement which indicated an intent to apply for a variation of aircraft type to this air operators certificate. The Civil Aviation Authority eventually accepted this as an application. Ansett later (19 July 1994) applied to surrender the certificate held by Ansett Transport Industries Limited and for the co-

incident issuance of a certificate to Ansett International Limited. By this time the rights to international routes had been transferred by the International Air Services Commission from Ansett Transport Industries to Ansett International Limited.

The approval of an air operators certificate is an important part of the method used by the Civil Aviation Authority to ensure that an operation is conducted in accordance with the law, that standards are set and met, that the necessary training is provided, and that the operation meets safety requirements. The investigation team conducted a review of the air operators certification process to determine whether there were any weaknesses in the system and, if there were, whether they contributed to the accident. The review found some occasions where the legislation had not been complied with and where administrative processes were incorrect or incomplete. An example of incorrect administrative process is that the air operators certificates approved the use of both Australian and United States registered aircraft although the approving officer did not have a delegation to cover this approval.

The following paragraphs cover only the issues which are relevant to the investigation.

1.17.2.1 Planning

A review of the air operators certification process indicated that, apart from a requirement for appropriate manuals to be submitted 30 days prior to commencement of operations, few other formal milestones were set by the Civil Aviation Authority to ensure that other processes would be completed in time for the air operators certificate approval. There was no evidence that a formal project management plan, following the procedures recommended in the Manual of Air Operators Certification, was used by Authority officers.

1.17.2.2 Application for air operators certificate

Civil Aviation Order 82, paragraph 3.1 requires that an application for an air operators certificate be made in a form approved by the Civil Aviation Authority. Ansett intended that its international division would assume responsibility for the introduction and operation of the B747 services. As part of the process a new air operators certificate was required to be issued to the international division. Ansett management completed a pre-application statement in accordance with the Manual of Air Operators Certification for an initial issue of an air operators certificate but requested a variation of two existing air operators certificates instead of a new air operators certificate. They did not follow the pre-application statement with a formal application. Civil Aviation Authority staff, who were aware that an application had not been submitted, agreed to accept the pre-application statement as a formal application and to issue a new air operators certificate to Ansett International Limited

1.17.2.3 Civil Aviation Order requirements

Civil Aviation Order 82, paragraph 3.3 required the applicant to submit, at least 60 days prior to commencement of operations, an operations manual for approval. The Civil Aviation Authority staff approved a reduction from 60 days to 30 days without making an application to vary the requirements of the Civil Aviation Order (the Manual of Air Operators Certification indicates that an applicant may submit a supplement or amendment to an existing manual rather than having to produce a new manual).

Civil Aviation Order 82.5, paragraph 1.2 indicates that each certificate authorising regular public transport operations in high-capacity aircraft is subject to the condition that the obligations set out in the order are complied with. Civil Aviation Order 82.5, paragraph 3.2 requires that an operator's training and checking organisation be in accordance with appendix 2 of the order. Paragraph 4 to appendix 2 sets out the requirements for a training and checking

4 — TRAINING AND CHECKING MANUAL

4.1 - Each operator must provide a training and checking manual for the use and guidance of persons appointed within the training and checking organisation and must furnish copies of the manual to:

(a) the Assistant General Manager (Safety Regulation) of the area in which the operator is domiciled;

(b) all operating crew members assigned to checking and/or training duties.

4.2 - The training and checking manual must include the following material:

(a) the structure of the training and checking organisation and the assignment of duties and responsibilities to the appointments within the organisation;

(b) course outline, detailed syllabus, completion standards and specimen record forms for each flight or simulator training programme currently in use;

(c) minimum qualifications and experience for check captains;

(d) flight time limitations and recent experience for pilots engaged in flight checking or training duties;

(e) training checklists (if applicable) and the occasions on which their use is authorised;

(f) command responsibility during training and checking flights, including licence renewal proficiency checks;

(g) minimum numbers of crew and minimum crew qualifications for specified types of training;

(h) general restrictions, specifications or safety precautions for flight training (e.g. fuel load, ballast, minimum weather conditions);

(i) prescribed methods of conducting various training sequences including:

(i) technique and standard to be achieved;

(ii) common faults; and

(iii) method of simulating emergencies and/or malfunctions; and

(j) procedure to be followed when a satisfactory standard is not achieved.

4.3 - The material referred to in paragraph 4.2 is subject to the approval of the Authority and is not to be varied without the Authority's prior approval, although the operator may include additional material for information and guidance without the Authority's approval.

5 — TRAINING METHODS

5.1 - Each operator must maintain a training file in respect of each flight crew member, recording at least:

(a) each ground training course completed or attempted, including the results for each phase or subject and the final assessment of the standard achieved; and

(b) each endorsement training course completed or attempted, including the results of each phase of training, the number of times each exercise was undertaken and the results of tests or checks; and

(c) each flight or simulator proficiency check completed or attempted, including the number of times each exercise was undertaken and the results of the checks; and

(d) each period of training, other than training referred to in paragraph (a), (b) or (c), undertaken in an aircraft or simulator, including the exercises completed or attempted, and an assessment of the standard achieved.

Figure 13. Civil Aviation Order 82.5 Appendix 2, paragraph 4.

manual. In particular, it indicates that a manual must be provided and to whom, the material that must be included, and the need for Civil Aviation Authority approval. A copy of Civil Aviation Order 82.5, appendix 2, paragraph 4, is included in this report as figure 13. Ansett did not provide a B747 supplement for either its training or checking manual to the Civil Aviation Authority for approval prior to commencement of operations. Ansett management did not believe that these were required.

1.17.2.4 Civil Aviation Authority's Manual of Air Operators Certification

The Manual of Air Operators Certification consolidates the requirements published in legislative and regulative documents of various kinds, which are applicable to commercial aviation operations. The manual also incorporates recommended practices for the guidance of both airline operators and Civil Aviation Authority officers. The manual is not a legal document. However, where the manual repeats a requirement which stems from another source, the authority for that requirement lies in the document from which the requirement was extracted.

A number of the administrative procedures set out in the Manual of Air Operators Certification were not followed. There were three areas of significance. The first area related to the Civil Aviation Authority's monitoring of the introduction of the B747, the second was the submission of manuals as part of the air operators certificate application and the third was the use of checklists during the application process and prior to final approval.

Planning is discussed in paragraph 1.17.2.1 of this report. The Manual of Air Operators Certification requires that a project team be formed to co-ordinate activities of the Civil Aviation Authority and the operator during the introduction of a new type and to monitor progress. The Civil Aviation Authority district office in Melbourne formed a project team to monitor Ansett's introduction of the B747 aircraft. Due to lack of resources, the team numbers and experience were limited and assistance was sought from the Civil Aviation Authority's Sydney office. Members of the team were therefore based in both Melbourne and Sydney. During the introduction process three meetings were held and regular communications took place between Ansett and the Civil Aviation Authority project team to coordinate and review progress of the B747 introduction. The Civil Aviation Authority personnel who attended these meetings changed as the project team changed through illness and unavailability. No Sydney member of the team attended any of these co-ordination/ monitoring meetings .

A review of the files associated with the project team's activities indicated that many documents that might have indicated monitoring activities and the decision making process were missing from the official record. However, team members interviewed stated that many activities were completed despite the lack of supporting evidence on files.

The Manual of Air Operators Certification paragraph 3.3.2.2 indicated that type-specific flight crew training manuals, or a supplement to an already existing manual, must accompany the application for variation to an existing air operators certificate. The same manuals were also required for the issue of a new air operators certificate. Although there was a requirement for training and checking supplements to be submitted, Ansett understood that their checking manual satisfied the certification requirements regarding training and checking manuals and supplements. Documents from Ansett and Civil Aviation Authority files indicated that both parties understood the need for relevant manual supplements to be produced 30 days before the operation began. However, the B747 supplement to Ansett's checking manual was not submitted until December 1994, some two months after the accident.

The Manual of Air Operators Certification contains information on the suggested structure of a training and checking manual, a checklist to be completed prior to air operators certificate approval and a listing of the Civil Aviation Orders that must be complied with. These are all

designed to assist Civil Aviation Authority staff and applicants to complete the air operators certificate application and approval process correctly. Records indicated that some hard copies of checklists were used; however, a hard copy of the final checklist to be used prior to air operators certificate approval was not found. The Manual of Air Operators Certification recommends that a completed 'checklist for issue of air operators certificate', for both operational and airworthiness areas, be presented to the delegate by the project manager prior to air operators certificate approval. A copy of this checklist proforma is included in the report as appendix 2(A) and 2(B). The Civil Aviation Authority officer, who approved the air operators certificate and was the project manager at the time, indicated that he mentally ran through the lists prior to approving the air operators certificate. Before authorising the approval, he conferred with each of the Civil Aviation Authority participants and confirmed that there were no unresolved actions which would prevent approval. However, he did not receive a completed hard copy checklist. He was aware that the training and checking manual was on the list and that it was not available, but he decided that it was not essential to the approval of the air operators certificate.

1.17.2.5 Manual approvals

The air operators certificate was approved before a training and checking manual (B747) supplement had been submitted or approved. The operations manual amendment had been provided to the Civil Aviation Authority but there were no records to indicate that the operations manual supplement had been accepted or approved. Previous investigations and discussions with Civil Aviation Authority staff during this investigation indicated that it was Civil Aviation Authority practice to accept rather than approve the contents of operations and training and checking manuals. By 'accepting' the manuals, the Civil Aviation Authority appeared to only check that prescribed contents were included, and did not sanction them officially with a delegate's signature and formal notification of approval to the operator. This practice conflicts with the legal requirements specified in Civil Aviation Order 82.0, paragraph 3.3 and Civil Aviation Order 82.5, appendix 2, paragraph 4.3 (see figure 13).

1.17.2.6 Pressures

Civil Aviation Authority staff indicated that there were insufficient resources available in the district office to manage the air operators certificate approval process in accordance with all the Manual of Air Operators Certification provisions. The most notable deficiency was the absence of a B747 specialist. The previous B747 flying operations inspector had left the Civil Aviation Authority's employment and had not been replaced. As a result the staff had to use an abbreviated process but in so doing were confident that safety would not be compromised. The situation was exacerbated when the project co-ordinator became ill and the district manager participated in an Ansett B747 conversion course. The pilot and flight engineer type specialists seconded to the project team until Melbourne staff again became available were based in Sydney whilst most of the air operators certificate approval processes took place in Melbourne.

Ansett's aircraft did not arrive in Australia until immediately before the commencement of B747 services and Civil Aviation Authority staff indicated that this placed the air operators certificate approval process under increased pressure. Civil Aviation Authority staff indicated that development and approval of training processes partly depended on having the aircraft available. This was especially important to their review of training planned to cover differences between the Qantas and Ansett aircraft (for example, engines and cockpit layout). Many of the differences were not apparent until the training personnel inspected Ansett's aircraft in Melbourne on its arrival.

Ansett planned to commence services to Osaka on 4 September 1994. To meet this date, revenue-earning proving flights had to be conducted beforehand. The first of these flights was due to depart Sydney for Perth on the evening of 30 August 1994. The air operators certificate was

finally approved at 1930 on 30 August 1994, immediately prior to the departure of the Perth flight. The approving officer reported that he was standing on the air bridge at the Sydney terminal in the presence of a number of the operator's representatives, and that he used a mobile telephone to confirm with his staff that there were no last-minute hitches to his approval of the air operators certificate. He indicated that he did not feel that he was under any significant pressure to approve the air operators certificate as Ansett was aware he had the final say and they had provided an alternative aircraft to take the waiting passengers to Perth if necessary.

1.17.2.7 Flying operations inspection of Ansett

(a) Pilot specialist

The B747 pilot specialist seconded from Sydney was responsible for the initial approval of the operator's check pilots. These approvals were carried out on a limited number of flights between 29 August 1994, when the aircraft arrived in Australia, and 4 September 1994, when international operations started. The pilot specialist indicated that it was his job to complete the flying operations inspector input to the startup process. He was involved with the approval of the operator's check pilots but not with the line training. Whilst the pilot specialist was able to check the manipulative ability of the pilots under check, he was unable to complete an assessment of the manuals and procedures as these were not all available to him prior to 4 September 1994. It was the pilot specialist's and the project team's initial understanding that the training and checking manual would be available by the completion of the first training course and before commencement of operations. However, the pilot specialist did not receive the training and checking manual as expected. The pilot specialist informed the project manager of the lack of manuals and of a number of other problems with those documents and procedures he was able to check. Whilst there were records of the specialist's reports and of concerns voiced by other Civil Aviation Authority project team staff about missing manuals, there were no records to indicate that any specific action had been taken to ensure that the manuals were in place prior to air operators certificate approval other than to arrange delivery of the operations manual amendment.

The project manager advised that he felt the pilot specialist was overreacting because of his long association with Qantas and that he was attempting to compare Qantas' procedures with those of Ansett, an airline which was just starting B747 operations. The project manager felt that it would take time for the new operator to reach a standard of manuals and procedures similar to Qantas' standard. Notwithstanding this difference of opinion, when the pilot specialist was asked by the project manager on 30 August 1994 if he knew of any reason why the air operators certificate should not be issued, he answered that he did not.

(b) Flight engineer specialist

The flight engineer specialist, also based in Sydney and a part-time inspector employed on contract by the Civil Aviation Authority, was already aware of the background and experience of the check flight engineers before he approved them. The check flight engineers were approved during flights on 29 and 30 August 1994, immediately prior to startup, when he was able to assess their panel skills. He was unable to check the flight engineer section of the training and checking manual or the procedures to be used during line training as these were not available prior to the commencement of services in the B747 and were not received by him until November 1994. The flight engineer specialist commented that the lack of training manuals and procedures was the major problem he encountered with the introduction of the B747. The flight engineer specialist did not know whether his concerns about training and checking information were forwarded to the Civil Aviation Authority's project team manager. The review of the files indicated that some but not all of the flight engineer specialist's concerns were passed on by the pilot specialist during his discussions with the project manager. No evidence was found to indicate that the concerns had been adequately addressed.

1.17.2.8 Operator background

The Civil Aviation Authority staff advised that they were aware that a number of Civil Aviation Order requirements had not been met and that a number of provisions of the Manual of Air Operators Certification had not been completed at the time that the air operators certificate was issued. However, they believed that because Ansett was well established and had a mature training and checking system in place for other aircraft types, the various processes would be completed eventually and safety would not be compromised. As most of the endorsement training was being provided by Qantas using an approved system, and as sufficient experienced crew had been employed, they felt that it was acceptable to waive the requirement for Ansett to produce the complete training and checking package for the B747 until some time after operations commenced. Relevant Civil Aviation Authority staff subsequently stated that, with this in mind, they were not concerned that B747 supplements to the training and checking manuals were not in place when the air operators certificate was approved.

1.17.2.9 Civil Aviation Authority staff training

The Civil Aviation Authority district office staff advised that whilst the district office manager had received some training in the legislative aspects of the Act, its regulations and orders, most of the others had not. The staff member who was project manager and acting district office manager at the time of the air operators certificate approval advised that he had not received any legislative training nor did he have any experience with the B747 aircraft. He was consequently forced to rely on others for assistance and advice. He was placed in this position because the original project manager had become seriously ill and the district office manager had participated in the third of the operator's B747 courses.

1.18 Crew actions

1.18.1 Operations manual procedures

The B747 operations manual distributed to Ansett's flight crew members contained page 18.20.03 ('Landing gear alternate operations'). This page described the recommended procedure to be followed in the event that the 'red gear light remains illuminated (thrust lever(s) not at idle setting)'. The procedures described are to be followed when the red gear warning light on the centre instrument panel remains illuminated following gear retraction or gear extension (see figure 14 for a copy of the 'red gear light remains illuminated' procedure).

The introductory section of the operations manual describes the intent of each chapter and the expected responses by flight crew. The alternate operations in chapter 18 are described as

> procedures designed to cope with 'irregularities' not included on the Emergency/Abnormal Checklist, but available for reference...Alternate operations may be performed by recall or references; also they may be reviewed by the crew member prior to the accomplishment of the procedure.

This section also adds

> Some alternate operations such as (list provided, but not the 'red light remains illuminated' procedure) address situations in which reference to the Operations Manual is desirable ... The following alternate operations require immediate action and must be accomplished by recall:...(did not include the 'red light remains illuminated' procedure).

Boeing flight test personnel consider that there is no requirement for a crew to refer to this page prior to performing the actions. The Boeing opinion was that it is the flight crew's decision.

RED GEAR LIGHT REMAINS ILLUMINATED

(Thrust lever(s) not at idle setting)

FOLLOWING GEAR RETRACTION:
Gear Annunciator
Switches.....PRESS PRIMARY THEN ALTERNATE
Gear down annunciator lights should be extinguished.
Gear Door Open
Light.....CHECK EXTINGUISHED
If illuminated, follow GEAR DOOR OPEN LIGHT ILLUMINATED alternate procedure prior to completing this procedure.

With all doors closed and no gear down indications, the gear is retracted.

WITH ANY GEAR DOWN INDICATION AND FLIGHT CONDITIONS PERMITTING:
Either Door Annunciator
Switch....PRESS AND HOLD DURING GEAR CYCLING
Landing Gear Lever
(below V_{extend}).....DOWN
Monitor affected gear door open annunciator light.
Light should illuminate while gear in transit, then extinguish with gear extended.
Landing Gear Lever
(below $V_{retract}$).....UP
Monitor affected gear door open annunciator light.

If the affected gear door open annunciator light illuminates then extinguishes, the gear is retracted.
Landing Gear Lever.....OFF

If unable to verify gear retracted, observe landing gear extended placard.

FOLLOWING GEAR EXTENSION:
Gear Annunciator
Switches....PRESS PRIM THEN ALT

Check condition of GEAR DN annunciator lights. Determine for each gear (5) in both PRIM and ALT whether annunciator light is illuminated (green) or NOT illuminated.

If GEAR DN annunciator light for any one gear fails to illuminate during both PRIM and ALT checks, that gear must be considered NOT down and locked. Use Alternate Landing Gear Extension procedure.

If GEAR DN annunciator light for any one gear illuminates during either PRIM or ALT checks, that gear can be considered down and locked.

NOTE: Depending on the flight crew's assessment of the situation, the landing gear may be recycled using the normal system prior to initiating the Alternate Landing Gear Extension procedure.

NOTE: If the aural warning horn cannot be silenced after accomplishing this procedure; at Captains discretion, AURAL WARNING POWER circuit breaker on P6 panel may be pulled.

CAUTION: all warning bells, horns, chimes, wailers, and clackers are inoperative.

Figure 14. Extract from operations manual describing the landing gear alternate operations.

When the landing gear warning horn initially sounded, the pilot in command immediately checked that the thrust lever for the shut-down engine was not in the idle setting. Without advising the rest of the crew that he was following the 'red gear light remains illuminated' procedure, the pilot in command asked the flight engineer to check the gear annunciator lights.

The flight engineer did not follow the procedure for sequentially checking both primary and alternate switch selections on the gear annunciator panel, as called for in the 'red gear light remains illuminated' procedure. He only used the primary selection when responding to the pilot in command's query and did not recognise, or indicate to the pilot in command, that the four lights which illuminated were an indication of incomplete extension.

The pilot in command was more familiar with the contents of the 'red gear light remains illuminated' procedure than the others on the flight deck, because of his considerable previous experience as a senior check and training pilot and simulator instructor. In particular, he was aware of the second note on the page which addressed the possibility of having the landing gear completely extended with the aural warning still sounding.

The flight engineer used the alternate switch selection to check the annunciator panel when he volunteered the 'four greens' condition, just prior to the warning horn sounding for the second time. He did not check the annunciator lights again.

1.18.2 Pilot in command actions

During many years of flying and training, the pilot in command had operated with the knowledge that the landing gear annunciators on the flight engineer panel are the definitive indication of the state of the landing gear and indications from that panel should be believed and acted upon. The pilot in command said that he had worked for most of his career in airlines which operated with very experienced flight engineers and the culture which prevailed in those airlines was to accept information supplied by the flight engineers as being authoritative.

The pilot in command indicated that once he had decided that the gear was down as a result of his interpretation of the flight engineer's initial response and despite the horn and the red gear light, he did not consider that a go-around was necessary.

The pilot in command said that he was aware, prior to landing, that the configuration of the aircraft was not optimum. However, as the various flight parameters and aircraft systems were either steady or converging towards their desired readings and positions, he decided that it was safe to land. At this time, the airspeed was still indicating approximately 183 knots (21 knots above the nominated maximum approach speed) and the flaps were still travelling towards the flaps 25 position.

When he selected flaps 30, the pilot in command had resolved that further pursuit of the cause of the warning horn was counterproductive, as he needed to monitor the aircraft manipulation by the co-pilot during the imminent landing. The pilot in command had decided that both the resolution of the warning horn problem and the approach were sloppy and that he would conduct an in-depth debrief for the flight-deck crew at an appropriate time after landing.

1.18.3 Co-pilot actions

The co-pilot said that he had listened to the pilot in command and the flight engineer discussing the landing gear warnings and was convinced by that discussion and his knowledge of the operations manual that the landing gear was extended and that it was safe to continue with the landing.

The co-pilot said that he mentally handed command of the aircraft back to the pilot in command when the problem developed, and had concentrated on flying the aircraft for the approach and landing. The pilot in command had taken command of the discussion and trouble shooting concerned with the shutdown of the engine and the subsequent return to Sydney, so the co-pilot expected the same procedure to be followed whilst dealing with the warning horn.

The co-pilot had flown the aircraft with the autopilot engaged to 500 feet, where he resumed hand flying. At no stage did he feel any apprehension about the approach or have any perception that the landing gear was not extended until advised by Air Traffic Control. The landing checks had not been completed, the inboard flaps were still travelling towards the flaps 25 position and the airspeed was approximately 26 knots above the target speed for touchdown. The co-pilot attributed his acceptance of this situation to his lack of experience on the B747.

1.18.4 Flight engineer's actions

The operations manual requires that the flight engineer complete a number of tasks in the latter stages of final approach. As well as reading the checklist, he is required to 'check hydraulic brake and system pressure indicators and system quantity "normal"'. He is also required to 'monitor all system panels with particular attention to forward panels'.

The flight engineer advised that during training he was criticised for inadequate monitoring of the flaps and the hydraulic system on final approach, as a pressure drop during gear and flap extension could be indicative of a leak. He was also concerned about the number one air-driven hydraulic pump. The flight engineer had reported it as being defective on previous occasions and he was concerned that a defect could reappear with the engine shut down. For both of these reasons, the flight engineer said that he was concentrating on the hydraulic indications on the side and the forward panels. He was not aware of the proximity of the ground and was not aware that a landing was imminent until the aircraft was flared for the landing.

The flight engineer reported that he selected the air-driven pump to the AUTO position normally, after engine start on the Sydney tarmac, and did not switch it OFF until he secured the aircraft after the accident. Neither the B747 nor the B767 (his previous aircraft type) procedures call for any adjustments to be made to the hydraulic switch selections when engines are shut down in flight.

The flight engineer did not think that he needed to suggest that a go-around was necessary as he considered that the landing gear was extended. He also trusted that the pilot in command was in control of the situation.

1.18.5 Landing checklist

Completion of the landing checklist ensures that the aircraft is in the required configuration for landing. Some actions may be initiated before they are called for in the checklist. However, the completion of the checklist confirms in a formal manner that all actions have been accomplished. In the operator's procedures, the manipulating pilot is responsible for the control of the checklists. As the co-pilot was the manipulating pilot, it would normally have been his responsibility to call for the completion of the checklist. However, he did not make this call.

The flight engineer said that he recognised that the checklist was not complete just before the aircraft landed and silently conducted a scan to ensure that appropriate items were actioned.

The pilot in command indicated he was aware that the checklist had not been completed and had informally satisfied himself that all remaining items were done.

1.19 Flight engineer panel skills

Most of the procedures used by the flight engineers in the operation of their panels are not checklisted items and are required to be learned by rote and through repetition. The training for Ansett's flight engineers and pilots was identical until they reached the simulators, where the pilots learnt manipulation and aircraft management skills appropriate to the B747 whilst the flight engineers developed skills concerned with the operation of the flight engineer panel. Procedures involved in the management of non-normal operations were also introduced and practised during this phase.

Qantas ground training staff considered that the most intensive learning of panel skills for a flight engineer to be in the line flying phase, where systems are used in an operational environment. The trainers reported that a flight engineer on a B747-300 was an important part of the team because the aircraft was designed to be operated with a flight engineer, and many systems could only be operated and monitored from the flight engineer's panel. It was therefore important for flight engineers, during the line training, to learn and consolidate the scans and the switching sequences used to operate and monitor the various systems.

A survey of four overseas airlines operating in the Asia-Pacific region indicated that the flight engineer from the accident flight was scheduled for his first line check whilst he was still below their average for hours on type and sector exposure. However, he had exceeded the Civil Aviation Authority's minimum requirements. After added training sectors, the flight engineer approximated the survey average when he commenced his second line check. Although he passed this second line check, the flight engineer reported after the accident that he was comfortable in the job but felt that he needed more training time under supervision to develop experience and proficiency on the flight engineer panel. He did not convey this information to Ansett flight operations management before the accident.

Qantas training staff and contract training flight engineers from Ansett suggested that the transition to the B747 panel was more difficult for flight engineers coming from a B767 than for those coming from other aircraft designed to be operated with a flight engineer. This is partly attributable to the nature of the flight engineer's task on the B767 where advanced technology assists in troubleshooting and trend monitoring. For example, the flight engineer would receive an on-screen message on the B767 identifying a gear malfunction if the nosewheel was not extended.

Development of Ansett's B747 flight engineer line training form/syllabus was not completed until the end of September, almost a month after the revenue flights and line training commenced. The form contained ten pages of normal flight profile, system knowledge and abnormal profile items to be discussed, demonstrated and practised by a flight engineer under training. Ansett's normal procedure was to raise a form for each trainee and have a training flight engineer sign off each item from the syllabus as it was dealt with during the flight training program. This procedure ensured that each trainee covered the entire syllabus prior to being checked to the line.

The finalised flight engineer training form/syllabus became available after the flight engineer's first attempt at a line check. There was no form raised for this flight engineer during his flight training, and several other company flight engineers completed both their training and line checks without the benefit of a line training form/syllabus. Therefore it was not possible for the investigation team to determine the extent to which panel skills proficiency was covered during line training of the flight engineer.

1.20 Stabilised approach

When the aircraft landed, the 'landing' checklist was not complete, the airspeed obtained from the flight data recorder readout was 183 knots (approximately 26 knots above target threshold speed), the inboard flap was moving towards flaps 25, the landing gear warning horn was sounding and the gear unsafe light was illuminated.

The B747 flight crew training manual was used during both the simulator and the aircraft flight training for Ansett's crews. In chapter two, whilst dealing with techniques for manual landings, both normal and with one engine inoperative, the document states:

> The airplane must be stabilised on final approach at least 700-500 feet above field elevation.

The manual adds, in the section providing instrument landing system approach profiles, that the final approach configuration and airspeed should be established at the glide slope intercept and that the landing checklist should have been completed.

The flight crew training manual did not define the characteristics of a stabilised approach and when queried, Boeing Commercial Airplane Group replied that its flight crew training department used 'stabilised' to describe

> an approach where the airplane is on the correct glide path with a stable attitude, heading, rate of descent, airspeed, and power setting to reach the target point on the runway at the target speed. The airplane should be on stable approach a minimum of 500 feet above the runway...earlier is better.

The normal operations section (section 4) of the Ansett operations manual did not have a definition of 'stabilised approach'. The part dealing with instrument landing system approach profiles provides different final approach parameters to those stated in the flight crew training manual and does not mention 'stabilised approach' tolerances.

Some of Ansett's flight crew members were able to specify the parameters for a stabilised approach in their particular aircraft types. These appeared to have been acquired through word of mouth or during simulator sessions for those types, as an examination of operations manuals for Ansett's B737 and B767 revealed no written definition of a stabilised approach.

There was no definition of a stabilised approach in Ansett's General Operations Procedures Manual. However, the manual detailed requirements for support pilots to monitor a number of parameters during approaches below 500 feet above field elevation. Monitoring pilots were required to call if these parameters deviated from stated tolerances. The manual did not include actions to be taken in response to such a call. Moreover, the term 'stabilised' was not defined nor was there a definition of go/no-go parameters where an approach should be discontinued.

Neither the pilot in command nor the co-pilot could state the parameters which defined Ansett's concept of a stabilised approach for the B747. The co-pilot was aware of the parameters for a B727, his previous aircraft type in the company, but could not remember being advised of those applicable to the Ansett B747.

Qantas operating procedures require a stabilised approach path by 500 feet above ground level, with normal thrust, rate of descent and airspeed relevant to the aircraft weight and prevailing conditions. If the stable configuration is not achieved by 500 feet above ground level, a go-around is mandatory. During the second simulator exercise for the Ansett crews, the syllabus stipulated discussion about a number of topics concerned with the approach phase of operations, which included thrust settings, standard calls and tolerances in such areas as tracking, vertical profile and rate of descent.

Cathay Pacific did not have a definition of stabilised approach. It did require the aircraft to be in a stabilised configuration with the 'landing' checklist complete by 1,500 feet above the runway threshold in instrument meteorological conditions and by 1,000 feet above the threshold in visual meteorological conditions. It also emphasised that the desired approach airspeed should be established and held with a descent rate of less than 1,000 feet per minute. The operations manual stated that large sudden thrust changes are an indication of an unstable approach.

The pilot in command advised that he did not consider the approach to Sydney as unstable. He said that the airspeed was stable, albeit fast, and the thrust was not subject to large adjustments. From the pilot in command's training and checking experiences, the aircraft was steady and the vital parameters were converging towards appropriate targets, so he assessed that it was acceptable to continue with the landing.

1.21 Intercom system

1.21.1 Operator

Ansett did not require any flight-deck crews to utilise the intercom system for intra-cockpit communications and the crew members on the accident flight relied on free speech to communicate with each other. The cockpit voice recorder indicated that the flight engineer passed the initial report on the condition of the landing gear to the pilot in command at reduced volume level or in a distant tone of voice and in a less distinct manner compared to his previous communications with the pilots.

During several flights in the operator's aircraft, an investigation team member noted that on occasions, instructions between crew members needed to be repeated during vital phases of flight (for example, shortly after takeoff and whilst on approach). It was also noted during cruise that the flight engineer moved his seat forward to have any extended discussion with the pilots.

1.21.2 International Air Transport Association's Safety Advisory Committee survey

In response to a request by the investigation team, a survey was conducted of airline members of the International Air Transport Association's Safety Advisory Committee regarding their attitudes and policies on the use of headsets and intercom. Of the 19 member airlines that responded, ten stated that they required their crews to use headsets and intercom for intra-cockpit communications during all or part of a flight.

1.21.3 Previous research on flight-deck noise

In January 1994, the British Airways Health Services completed an internal report concerning noise and communication on the flight deck. The report contained results of an investigation instigated because of reports of flight crew suffering noise-induced hearing loss and concerns that non-auditory effects of ambient flight-deck noise may be significant.

The report stated that flight-deck procedures used in many company aircraft fleets involved keeping an ear uncovered for verbal crew communication whilst monitoring the radio with the other ear (a similar procedure was used by the accident flight-deck crew). One of the concerns about this practice was that the volume level of the radios needed to be high so that they could be heard above the ambient noise levels affecting the uncovered ear.

Tests of ambient noise levels in B747-200 aircraft indicated levels slightly lower than levels requiring ear protection under UK Control of Noise at Work Regulations 1989. Proposed European health and safety legislation applicable to flight decks would probably require the provision of appropriate hearing protection for flight crew.

Further tests resulted in the following recommendations being made in the report:

> [that] urgent consideration be given to the provision of active noise attenuating headsets for all flight crew on the flight deck of all [company name supplied] aircraft...

and

> [that] standard operating procedure should be changed so that crew intercom on the flight deck is used for normal crew intercommunication...

A British Airways Health Services representative has advised that the recommendations were accepted and will be implemented during a six-month period commencing in September 1996.

1.22 Crew resource management

Flight crew actions are a causal factor in more than 70 per cent of worldwide airline accidents. A significant number of these accidents have been related to sub-optimal crew co-ordination.

Research conducted by the National Aeronautics and Space Administration's Ames research centre and bodies such as the University of Texas has supported the view that the lack of crew teamwork and co-ordination is a potentially significant weakness in air transport carrier operations. This research however, has also indicated that improvements can be achieved through training which focuses on non-technical skills such as delegation of tasks, communication, priority management and leadership.

Crew resource management principles such as those mentioned above have been taught in airlines since the 1970s. Crew resource management concepts and training have gained increasing acceptance worldwide and have been adopted by many major airlines internationally. In most cases, crew resource management training has been well received by crews and such training has been linked with objective, measurable improvements in crew performance.

The regulatory authorities in the United Kingdom and the United States of America have recognised the value of crew resource management training. In September 1993, the United Kingdom's Civil Aviation Authority (UK CAA) released Aeronautical Information Circular AIC 143/1993 titled 'Crew Resource Management'. This circular required all pilots engaged in public air transport operations to attend a crew resource management course accredited by the UK CAA lasting a minimum of two days, although the UK CAA considered that a three-day course would be preferable to cover the necessary material. The circular also set out a model syllabus for a crew resource management course.

In February 1993, the United States' Federal Aviation Administration (FAA) released Aeronautical Circular AC120-51A 'Crew Resource Management Training' which replaced an earlier aeronautical circular on the subject of Cockpit Resource Management, which had been released in 1989. AC 120-51A provided guidelines for air carriers in the implementation of crew resource management principles.

In December 1994 the FAA released a Notice of Proposed Rule Making containing a proposal to mandate crew resource management for high capacity airlines and some commuter operators. The FAA proposed that technical crew should receive 12 hours of initial crew resource management awareness training and four hours annual crew resource management refresher training.

The FAA made crew resource management training mandatory from March 1996; however, the FAA chose not to impose a minimum duration on crew resource management programs. The FAA stated that

> the FAA's experience with...highly successful crew resource management programs indicates that the most effective programs contain approximately 12 hours for pilot initial crew resource management training and 8 hours for flight attendant initial training. Recurrent training under these established programs contains approximately four hours for pilots and flight engineers...(FAA Docket No. 27993; Amendment No. 121-250 and 135-57)

The Australian Civil Aviation Authority had no legislated or regulated crew resource management training requirements at the time of the accident.

Many airlines which provide crew resource management training find that a two-day initial classroom session is required to introduce technical crew members to crew resource management concepts. Ansett retained a consultant associated with the University of Texas and with the National Aeronautical and Space Administration to assist with the development of a crew resource management program. The consultant, along with some Ansett managers, recommended a two-day startup course. However, Ansett's flight operations management decided to introduce a streamlined crew resource management program based on a series of half-day classroom sessions which would be briefer than those provided at some other airlines, but would be refreshed annually.

The classroom sessions were conducted in conjunction with Ansett's technical currency check program and an annual non-jeopardy line oriented flying training (LOFT) simulator exercise. Each classroom session consisted of lectures, videos and group discussions on various crew resource management topics. The first course, run in 1993, emphasised teamwork and situational awareness and covered assertion and communication skills. The following year's program covered topics including interpersonal skills, communication, assertion, briefings and problem solving.

Ansett conducted an evaluation at the end of each classroom session. These evaluations indicated that the course content and method were well received by the great majority of participants. However, participants frequently commented that the time allowed for the course was insufficient to adequately cover the course content.

When interviewed by the investigation team, some Ansett flight crew not directly involved in the accident considered that the crew resource management training they had received was overly brief and not fully effective.

The two crew members from VH-INH who had participated in the Ansett crew resource management training program could recall little of the course content until prompted by the investigators. They said that the crew resource management program was not conducted in a manner conducive to concept application or to high retention and appeared to hold a low profile within the company, considering the half-day per year of classroom time allocated to such extensive concepts.

Ansett intended that technical crew, having been exposed to the theory of crew resource management in the half-day classroom sessions, would then have the opportunity to exercise and develop their crew resource management skills in the subsequent LOFT simulator exercise. However, these exercises were not necessarily scheduled to immediately follow the crew resource management classroom training.

The co-pilot had completed one crew resource management LOFT simulator exercise, although this had been scheduled six months after the initial crew resource management classroom session. The flight engineer had not completed a crew resource management LOFT simulator exercise.

Although he had flown many LOFT training simulator sessions and had participated in many pilot-in-command training programs whilst in overseas employment, the pilot in command had not experienced any formal crew resource management training. He said that he had a general understanding of crew resource management principles but was not conversant with current world standards.

1.23 Crew duty times

During the return flight the crew was asked by Ansett's operations section if they were willing to complete a turn-around. The pilot in command answered through the flight engineer that he was and that they would organise details after landing. Several plans were being considered by Ansett management, one of which was to transfer the crew and passengers to another B747 at Sydney. This was the only option notified to the crew, and, regardless of what the management was planning, the option of turning around after landing was delivered in a way that the crew assumed that this option would proceed unless they vetoed it for reasons such as legality.

Ansett was granted an exemption against Civil Aviation Order part 48 on 19 October 1993 by the Civil Aviation Authority, provided Ansett formulated flight crew rostering and operating practices in accordance with the document titled 'Flight Crew Flight and Duty Limits (31 Aug 93)'. This document limited the maximum rostered hours per flight duty period to 14 hours for operations and crew complement identical to that for the accident flight. The document made provision for extension of these rostered hours to 16 hours and stipulated the circumstances which would allow such extension. The document also limited the rostered flight deck duty time to 10.5 hours with a provision for extension to 11.5 hours.

Ansett had reached agreement with both technical flight crew industrial associations to adopt from 1 July 1993 more restrictive rostering practices than those described in the 31 August 1993 document. The agreement limited the flight duty period to 12 hours with provision for extension to 14 hours. The agreement also excluded extensions beyond those specified within the agreement except by further consensus with the associations. It also specified that Civil Aviation Authority flight and duty limits would apply where no limit was stated in the agreement.

Thus the agreement with the associations placed more restrictive flight and duty time limitations on Ansett's technical crew rostering practices than did the Civil Aviation Authority exemption.

Further agreement signed in June 1994 extended the 1993 agreement to technical crew members required to fly to Osaka and/or Hong Kong.

The accident flight was correctly rostered.

The flight crew signed on at 0755. The aircraft was pushed back at 0934 and departed on the first sector at 1007. Following the engine shutdown, the aircraft was expected back at the terminal at approximately 1230 (had the accident not occurred). The replacement aircraft was expected to be pushed back at 1330 and to arrive at the terminal in Osaka at 2237. Sign-off was expected at 2307 (30 minutes after arrival at the terminal).

The maximum extended flight duty period was 14 hours (from the agreement) and the maximum extended flight-deck duty time was 11.5 hours (from the 31 August 1993 document). Had the replacement flight proceeded, the minimum flight duty period would have been 15 hours and 13 minutes (sign-on to sign-off) and the flight-deck duty time 12 hours and four minutes (from push-back to engine shutdown).

For the turnaround to have proceeded, Ansett was first required to secure the agreement of both the crew and the associations for the extension beyond the industrial agreement limits for flight duty. Secondly, they were required to obtain a concession from the Civil Aviation Authority against the flight-deck duty limitations. Neither of these actions was initiated before the aircraft landed without the nosewheel extended.

2.0 ANALYSIS

2.1 Introduction

This analysis considers the five principal areas where there were opportunities for the accident to be prevented. These are:

- number one engine oil loss;
- nose landing gear;
- flight crew management of the abnormal landing gear situation;
- organisational factors; and
- defences.

The first two relate to the oil leak in the number one engine and the failure of the nose landing gear to extend. The third area relates to the crew's decision to continue for a landing when they had warning indications that the nose landing gear was not extended. The fourth area relates to the influence that organisational factors had on the crew not identifying and resolving the landing gear problem. Finally, the analysis discusses the safety net, or defences, which failed to prevent the accident happening.

2.2 Number one engine oil loss

2.2.1 Oil leak

The investigation determined that the engine oil leak, which resulted in the number one engine being shut down, originated from a loose angle gearbox housing cover. This cover was leaking oil because an angle gearbox casing internal thread, which retained a threaded insert securing one of the cover attachment bolts, had been stripped. Examination of the failed insert showed it had most probably been installed flush with or above the surface. Pratt & Whitney maintenance manual references and service bulletins allowed the installer to fit the inserts flush; however, this did not ensure that the inserts were installed in such a way as to ensure a preload when the cover bolts were tightened.

Problems with the angle gearbox cover fasteners had previously been identified by Pratt and Whitney who had issued two service bulletins aimed at rectifying the problems. The modification action required by service bulletin SB 72-410 was not incorporated when the aircraft underwent maintenance in Singapore in February 1994. Consequently, an opportunity to prevent the oil leak and subsequent engine shutdown was missed.

Neither service bulletin addressed the root problem of not having the insert sufficiently below the angle gearbox surface.

2.3 Nose landing gear

2.3.1 Air-driven hydraulic pump aspects

Evidence obtained from Boeing indicated that the engine-driven hydraulic pump on the windmilling engine, assisted by an operating air-driven hydraulic pump, should have been capable of delivering sufficient pressure and flow to provide almost normal operation of the gear and flaps. However, analysis of flight data recorder information confirmed that the operation of the gear and flaps on the approach into Sydney on the accident flight was about

one tenth of the normal speed. This was similar to the data obtained during post-accident maintenance test flying of the accident aircraft when the air-driven pump was selected 'OFF'. Therefore, it is concluded that the air-driven pump probably was not delivering hydraulic pressure and flow during the gear and flap extension on the accident flight.

The recorded flight data is consistent with the report by the flight engineer of reduced pressure in the number one hydraulic system.

There are several possible explanations for the degraded performance of the number one hydraulic system. The more likely are considered below:

1. *There was a fault in the air-driven pump or in its drive.* This has been discounted because rigorous examination and testing of these components by their respective manufacturers after the accident found no faults that would have caused them to perform other than as designed [see 1.12.3.3 (b)].

2. *There was an intermittent electrical problem in the pump control system between the pump switch on the flight engineer panel and the pump drive controls.* This has been discounted because checks of the switches and connections found no faults (see 1.12.3.4).

3. *There was insufficient air pressure available in the pneumatic duct to drive the air-driven pump.* This has been discounted because the configuration of the duct would not have prevented sufficient capacity being available to operate the number one air-driven pump (see 1.12.3.4).

4. *The air-driven pump switch was in the OFF position.* This was not resolved. The flight engineer said that he had operated the switch normally throughout the flight (see 1.18.4) and did not select OFF until he closed the aircraft down after the accident. He also stated during interviews that he had seen the air-driven pump 'run' light illuminate during the return to Sydney (see 1.1). The flight engineer demonstrated signs of being subject to pressure during the flight (see 2.5.1.2(b)) and it is possible that he may have inadvertently selected the switch to OFF at some point during the return to Sydney. However, he said that he did not do this.

The air-driven pump system had a record of defective operation before the accident but no system faults were found during post-flight troubleshooting.

The reason for the highly degraded performance of the number one hydraulic system on the accident flight was not determined.

2.3.2 Nose landing gear extension failure

The nose landing gear door actuator internal lock was the only component in the nose landing gear extension and retraction system that had the potential to contribute to the non-extension of the nose gear. This was because of the intermittent higher pressures needed to unlock it, identified during the post-accident checks.

It is normal for the main landing gear and the nose landing gear to unlock at different hydraulic pressures and in this case there probably was sufficient system pressure to unlock the main landing gear, but insufficient to unlock the nose landing gear. Had the system pressure been allowed to stabilise on the nominal value, the actuator probably would have eventually unlocked, despite the nose landing gear door actuator requiring higher than specified pressure. The nominal system pressure could only be achieved if flap movement ceased, redirecting pressure and flow to the nose landing gear. Such a rise of system pressure was unlikely to have

occurred because the flap selections were changing and the flaps were not static long enough to allow system pressure recovery before the aircraft landed.

Assuming that the air-driven hydraulic pump was not providing pressure and flow to augment the output from the hydraulic pump on the windmilling number one engine, the high demand of simultaneous gear and flap movement would have been beyond the immediate capability of the number one engine pump. Consequently, flap and gear selections would have caused a significant system pressure drop and a reduction in flow rate. The flight engineer commented that the hydraulic pressure had reduced to below 1,000 pounds per square inch shortly before the aircraft intercepted the instrument landing system glideslope, but there was no indication that either pilot heard this comment. Thus an opportunity for the crew to recognise a potential problem area and to modify planned flap and landing gear extension initiation was missed.

2.3.3 Landing gear warning and indication system

Post-accident examination and testing did not find any faults in the landing gear warning and indication system.

2.4 Flight crew management of the abnormal nose landing gear situation

2.4.1 Active failures

Active failures were those crew actions or omissions which contributed to the accident.

From the time that the warning horn began to sound until touchdown on the runway, the crew could have discontinued the approach. However, they did not initiate a go-around despite circumstances that should have prompted such action. The following paragraphs consider the circumstances surrounding the active failures involving the flight crew.

2.4.1.1 Detection and communication of the landing gear problem

The first justification for a go-around was the non-illumination of the green nose gear light on the flight engineer's annunciator panel. Had the flight engineer recognised the absence of the light and communicated to the pilot in command that there was a problem, the option to go around and resolve the problem probably would have been exercised.

Evidence from the cockpit voice recording clearly indicates that the flight engineer did not realise that one light was missing on the landing gear panel. He correctly advised the pilot that there were four lights illuminated. However, because he had not recognised that the nose gear was not extended, he did not qualify the information or pass it in a tone of voice that would have alerted the pilot in command to the existence of the problem.

2.4.1.2 Pilot in command's perception

The pilot in command said after the accident that he understood from the flight engineer's first reply that the landing gear was extended. This is supported by analysis of his behaviour and comments as recorded on the cockpit voice recorder. He may have misheard 'four' as 'all', or he may have had an expectation that the gear was down and perceived that to be the situation when not able to hear exactly what the flight engineer replied.

Irrespective of the reasons for the misperception, there is strong evidence that the pilot in command's actions after this exchange were predicated on his perception that the landing gear was fully extended.

2.4.1.3 Operations manual procedure

The procedure to be followed when the 'red gear light remains illuminated with the thrust lever(s) not at idle setting' is contained in the Ansett Operations Manual. This procedure calls for the flight engineer to check for the illumination of each of five lights in both the primary and alternate indicating systems on the landing gear annunciator panel. However, when the pilot in command asked the flight engineer for the status of the landing gear, the flight engineer did not recognise that the pilot was following the operations manual procedure and, on this occasion, only checked the primary system lights. If the flight engineer had associated the landing gear warnings and the pilot in command's landing gear status request with the procedure, he may have remembered to check both primary and alternate indicating systems or may have referred to the written procedure.

There was no Ansett practice, either written or understood, which required crews to refer to the procedure as a checklist. To the contrary, the operations manual described this procedure as one that could be achieved through recall and left it to the crew's discretion whether they referred to the manual. This is consistent with Boeing practice.

The pilot in command's recent experience was with airlines which employed experienced flight engineers on the flight deck. He accepted and relied on the information from those flight engineers and appeared to have developed a less formal approach to the transfer of information between himself and flight engineers. His request for 'how many lights you got back there' would probably have obtained a response from an experienced flight engineer indicating that there was a problem. However, the form of the question asked did not cause the inexperienced flight engineer on this flight to recognise that the pilot was initiating the operations manual procedure.

A more appropriate question for the pilot in command to have asked may have been 'Do you have five lights on both the primary and secondary systems?'. A question such as this probably would have directed the inexperienced flight engineer's attention to the need to check both indicating systems on his annunciator panel for five lights. It probably would also have broken the mindset in all of the cockpit crew members and triggered the need to go around and resolve the problem.

2.4.1.4 Uncoordinated troubleshooting

Evidence from the cockpit voice recording showed that the troubleshooting of the cause of the warning horn by the pilot in command and the flight engineer was uncoordinated and disjointed. The pilot in command was concentrating his comments on the landing gear and the flight engineer was commenting about the flap movement, indicating two independent thought processes. The flight engineer's focus may have been directed to the flaps because the horn sounded when the pilot in command selected flaps 25 and stopped when the pilot reselected flaps 20. This apparent indecision continued for 18 seconds until the flight engineer stated for the second time that there were four green lights. He had ascertained this by checking the alternate indicating system.

The pilot in command repeated this second 'four greens' call but again appeared to interpret the flight engineer's message to indicate that the landing gear was extended. It is likely that the pilot in command registered the confident tone and manner of delivery, rather than the actual words used, despite his repeating them. This is consistent with research regarding the interpretation of speech (see appendix 1 (f)). The pilot then reselected flaps 25 and asked the flight engineer 'are all green lights on both primary and secondary?' seeking a final confirmation, as the aircraft passed 500 feet, that the landing gear was down. The flight engineer answered in the affirmative.

Although the flight engineer correctly reported that all the lights he had seen on both indicating systems were green, he had not rechecked both indicating systems, and had not recognised that

one light was missing. The pilot in command was seeking a final confirmation from the system which he knew accurately depicted the status of the landing gear and the flight engineer answered the query in a manner that did confirm to the pilot that the landing gear was extended.

For the same reasons discussed in 2.4.1.3, had the pilot in command been more direct with his question and asked for confirmation of five lights on both systems, the mindset that the landing gear was extended may have been broken and a go-around initiated.

2.4.1.5 Co-pilot's actions

The decision to allow the co-pilot to continue to fly the aircraft enabled the pilot in command and flight engineer to concentrate on resolution of the landing gear warning. This was a good procedure although there was no formal allocation of tasks by the pilot in command, a practice which would have been in accordance with crew resource management principles.

The co-pilot did not take part in resolution of the warning as he continued to fly the aircraft. Although the aircraft manipulation task required almost his full attention he did hear the conversations between the pilot in command and the flight engineer regarding the status of the landing gear. However, he too did not recognise the significance of the information in the flight engineer's replies. The co-pilot appears to have been influenced in the same way as the pilot in command to assume that the landing gear was extended. The flight engineer's information did not alert the co-pilot that one light was missing and therefore did not alert him to the need to go around.

2.4.1.6 Ambiguity

A further justification for a go-around was that the crew had not adequately resolved the ambiguity between their perception of gear extension and the evidence of the gear warning horn and the gear warning light on the pilots' centre panel.

During the approach, after the warning horn first sounded, the pilot in command made several statements indicating that he was puzzled by this ambiguous situation. (See extract from the cockpit voice recording on the flight data recording insert.) At 12:19:13 he stated, 'Oh why have we got that one there?'; at 12:19:16 he stated, 'Why have we got that one?'; and at 12:19:29, 'The gear, we still got a red light there, is it in?' (apparently referring to the gear lever). Even as the landing was imminent he stated, 'Don't know why we got a red light'; and then moments later, in response to the flight engineer's comment on the flaps, 'Flaps are running, yeah, but still we shouldn't have that horn'. The pilot in command appeared to place greater reliance on the information from the flight engineers' annunciator panel, as supplied by the flight engineer, than he did on the warning light and horn. Thus he did not resolve the ambiguity and did not make the go-around decision. The pilot was aware that under certain circumstances, the warning horn may sound with the landing gear completely extended, and this awareness may have contributed to his indecision.

2.4.1.7 Stabilised approach

The final circumstance which would have justified a go-around was that the approach was not stabilised. As the aircraft landed, the airspeed was well in excess of the target speed, the flaps had not completed their travel to the selected position, the pre-landing checklist had not been completed and some standard challenge and response items had not been completed. This is discussed further in section 2.4.2.9.

The pilot in command later said he was aware that the approach was 'sloppy'. He had considered that the landing would be safe if the approach was allowed to continue because from his

experience he knew that a flaps 25 approach was acceptable. He also knew that there was sufficient runway length to allow the aircraft to stop, despite the extra speed. He considered that the approach was stable as each parameter was either steady or was converging towards the desired setting. However, he had resolved to discuss the approach with the cockpit crew at an appropriate time after landing to highlight the deficiencies in their performance.

2.4.2 Local factors

Local factors are task, situational or environmental factors which affect task performance and the occurrence of active failures.

Significant local factors which influenced the performance of the flight crew were:

. the composition of the crew;
. cockpit noise levels;
. subtle pressures;
. flight engineer preparedness for the task;
. the flight engineer's panel skills;
. task overload;
. the layout of the flight engineer's panel;
. crew resource management; and
. stabilised approach procedures;

2.4.2.1 Composition of crew

The pilot in command was a very experienced B747 pilot, while the co-pilot and flight engineer were inexperienced on type. The evidence suggests that this steep difference in experience levels, angled up to the pilot in command, contributed to both the copilot and flight engineer allowing the pilot in command to assume a large degree of their responsibilities during the analysis of the landing gear warnings. They apparently allowed this to happen in recognition of the pilot in command's greater experience, knowledge and status. This situation was also evident when the pilot in command took command of the trouble shooting for the oil leak problem. It is therefore likely that the performance of the flight crew partly reflected the discrepancy in experience between the pilot in command and the two other crew members.

Reports from previous aircraft accident investigations have established the inadvisability of rostering inexperienced crew members together, and the effects of steep trans-cockpit authority gradients (see appendix 1 (h)). The pilot in command had been allocated the particular co-pilot to ensure that the co-pilot's performance indicated readiness for a line check. In addition, the flight engineer was included in the crew on his first unsupervised flight. This placed a high level of responsibility on the pilot in command, requiring him to monitor the performance of two inexperienced crew members. Although this was a startup operation where many crew members were operating under training, the company specifically contracted experienced crew members to help with staffing. However, in this case the company did not manage the rostering to achieve a good balance of experience levels in the cockpit. The result was that the crew on the accident flight operated with a steep trans-cockpit authority gradient, as well as with a high level of inexperience on type, on the part of two of its three members.

2.4.2.2 Cockpit noise levels

There are several factors which, either singly or in combination, could explain why the flight engineer's reply of 'four—four greens' apparently did not register clearly enough with the pilots

for them to recognise the problem it conveyed. Firstly, the crew members were not using intercom during the approach to the landing. Secondly, intra-cockpit communication was affected by significant ambient cockpit noise, part of which was caused by the warning horn. Thirdly, evidence from the cockpit voice recorder indicated that the flight engineer was probably facing away from the pilots, observing his panel, thereby reducing the strength of his reply when he made the first 'four greens' response.

In addition, the air traffic control radio transmission immediately after the flight engineer's initial status comment added to the noise surrounding the pilot in command. The research from British Airways Health Services (see 1.21.3) clearly states that radio volumes are invariably higher when a headset is used in the way that it was on this flight deck, so that radios can be heard above the ambient cockpit noise. Consequently, when the radio communication immediately followed the flight engineer's status response, it would have contributed to the general noise competing with the content of the flight engineer's response.

The noise surrounding the pilot in command and the low volume of the flight engineer's comment would have caused the pilot in command to rely more on intonation and contextual features of the comment than on the actual words spoken. Had noise attenuating headsets been used in conjunction with intercom, much of the extraneous noise would have been filtered and the flight engineer's comment would not have been delivered at a reduced level. Thus the pilot in command would have been better able to concentrate on the meaning of the flight engineer's words and may have recognised that a problem existed.

Evidence obtained from cockpit voice recording analysis indicates that the cockpit noise may have been a factor in the flight engineer not recognising that the gear annunciator panel indication was abnormal. His initial failure to detect the abnormal gear indication occurred while the gear warning horn was sounding. Research has shown that noise can have adverse effects on performance (see appendix 1 (c)), and in this case the unexpected noise from the warning horn may have affected the flight engineer's performance. There is some evidence on the cockpit voice recording of more confused and halting speech by the flight engineer whilst the horn was sounding than when it was not.

2.4.2.3 Subtle pressures

The crew members were probably affected by subtle pressure arising from their perception that management expected that the crew and passengers would change aircraft and continue the flight. Although management was considering other options, the crew were only aware that, provided they agreed to the request to continue, they would be continuing with the task. They were also aware that continuation could cause them to approach the flight and duty limits and for this reason they were motivated to minimise the changeover time after landing. It is possible that the perceived need to turn around quickly influenced the pilot in command's failure to consider a go-around and blocked his recognition of the ambiguity between the warnings and his belief in the safe configuration of the aircraft.

Time pressure also resulted from the pilot in command and flight engineer having less than two minutes from when the warning horn first sounded to resolve the reason for the horn and continue with the landing, or to elect to go around and deal with the problem away from the airfield. As the aircraft continued on the approach, the time pressure mounted to the point where, at 170 feet above ground level, the pilot in command decided that the aircraft was in a safe configuration to land and that insufficient time and altitude remained to resolve the reason for the warning horn. The pressure of time was exacerbated by the aircraft travelling approximately 25 knots faster than normal in the latter stages of the approach.

Although the warning horn was still sounding as the aircraft passed 500 feet, the pilot in command received confirmation, to his satisfaction, that all of the gear lights were green. At that stage the aircraft was cleared to land and the runway was visible to the crew. It is probable that the closeness of the runway and the perceived urgency to continue with the task in the replacement aircraft combined to influence the pilot in command to continue towards a landing despite the acknowledged sloppiness of the approach.

2.4.2.4 Flight engineer preparedness for the task

The flight engineer had been assessed as meeting the requirements for endorsement on the B747. However, there is evidence that his preparedness for line flying was marginal. Had this been identified and rectified during his line training he probably would have been better prepared to cope with the situation on the accident flight.

Evidence from interviews with his line trainers revealed that he exhibited an elevated level of anxiety in some situations, did not react well to pressure and lacked confidence in his ability as a B747 flight engineer. However, the opinions of these trainers were not recorded on his weekly line training reports. Adding to his anxiety and underconfidence was the fact that he had failed initial check rides in both the simulator and aircraft. These factors led to him being anxious before the accident flight and not sleeping well, which together probably contributed significantly to his poor performance on the flight.

If the appropriate supervisors had spoken to the line training and checking flight engineers who had flown with the flight engineer, with the objective of analysing his performance after the first line check failure, they may have recognised that he lacked confidence and needed more training than the two sectors allocated. They may also have realised the need for a specific, remedial program concentrating on building confidence and consolidating the panel skills identified in the failed-check report as being deficient.

If more and better focussed training had been undertaken and the flight engineer's self confidence in the operation of the B747 panel had been raised, it is likely that his anxiety would have been reduced, thus increasing the potential for a better sleep pattern and fewer performance errors. Two factors identified in research (see appendix 1 (c)) as contributing to the susceptibility of individuals to performance degradation due to exposure to noise, are levels of arousal and the individual's level of anxiety. If the flight engineer had been more comfortable in his task and better rested, he may not have suffered an apparent performance degradation with the onset of the landing gear warning horn.

2.4.2.5 Flight engineer's panel skills

At the time of the accident, the flight engineer appeared to lack the integrated skills on the B747 necessary to perform tasks under pressure. This is particularly evidenced by the reported deficiencies in his first line check. Although he had passed his second line check, it is probable that the pressure of the situation on the approach to Sydney, when combined with his minimal skill level, resulted in his misinterpreting the indications on his panel. His misinterpretation of the gear annunciator panel is consistent with a lack of panel skills.

One consequence of under-skilled performance is that more attention is required for central tasks and less attention is available for problem solving and troubleshooting.

An experienced flight engineer would be expected to have a mental picture of how the panel would look for a normal situation and would be able to instantly recognise an abnormal panel indication without having to count the number of lights. The flight

engineer had not operated the flight engineers' panel long enough to consolidate his skills to an experienced level and had demonstrated reduced performance when operating under pressure.

2.4.2.6 Task overload

There was some evidence that the flight engineer, in responding to the pilot in command's attempts at resolving the non-normal situation, may have been affected by increasing pressure caused by the failure to resolve the problem, the reduction in time available before the landing and the distraction provided by the warning light and horn. Research (see appendix 1 (e)) indicates that a raised level of anxiety about task performance can reduce cognitive effectiveness to the point where increasing task demands narrows the attention and errors are made. The flight engineer's preoccupation with hydraulic pressures and the movement of the inboard flaps late in the approach, to the exclusion of other important matters such as proper completion of the landing checklist, is consistent with the narrowing of attention accompanying this 'task overload' situation.

2.4.2.7 Layout of flight engineer's panel

The design of the flight engineer's landing gear indication panel probably contributed to the flight engineer not recognising that the nose gear was not extended. The panel is designed in such a way that the engineer must look for the absence of a green light to indicate that part of the landing gear is not down. This logic is the reverse of that which typically applies to warning lights, where the presence of a light usually indicates a problem (see appendix 1 (d) and figure 15).

Moreover, the line of four main gear lights could present an apparently complete picture to an observer whose panel skills had reached a minimum qualification level but were not yet fully developed. The nosewheel light is located higher than, and slightly to the left of, the main gear lights and this could increase the risk that an unlit nosewheel light would not be noticed.

Evidence obtained during the investigation (see 1.16.2) suggested that the design of the panel had possibly contributed to other misinterpretations of landing gear configuration. One international airline appears to have attempted to clearly delineate all landing gear lights on the flight engineers' annunciator panel by adding fine lines around them in such a way as to draw the nosewheel light into the group. This is a simple and effective modification which could be easily applied to an aircraft model which has ceased production.

2.4.2.8 Crew resource management

Evidence from the cockpit voice recording indicates that, in the latter stages of the approach, the cockpit crew were not performing as an effective team and that this contributed to the development of the accident. Cockpit crew coordination difficulties included: ineffective question and answer communication, crew members performing tasks in isolation, and crew members not challenging departures from standard procedures.

2.4.2.9 Stabilised approach procedures

The stabilised approach is an industry-recognised method of ensuring that the number of variables occurring during the final approach to landing are reduced to a minimum. This then permits the flight crew to direct their attention to environmental factors outside their control and ensures the highest probability of a safe landing. The 'stabilised approach' concept also provides for a standardised 'go/no go' check for crews whereby, if certain

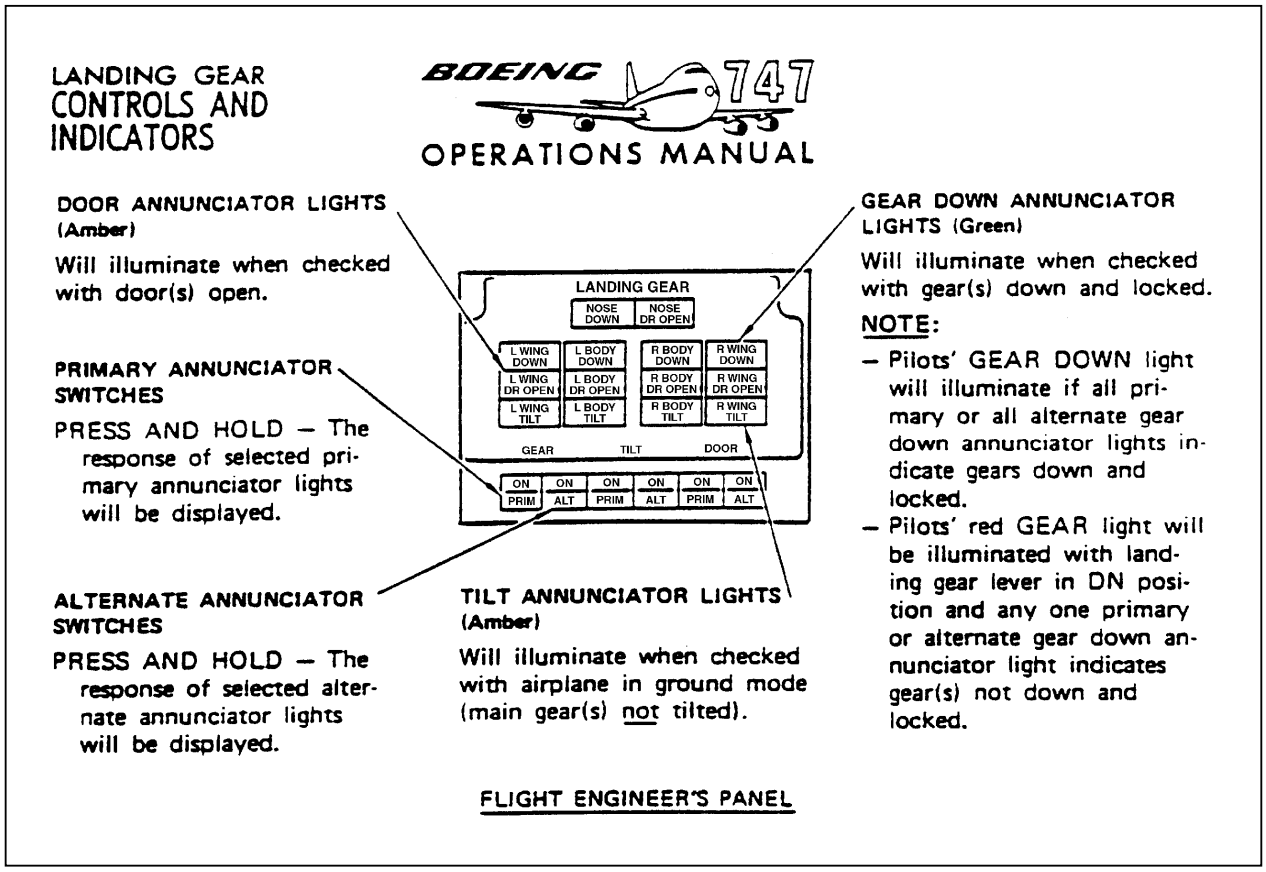

Figure 15. Depiction of the landing gear annunciator panel from the flight engineer station on the B 747-300 flight deck.

desired criteria have not been achieved at a predetermined point, it is an indication that something is wrong with the approach and a go-around should be initiated.

Evidence obtained during the investigation indicated that Ansett had not published 'stabilised approach' criteria for a number of its aircraft including the B747, although most crews were aware of non-written requirements for Ansett's other aircraft. The co-pilot and flight engineer had been exposed to the Qantas parameters and associated tolerances during their simulator training, but their ability to refer to the parameters constituting a stabilised approach in the Ansett environment was hampered by the absence of this information from the Ansett manuals.

The pilot in command was from outside the organisation and was not aware of the Ansett non-written procedures regarding stabilised approaches. He therefore relied on his experience. Although the configuration of the aircraft during the approach did not meet the requirements of Cathay Pacific's 'stabilised approach' concept, the pilot in command considered that the approach was stable as each parameter was either steady or was converging towards the desired setting. He also considered the aircraft to be in a safe configuration for landing under the existing circumstances. He did not judge that the higher airspeed justified a go-around, given the length of runway available, and therefore decided to continue with the landing.

There is no guarantee that a written definition of a 'stabilised approach' would have resulted in a go-around. However, if a definition had been published and emphasised during simulator and line training, it may have acted as a trigger for a go-around initiation when the go/no go point was reached and parameters were still outside the required tolerances.

2.5 Organisational factors

2.5.1 Ansett

2.5.1.1 Training

Ansett's flight operations department planned and implemented a training program which was aimed at providing adequately trained crews by the startup date of the B747 operation. Several deficiencies related to that program contributed to the environment in which the accident occurred. These included:

(a) training of the accident flight engineer;

(b) crew resource management training;

(c) changing procedures during ground training of flight crew;

(d) flight training to the line; and

(e) training of contract crew members.

(a) Training of the accident flight engineer

Local factors affecting the performance of the crew included:

- the flight engineer was not adequately prepared for the situation with which he was faced;
- the flight engineer lacked panels skills; and
- the flight engineer exhibited behaviour characteristic of task overload.

In the light of this, the investigation attempted to determine whether aspects of the B747 training system organised by Ansett contributed to these local factors being present on the accident flight. The following evidence suggests that it did.

Flight engineers to be trained for startup operations were selected mainly on seniority. As a consequence, prior to him starting training, there was little opportunity to establish that the flight engineer would have more than average difficulty in transitioning to the B747. Interviews with the flight engineer and his trainers after the accident indicate clearly that despite passing all relevant tests, he had been, and was still, experiencing difficulties in transitioning to the aircraft. As a result he set out on the accident flight underconfident, anxious and tired. The application of a broader range of selection criteria by Ansett management may have identified a flight engineer experienced in operating panels similar to that of the B747 and one who would have been better able to cope with the more challenging environment that accompanies the early stages of a new operation.

The development team management had not ensured that documentation critical to monitoring trainees' progress was made available on time to all who needed it. In particular, there were no Ansett flight engineer line training form/syllabus or standards available for any flight engineers trained during the first month of flying and none were supplied to the trainers of the flight engineer during his six weeks of line training.

The problem of setting and monitoring line training standards was exacerbated by the informal manner in which the contract line trainers were processed and accepted for line training duties. One line trainer who trained the flight engineer had not operated in a training role for 20 years. Despite this, he, like all the other contract training staff, was given no preparatory briefings or training on what was required of him when acting as a line trainer. Indeed, he stated that he was not aware that he was required to be a trainer until he reported for duty on his first flight.

The flight engineer had problems throughout his training having failed his initial simulator check and his initial flight line-check. However, the Ansett training system had not established threshold standards against which supervisors could identify individuals who needed special attention. Thus, after the flight engineer's initial line check failure, no process was automatically commenced to ensure that his problems were fully investigated, documented and dealt with appropriately. Management did not consult the flight engineer's trainers or develop a remedial program and appeared to rely on task exposure during only one extra training trip to correct the problems identified during the line check. A deeper analysis of events leading to the failed check flight, would probably have identified the need to boost the self-confidence of the flight engineer and to consolidate his panel skills prior to him being checked and approved for line flying.

Allied to this problem was that the Ansett training system did not incorporate a comprehensive reporting process where the strengths, weaknesses and progress of trainees were accurately reflected.

Overall, the flight engineer training system failed to identify that the flight engineer was underconfident and anxious about his performance. By not ensuring that a suitable period for task consolidation was allocated after his first line-check failure, management increased the risk that the flight engineer would experience task overload and make errors such as occurred on the accident flight.

(b) Crew resource management training

Ansett had introduced crew resource management training for its crews even though there was no regulatory requirement for such training. Nevertheless, the performance of the crew on the approach into Sydney was degraded by less than optimal teamwork in the cockpit. Several training-related organisational factors contributed to this.

Firstly, the company had adopted the regimen of a half-day training course annually for its flight-deck crews, supplemented by a related LOFT session in the simulator. This contrasts with the trend in other airlines to spend one to two full days on such courses. Evidence from most of the flight crew interviewed was that the impact of the course content was reduced because of the short duration of training. This led to poor retention and transfer of the concepts to the flight deck.

Secondly, Ansett did not ascertain the status of crew resource management knowledge of contract pilots and flight engineers before they commenced operations with the company. Thus, they missed an opportunity to identify the pilot in command's lack of crew resource management training. If his lack of training had been identified and he had been given such training before he started flying with Ansett, he may have better applied some of those concepts during the latter stages of the accident flight.

Thirdly, the flight engineer's recent operating experience had been in the Ansett B767 fleet, where the flight operations department culture tended to treat the flight engineer as a 'systems specialist' rather than as a crew member integrated into all aspects of the flight deck operation. Although he had participated in the Ansett crew resource management training sessions, the flight engineer had not had this theoretical training reinforced by a practical crew resource management LOFT exercise.

Fourthly, the co-pilot had undergone both crew resource management classroom sessions and one associated LOFT exercise in the simulator. However, the evidence from the cockpit voice recording indicates that neither he nor the flight engineer recognised the need to be assertive or the need to exercise other important aspects of crew resource management during this occurrence.

The above evidence supports a conclusion that Ansett's crew resource management training program was not fully effective in instilling crew resource management principles into the operational culture of the company's flight crews. When this was combined with a lack of such training for the pilot in command, it contributed to less than optimal teamwork in the cockpit during the latter stages of the approach to Sydney.

(c) Changing of procedures during ground training of flight crew

The late start of the ground school training meant that the development team was being trained without the designed buffer between the team's training and that of the first of the non-management crews. As a result some of the procedure development, which was to have taken place during development team training, appeared ad hoc and unstructured. This was particularly evidenced by unsigned, new procedures being distributed to non-management crews at night for use from the next day. The lack of definitive Ansett procedures in an operations manual supplement for the B747 resulted in a mixture of procedures being taught to the flight crews. This created uncertainty and inconsistency in the expectations of trainees on the second course regarding the procedures to follow.

(d) Flight training to the line

Ansett management did not ensure that all technical crew members had received an operations manual which contained an appropriate normal operations section before flight training to the line commenced. The impact of this was to foster an environment where non-standardised procedures were being taught. The spread of non-standard procedures on early training flights was probably exacerbated when trainees, including the flight engineer, flew with a number of different trainers.

Evidence suggests that the driving force behind line training programs was the achievement of the minimum hours and sectors flown so that a flight check could then be conducted. An informally stated aim, supported by comments from Ansett staff and by evidence from the planning flow chart, was to get the Ansett crews on line so that the contract crews could be dispensed with.

Once flight training had commenced, programs were poorly managed. Ansett management held no briefing sessions with contract crews to standardise the procedures to be taught and used within the B747 operations. As a consequence, these trainers had little choice other than to apply standards from their previous employment. Line training forms/syllabuses were not distributed uniformly or on time and no obvious, co-ordinated overview was maintained to assess an individual's progress. Without these forms and knowledge of Ansett standards, trainers had no benchmarks against which to gauge trainees' progress towards flight checks.

In this environment, the flight engineer was programmed for his flight checks without having been assessed against designated levels of performance other than those brought in with the contract trainers from their previous employment and those applied during the two check flights. Because there was no line training form/syllabus available for the flight engineer, there was no way to confirm that all syllabus items were covered during his training flights. It is also probable that the training flight engineer, who did not have recent training experience, only applied standards accrued through his years of B747 flying in his assessment of the flight engineer's performance capabilities.

(e) Training of contract crew members

Contract pilots and flight engineers were not effectively trained or indoctrinated in Ansett's operating philosophy. Ansett's introductory program only ensured that the contract crew members were properly licensed, met currency requirements and had attended administration, weight and balance and performance lectures. No discussions or briefings were provided on training standards, methodologies, thresholds to be achieved for checks to the line, or standardisation of the checks.

Some contract crew members did not receive all manuals needed to operate the aircraft according to Ansett philosophies. However, Ansett's management expected that one of the principal methods for learning the Ansett philosophies was by reading the manuals. This inconsistency caused confusion among both contract trainers and Ansett trainees.

Contract training pilots were assessed on their training abilities in the course of one simulator session, but no assessment was made of the training flight engineers' training ability. One result of the lack of assessment of contract flight engineers was that one of them was used in a training role without relevant recent experience as a trainer, without undergoing any refresher training in the role and without knowledge of his intended employment in that role until his first rostered flight for the company. This trainer, whose only direct knowledge of training standards were those from 20 years previously in B707 aircraft, subsequently trained the flight engineer from the accident for the trips immediately preceding both line checks.

Ansett management appeared to adopt the approach that the contract crews were employed for a specific task and would be supplied with the minimum needed to complete that task in the minimum time. The management did not train the trainers or assimilate the contract crew members completely into the Ansett operational philosophy, which left those crew members less than ideally prepared to supervise the Ansett flight crews' training. It was thus possible for the flight engineer to graduate from the training phase with underconfidence, residual anxiety and a lack of preparedness to deal with circumstances such as those which occurred on the accident flight.

2.5.1.2 Pressures

Pressures which adversely affect the performance of operational personnel can be either real or imagined. Their effect can vary depending on the type of pressure, its intensity and the individual's response to it. The evidence indicates that in this accident Ansett management staff and the flight crew were influenced by pressures and that these pressures may have been a significant factor in setting up an environment which increased the potential for an accident.

(a) Organisational pressures

The relatively late decision of the Ansett board to activate the International Air Services Commission determination resulted in the operational arms of the company being under pressure to plan and implement the B747 operation within the five months available before Kansai opened. Once the operations' commencement date was set, much of the organisational pressure stemmed from commercial imperatives. The various group leaders within the domestic operation assured the project manager that they could achieve the target. Although senior Ansett managers advised the investigation that they were prepared to delay the B747 introduction if strong arguments were presented to them, no-one recognised or suggested to management that a delay was probably required. Ansett flight operations department staff indicated that a postponement of the startup date was not considered to be a viable option.

There are some indications that company loyalty, and motivation within the company to help initiate a new operation enhanced real and imagined pressures to meet the 4 September commencement date. Throughout the investigation it was evident that a sense of 'let's get the job done' was an underlying feature of Ansett employee attitudes towards the introduction, although substantive evidence for this was impossible to quantify. Some evidence which could support such a contention is:

- the willingness of flight crew trainees to accept shortfalls in reference documentation;
- the willingness of the flight crew on the accident flight to extend their duty day beyond 14 hours to continue on to Osaka;

- the willingness of flight crew members to use procedures which varied with trainers, manual distribution and amendment frequency;
- the willingness of Ansett flight crew members to train their line trainers in Ansett operational philosophy whilst learning and consolidating new skills associated with a new aircraft and a new operating environment;
- the concentration of the flight operations department management on the achievement of training milestones to the detriment of manual development; and
- the acceptance by contract crews of the informal attitude of the flight operations management towards their indoctrination, training standardisation and documentation control.

(b) Crew pressures

The evidence indicated that the option to transfer to a spare aircraft and continue with the flight was presented to the crew members as the only alternative to the flight being cancelled. There were strong indications from the cockpit voice recorder that some subsequent crew actions and decisions were made with the presumption that there would be a change in aircraft and a continuation of the flight. Whilst management were considering other options, these were not conveyed to the crew. An unintended impact of this was that an environment of subtle pressure was created, motivating the crew to minimise delays during the approach, landing and turn-around to remain within flight and duty time limitations. Without this subtle pressure, a decision to go around and resolve the persistent landing gear warnings may have been more easily made.

The flight engineer was subjected to increased pressures from co-ordinating the details of flight and duty limitations, aircraft supplies and catering needs whilst he was also dealing with the aftermath of an engine shutdown and the fuel dumping process. Having to work with added pressures whilst managing unusual aspects of his own job may have contributed to his subsequent underperformance.

2.5.1.3 Planning and implementation

Ansett's flight operations development group did not use appropriate project management tools and resources in their planning of the flight operations aspects of the aircraft introduction. Those tools that were used did not have the capability to highlight possible impediments to the completion of important tasks. The result was that planning was flawed, the indoctrination process for contract crew members did not adequately prepare them for their allocated tasks, and manuals were not developed in a structured manner.

Ansett's flight operations management modified the flow chart used to plan the training program for their flight crews when the start of the program was delayed. Both the original plan and its modification did not incorporate details of tasks distinct from, but related to management's priority task of training its crews, which needed to be pursued concurrently with the training. These tasks included the development of relevant manuals for flight crew, the hiring and indoctrination of contract crews and the securing of air operators certificates and other approvals from the Civil Aviation Authority. As these tasks were not included in the original plan, any consequences of the delays were not highlighted and they could not be monitored against planned milestones.

The late start of the training program resulted in the need to extend the role of the contract crews to include training and checking. No adjustment to the flow chart was made to account for any added time needed for training or for checking the skills of the contract crew members in training roles.

The task of organising the recruitment and indoctrination of the contract crews was allocated outside the development group to a number of managers in the domestic operations area. This group did not have knowledge of the B747 and had insufficient time to develop a training program which fully addressed the contract crew members' indoctrination needs. The hiring of the contract crew members commenced too late to conduct an in-depth program incorporating more than performance lectures, licensing and currency updates.

The flight operations development team leader did not fully utilise available resources for the planning process, or later in its implementation. Several of Ansett's non-management pilots were experienced in both international and B747 operations, but their knowledge and experience were not used during the planning process. This knowledge and experience could have been used in the development of the checking manual supplement, the route manual supplement and earlier development of the Ansett operations manual and line training syllabuses.

2.5.1.4 Management and supervision

When implementation of the flight operations plan was delayed by a month and the development team leader allocated responsibility for tasks peripheral to flight crew training to managers outside the development team, he lost effective control of the project development process. In addition some tasks were allocated to managers who were heavily involved in the running of Ansett's domestic operations, were unable to allocate the required priority to the tasks and were not knowledgeable in B747 procedures. As a result, tasks were inadequately addressed. This is evidenced by the breakdown in the distribution of manuals, the lack of development of training syllabuses, the lack of incorporation of B747-specific procedures into appropriate manuals and the poor indoctrination of contract crews. A development project manager who was not participating in a training course would have been better placed to manage the project and ensure that all required tasks were completed.

2.5.2 Civil Aviation Authority

The introduction of the B747 to Ansett's services required the Civil Aviation Authority to comply with and/or complete a number of legal and administrative processes. These processes had been developed over the years to reflect, in the public interest, the minimum requirements needed to ensure that operations in high-capacity regular public transport aircraft were conducted safely. Civil Aviation Order 82.5, and in particular its appendix 2, set out comprehensive training and checking requirements that should have been met prior to commencement of operations. The Manual of Air Operators Certification sets out a series of administrative procedures designed to ensure an orderly and complete process. Had the Civil Aviation Authority complied with the requirements set out in the Civil Aviation Orders and processes set out in the Manual of Air Operators Certification, it is less likely that a situation would have developed where a crew member could be approved to conduct revenue flights without being adequately prepared to deal with circumstances such as those which occurred on the accident flight.

2.5.2.1 Resource shortages

Inadequate resources in the Melbourne office of the Civil Aviation Authority contributed to deficient handling of the approval process for Ansett's air operators certificates. The need to use type-rated specialist inspectors from Sydney, the loss of the project manager and poor communications between the regional offices added to confusion regarding the status of processes such as approvals for manuals and training syllabuses. The reduced resources limited the choice of the replacement for the ill project-manager and resulted in the appointment of

an officer who, like the original project-manager, did not have B747 type experience. Nor was he trained in the legislative requirements for air operators certificate approvals.

2.5.2.2 Responsibilities

The organisational culture within the Civil Aviation Authority was one where staff saw their role as providing assistance to the industry at the same time as they enforced the regulations. These roles need not be mutually exclusive. However, recent accident investigations in Australia highlighted the situation that the Civil Aviation Authority's culture had been inappropriately directed more towards providing assistance than enforcement of regulations. There was evidence in the events leading to this accident which indicated that the Civil Aviation Authority's organisational culture still tended towards provision of assistance rather than enforcement of regulation and surveillance. This view was supported by 'Plane Safe', the Report from the House of Representatives Standing Committee on Transport, Communications and Infrastructure (1995) on its inquiry into aviation safety in the commuter and general aviation sectors.

The Melbourne office staff varied the Civil Aviation Orders requirements for the production of manuals, as there was insufficient time to complete the process as set down in the orders. This assisted Ansett in meeting its 4 September startup goal.

The Civil Aviation Authority practice was to require operations manuals and training and checking manuals to be accepted (see 1.17.2.5) rather than approved, as required by the Civil Aviation Orders.

There was a view that because Ansett was a significant regular public transport operator, some of the regulatory controls were not needed in the short term and consequently were not applied.

Deficiencies identified during surveillance by the Civil Aviation Authority officers were not adequately addressed because the project manager felt that the surveillance reports were based on comparisons of Ansett practices with those of Qantas rather than with objective standards.

2.5.2.3 Training

The Civil Aviation Authority had a responsibility to ensure that its staff were aware of their responsibilities and that they understood the legal and administrative requirements of their jobs. Civil Aviation Authority staff advised that a lack of training was a factor in their performance.

Although training in the legislative processes had been provided to the Civil Aviation Authority's permanent district field office managers, sufficient training in legislative processes, regulatory responsibilities and administrative requirements had not been provided by the Civil Aviation Authority to all appropriate staff. Consequently, some of the requirements of the Civil Aviation Orders were varied without correct action being taken and other requirements were ignored. Administrative processes were abbreviated by staff who did not have sufficient knowledge to assess the consequences of such abbreviation.

2.5.2.4 Procedures

Had procedures been followed as set down in the Manual of Air Operators Certification, it is likely that the Civil Aviation Authority air operators certification process would have been more effective in ensuring that Ansett met its training and checking responsibilities.

The Manual of Air Operators Certification contained the procedures to be followed by applicants and staff when processing an air operators certificate application. Although these procedures are of an advisory nature, they were designed to ensure that all legal requirements were met prior to air operators certificate approval. The Civil Aviation Authority did not comply with procedures in the Manual of Air Operators Certification when responsibility for the approval of Ansett's air operators certificate was allocated to the Melbourne district office. In particular, approval for new, international, high-capacity, regular public transport operations, using foreign-registered aircraft, was required to be made at central office management levels, rather than at the district office level.

Manual of Air Operators Certification procedures which set out the application requirements, the requirements for the provision of manuals, the requirements for inspection of facilities, processes and manuals and the final checks prior to the approval of the air operators certificate were only partially adhered to because of a lack of resources and time.

2.5.2.5 Planning

Adequate planning was required to ensure that the Civil Aviation Authority was able to meet its commitments during the introduction of the B747 to Ansett's operations and to ensure that Ansett management also met its commitments. The evidence indicates that Civil Aviation Authority planning was deficient and this contributed to a failure to complete all the required processes.

Civil Aviation Authority staff were provided with the Manual of Air Operators Certification to assist with planning of support for the introduction of new aircraft type to a high-capacity regular public transport service. A review of the Civil Aviation Authority's processes indicated that a number of the tools provided in the Manual of Air Operators Certification, such as checklists and timetables, were not always used. The setting and monitoring of milestones within the Authority were not effectively conducted. Moreover, the Authority did not set formal milestones for Ansett to meet, which contributed to the confusion at Ansett regarding which manuals were required by what date.

2.5.2.6 Management control and supervision

A number of management control and supervision deficiencies were evident in the way the Civil Aviation Authority approached the introduction of the B747 to Ansett's operations.

Management of the Civil Aviation Authority processes was allocated to the Melbourne district office which did not have either a B747 specialist pilot or flight engineer as part of its staff. The specialist pilot and flight engineer who were used were based in Sydney, and whilst they provided what assistance they could, the duties associated with the Ansett operation were managed in conjunction with their normal tasks. No formal protocols were established to ensure that records were kept of actions taken in each office. A review of the Authority's files during the investigation found deficiencies in record keeping.

The Melbourne district office manager completed an Ansett B747 endorsement course in Sydney during the B747 introduction process, further depleting the management resources available to monitor that process.

Staff at the district office did not have the delegations to approve an air operators certificate for operations in overseas-registered aircraft, a requirement for the B747 introduction.

Surveillance of the line training was conducted from the Civil Aviation Authority's Sydney office whilst all of Ansett's management of the B747 introduction was carried out from Melbourne.

Finally, the CivilAviation Authority's specialist B747 pilot raised a number of issues as a result of his surveillance of the Ansett operation. Prominent amongst these were a number of training problems. The regulatory process broke down when these issues were not adequately addressed by the Authority's project management team.

2.6 Defences

Defences are elements of a system which are designed to detect hazards resulting from technical, human or organisational failures and to eliminate or reduce their possible effects—in other words, to provide a safety net. In the case of this accident four defences were found to have failed, were circumvented or were absent. These were:

- adequate procedures;
- landing gear warning and indicating system;
- crew qualifications and capabilities; and
- the go-around procedure.

2.6.1 Adequate procedures

The defence that is normally provided by adequate procedures failed because the operator did not ensure that appropriate procedures were in place to facilitate safe and effective operations. This is evidenced by late assembly, amendment and distribution of operational manuals; and training systems which did not incorporate performance monitoring, uniform syllabuses and checking or training standards.

2.6.2 Landing gear warning and indicating system

The aircraft's landing gear warning and indication system should have provided a significant defence against landing with the nose gear retracted. This defence failed mainly because of crew misinterpretation. However, inadequate design of the flight engineer landing gear annunciator panel, as evidenced by the arrangement of lights and the need to detect an absent light as a problem indicator, may also have contributed. Poor intra-cockpit communications probably contributed to the misinterpretation.

2.6.3 Crew qualifications and capabilities

Crew qualifications and capabilities are factors in providing a defence against incorrect decisions. This defence failed because Ansett did not ensure that all the B747 crew members were capable of performing the tasks allocated to them. This is particularly applicable in the areas of crew resource management, flight engineer abilities and skills and the indoctrination of contract crew members.

2.6.4 Go-around procedure

The go-around procedure provides a final defence when an unacceptable technical or operational situation occurs during the final approach. The crew did not go around when the landing gear warning horn continued to sound because they believed the gear was down. Also, because the pilot in command did not believe the approach to be unstable, and the crew was apparently determined to land, they did not go around even though the checklist had not been completed and factors normally recognised as constituting an unstable approach existed. Pressure resulting from a desire to conduct a quick turn-around may help to explain why this defence failed.

3.0 CONCLUSIONS

3.1 Findings

General

1. The crew was correctly licensed and qualified to operate the service as a regular public transport flight.

2. The flight was being used as a training flight for the co-pilot.

3. The flight was the first non-supervised line flight for the flight engineer.

4. There was a large difference in the level of experience on type between the pilot in command and both the other crew members.

Aircraft

5. The aircraft was serviceable prior to its departure from Sydney.

6. The number one engine was shut down due to loss of oil from a leaking angle gearbox housing cover.

7. The housing cover was leaking oil because an angle gearbox casing internal thread, which retained a threaded insert securing one of the cover attachment bolts, had stripped, allowing the cover to move and oil to escape.

8. It was possible to install the inserts in such a way that preload was insufficient, thus allowing the insert to vibrate until the threads failed.

9. Although the engine manufacturer had issued two service bulletins to correct the problem, neither addressed the root cause; nor was there any urgency specified for their incorporation.

10. The recorded performance of the number one hydraulic system during the accident flight was consistent with the demonstrated performance of the system when the number one engine was shut down and the air-driven pump was not delivering output.

11. The reason for an apparent reduction in output from the air-driven hydraulic pump system was not determined.

12. The only component in the nose landing gear system which exhibited test performance outside manufacturer's specifications was the nose landing gear door actuator. This component may have needed pressure and flow higher than specification levels to release the internal lock.

13. The flaps were moving almost continuously from the time of gear selection to touchdown. This, combined with the reduced output from the air-driven hydraulic pump, did not allow full system pressure and flow to be applied to the nose landing gear internal lock.

14. The landing gear warning and indicating system operated correctly.

Flight deck

15. The flight engineer did not recognise that the information presented on the landing gear annunciator panel indicated that the nose landing gear was not extended.

16. The design of the landing gear annunciator section of the flight engineers' panel did not facilitate quick recognition of the landing gear status when the nosewheel was not extended with the main gear.

17. Neither pilot recognised the significance of the words 'four greens' when spoken by the flight engineer in response to the pilot in command's query on the landing gear status.

18. The non-use of intercom and the ambient cockpit noise, combined with the lack of concern in the flight engineer's voice, probably contributed to both pilots not recognising the significance of the content of the flight engineer's comments regarding the number of green lights.

19. After the initial exchange on the gear status, the pilot in command appeared to have concluded that the gear was extended. Subsequent actions by the crew failed to resolve the ambiguity between the pilots' perception of the gear status and the continuing warnings.

20. The failure to resolve this ambiguity was partly a consequence of the pilot in command not using good crew resource management procedures, particularly with regard to initiating the 'red gear light remains illuminated' operations manual procedure without reference to the other crew members.

21. A go-around was not initiated despite the continuing landing gear warnings, the landing checklist challenge and responses being incomplete, the inner trailing edge flaps remaining in transit and the speed being 26 knots above target speed.

22. Subtle pressure resulting from the turn-around request and the invitingly close runway probably played a significant part in the crew's performance and decision making.

Organisational

23. Commercial imperatives resulted in the accelerated introduction of the B747 to the operator's fleet which, in turn, contributed to deficiencies in the management of manuals, procedures and line training.

24. Some of the flight operations department's development team, responsible for the management of the B747's introduction, were diverted onto a crew-training course at a critical stage of the introduction program.

25. The development team leader used management processes which did not highlight critical deficiencies during project planning or implementation.

26. The development team leader did not recognise the need to delay the start of B747 operations when it became apparent that some requirements would not be met.

27. B747-experienced staff within Ansett were not used to assist with planning or implementation of the B747 introduction.

28. The method of selecting flight engineers for training was driven principally by seniority rather than by a broader range of selection criteria, such as previous experience and adaptability.

29. Ground training of Ansett flight crew was completed in accordance with a Civil Aviation Authority approved syllabus.

30. Critical instructions and procedures had not been developed or put in place before the B747 training commenced. Procedures evolved rapidly and constantly as training progressed, causing confusion amongst trainees.

31. The training ability of contract flight engineers was not assessed prior to appointment or rostering in a training role.

32. The indoctrination of contract crews to Ansett's operating philosophies and procedures was inadequate.

33. Ansett crew resource management training was briefer than internationally accepted best practice.

34. Ansett's crew resource management training program was not fully effective in instilling crew resource management principles into the operational culture of the company's flight crews.

35. The Ansett operations culture tended to treat the B767 flight engineer as a 'systems specialist' rather than as a crew member integrated into all aspects of the flight deck operation. This background made it more difficult for the flight engineer to transition to the integral role played by a flight engineer in a B747 cockpit crew.

36. The overall training program did not adequately prepare the flight engineer for B747 operations.

37. Training standards, syllabuses and procedures for line training were either absent or deficient.

38. The Ansett training system did not incorporate a comprehensive reporting process.

39. Line checks were programmed to occur when minimum hours/sector requirements would be achieved but were not varied on trainee performance as reported in training reports.

40. Inadequate follow-up action was taken when the accident flight engineer failed his first formal check to the line. Discussions were not held with previous trainers, a remedial program was not developed and only two extra training sectors were allocated to correct the identified problems.

41. The manuals available to the crew did not include a definition of a 'stabilised approach' in a B747, nor was such a definition covered during training.

42. Management's option to use the same crew to complete the flight in another aircraft could not have been utilised without industrial and regulatory waivers, as it would have resulted in the flight crew exceeding their flight duty and flight-deck duty time limits.

43. Management and supervision of the Civil Aviation Authority's role in Ansett's B747 introduction was inadequate, partly because of a lack of training and partly because of a lack of resources. In addition, the Authority's management did not follow some aspects of its documented administrative instructions.

44. The Civil Aviation Authority's project manager issued an air operators certificate to Ansett before all the regulated requirements were met and without Ansett having developed and/or put in place all the necessary procedures.

45. Training for Civil Aviation Authority staff in the procedures for issuing an air operators certificate was inadequate.

46. The organisational climate prevailing in the Civil Aviation Authority at the time was biased towards commercial considerations rather than ensuring regulatory compliance and safety.

47. Real or imagined pressure, caused by a seemingly inflexible starting date for Ansett's B747 operations, probably influenced some of the actions taken by Civil Aviation Authority staff.

48. Civil Aviation Authority staff did not take sufficient action to ensure that concerns raised during inspections and surveillance were addressed.

3.2 Significant factors

1. Adequate steps had not been taken by the engine manufacturer to correct a known deficiency with the angle gearbox inserts. This led to the number one engine being shut down due to a loss of oil.

2. During the accident approach, reduced output from the air-driven hydraulic pump system severely degraded the capability of the number one hydraulic system to extend the nose landing gear in the time remaining between landing gear selection and the aircraft's touchdown.

3. The flight engineer did not perceive that one of the five gear annunciator lights on his panel was not illuminated when he was asked to check their status.

4. The pilot in command interpreted the information initially supplied by the flight engineer as indicating that the gear was extended. From this point the pilot in command maintained a mindset which influenced his further decisions and actions.

5. The co-pilot heard the conversation concerning the analysis of the landing gear between the pilot in command and the flight engineer, and formed the same conclusions as the pilot in command with regard to the status of the gear.

6. The crew's erroneous perception of the gear status was not corrected by subsequent communications nor by the effective use of crew resource management principles and practices.

7. A go-around was not initiated despite the continuation of warning indications, the approach not being stable and apparent unresolved ambiguity of the situation.

8. Significant local factors influencing crew performance were:

The crew composition set up a steep differential in crew experience levels which resulted in a degree of the co-pilot's and the flight engineer's responsibilities being relegated to the pilot in command and in the pilot in command assuming some of those responsibilities without discussion.

The flight engineer's training did not adequately prepare him for the circumstances of the accident flight which probably contributed to him not recognising that the nose landing gear light was not illuminated.

The crew was not using intercom for intra-cockpit communications. This probably contributed to a misunderstanding of communications between crew members.

There was a lack of a definition of a stabilised approach in Ansett's manuals.

Subtle pressure which arose from the crew being aware only of the option to transfer to an alternative aircraft and complete the flight in their remaining duty time, probably motivated them to continue with the landing to save time.

The design of the landing gear annunciator display on the flight engineers' panel was deficient. A flight engineer was required to detect a missing light as an indicator of a problem and the layout of the lights could present misleading information if the flight engineer possessed minimum skills or was under pressure.

9. Significant organisational factors contributing to the accident were:
Commercial imperatives to arrive at Kansai Airport at its opening resulted in an accelerated introduction of the B747 aircraft into Ansett's operations.

Planning, implementation and management of the operational aspects of the aircraft introduction were deficient, particularly with respect to manuals and procedures, indoctrination/training of contract crew members, crew resource management training and flight training to the line.

The Civil Aviation Authority issued the air operators certificates knowing that the requirements for their issue had not been fully met.

A culture persisted in the Civil Aviation Authority which appeared to concentrate on assistance to the aviation industry in preference to regulation enforcement.

Inadequate resources and training contributed to deficient handling of the approval processes for Ansett's air operators certificates by the Melbourne office of the Civil Aviation Authority.

4. SAFETY ACTION

Interim recommendations

During the course of the investigation the Bureau of Air Safety Investigation issued a number of interim recommendations (IR) to facilitate safety actions being addressed before the publication of the final report. The recommendations, identified by the Bureau's reference number, and relevant responses are reproduced below.

Classification of responses

The Civil Aviation Authority, and subsequently the Civil Aviation Safety Authority, along with Airservices Australia respond to the Bureau's formal recommendations in accordance with a memorandum of understanding. Although no formal procedures are in place for other respondents to Bureau recommendations, the Bureau expects to receive responses from all recipients.

The Bureau considers responses against the occurrence report and/or the recommendation text and assesses the acceptability of the response. These assessments do not necessarily indicate whether or not the action agency has accepted the recommendation in full or in part, but that the agency has:

- considered the implications of the recommendations;
- correctly recognised the intent of the recommendations without misinterpretation;
- offered acceptable counter-arguments against implementation, if it decides not to do so;
- offered an alternative means of compliance; and
- identified, if appropriate, a timetable for implementation.

Responses are classified as follows:

(i) CLOSED - ACCEPTED. The Bureau accepts the response without qualification.

(ii) CLOSED - PARTIALLY ACCEPTED. The Bureau accepts the response in part but considers other parts of the response to be unsatisfactory. However, the Bureau believes that further correspondence is not warranted at this time.

(iii) CLOSED - NOT ACCEPTED. The Bureau considers the response to be unsatisfactory but that further correspondence is not warranted at this time.

(iv) OPEN. The Bureau considers that the response does not meet some or all of the criteria for acceptability for a recommendation that the Bureau considers to be significant for safety. The Bureau will initiate further correspondence.

Safety outputs

In the following sections, Bureau safety outputs appear in bold. They are reproduced from original Bureau documents and may vary in textual layout.

Response text

Response text is published as received by the Bureau.

4.1 Interim recommendations and responses

IR940288 (issued 9 November 1994)

The Bureau of Air Safety Investigation recommends that the Civil Aviation Authority:

1. review the compliance requirements of the applicable Pratt and Whitney Service Bulletins to determine if the incorporation of the Service Bulletins requires expediting;

2. review the Extended Range Operations (EROPS) requirements to determine if engines not complying with the applicable Pratt and Whitney Service Bulletins still meet those requirements; and

3. advise the United States Federal Aviation Administration of the circumstances of this failure.

Civil Aviation Authority response (received 1 March 1995)

Interim Recommendation 1 : There are two Service Bulletins which refer to loss of retention of the gearbox tower shaft access cover and resultant oil leakage.

SB JT9D-7R4-72-307 details replacement of the threaded insert in the angle gearbox housing. Pratt and Whitney agree with the findings of the Materials Evaluation Facility Report and advise that both the Service Bulletin and the Engine Manual instructions for installation of the affected inserts are inadequate. The Engine Manual and Service Bulletin are to be revised to include specific instructions regarding the installation depth of the insert to ensure the top of the insert is below the level of the housing/cover parting surface.

In addition, P&W have been requested to review the “CAUTION” note in the Engine Manual relating to installation of the angle gearbox cover to include a visual inspection of the inserts for condition.

These actions should improve the overall integrity of the angle gearbox cover installation.

SB JT9D-7R4-72-410 details the incorporation of a rubber bumper to the fan exit case access panel. The bumper abuts the angle gearbox cover to prevent migration of the cover in the event that a cover bolt/insert fails.

An Airworthiness Directive will be issued to mandate the incorporation of this modification on P&W JT9D-7R4 engines fitted to Australian registered aircraft. The AD will require incorporation of SB JT9D-7R4-72-410 at the next shop visit and no later than 31 December 1995.

Both Australian operators of P&W JT9D-7R4 powered aircraft have modification programs in place and depending on parts availability, anticipate completion of their respective programs by mid year.

Interim Recommendation 2 : Airworthiness Directive AD/GEN/69 defines the Australian requirements for EROPS operations. This AD refers to FAA Airworthiness Circular AC120-42A as the basis for EROPS operational and maintenance standards.

At this time QANTAS Boeing 767-200 is the only P&W JT9D-7R4 powered twin engine aircraft approved for ETOPS operation in Australia.

Requirements fundamental to the engineering aspects of EROPS operations are Type Design Approval, In-service Reliability, and Continuing Airworthiness.

Type Design Approval addresses modification and maintenance standards suitable for

EROPS in the Configuration, Maintenance, and Procedures document (CMP) The CMP for the B767 (P&W JTD7R4) does not include either of the modifications referenced above in the required service bulletin listing. However, P&W advise that the majority of EROPS approved operators are incorporating SB JT9D-7R4-72-410 to reduce the probability of an oil leak.

Mandating SB '72-410 satisfies the note reference in AD/GEN/69 Amdt 1, para. 1.1, Note 3, which addresses requirements for additional modifications.

In-service Reliability is used to monitor EROPS operational performance of both the operator and the engine-airframe combination.

With respect to the subject incident, the aircraft concerned is not affected by any EROPS requirements. It is recognised, However, that the angle gearbox installation is common to the engine on the B767 and, as such, is subject to the same defects regardless of installation.

It should be noted that the angle gearbox is more accessible on the B767 installation than the B747. Inspection and rectification of in-service oil leaks can be accomplished far more readily on the B767.

Also, the Maintenance Manual trouble-shooting sections makes specific reference to oil leakage from the angle gearbox tower shaft cover when assessing high oil consumption.

One other point that should be noted when considering the risk of an in flight-shutdown from such an oil leak, is that QANTAS is a very experienced operator both of the P&W JT9D and EROPS in general.

Mandating SB '72-410 will reduce the risk of an oil leak in the event a future operator of P&W JT9D-7R4 appears on the scene.

Continuing Airworthiness addresses a whole raft of conditions relative to EROPS. One of these conditions refers to systems monitoring including oil consumption.

The procedures for oil consumption monitoring are laid down in FAA AC 120-42A.

Prior to the above incident, Ansett Engineering had been monitoring an increasing oil consumption. The oil consumption, while still below limits, had been increasing slowly over a period of some weeks. Due to the difficulty of inspecting the area, the leak from the angle gearbox cover had not been detected before the leak rate was sufficient to deplete the oil system in about an hour.

As mentioned above, oil consumption monitoring is a fundamental requirement for EROPS, Under the terms of AD/GEN/69 and AC 120-42A, aircraft should not be despatched with an adverse oil consumption trend. The B747 is not subject to the same requirements.

From the preceding words it can be seen that there is a low level of risk that a similar incident could occur during an EROPS flight of an Australian registered aircraft. Mandating P&W JT9D-7R4-72-410 will reduce that risk even further.

Interim Recommendation 3 : The FAA New England Region will be informed of the circumstances of the failure, action taken by this Authority and EROPS issues.

Response status: CLOSED - ACCEPTED

BASI note:

Since this response, the CAA issued AD/JT9D/27 which requires Pratt and Whitney Service Bulletin JT9D-7R4-410 to be complied with on all aircraft fitted with JT9D-7R4 series engines prior to 31 December 1995. In addition, Pratt and Whitney have confirmed that revisions to

Service Bulletin JT9D-7R4-72-307 and the engine manual requiring that angle gearbox threaded inserts be installed below the surface of the gearbox should be published in the latter half of 1996.

IR950089 (issued 31 January 1995)

The Bureau of Air Safety Investigation recommends that the Civil Aviation Authority review the requirement for the use of intercom for intra-cockpit communication. The Civil Aviation Authority should consider the safety enhancement afforded to flight crew members of multicrew aircraft when using intercom for intra-cockpit communications. Furthermore, the Civil Aviation Authority should consider mandating its use during all or specific parts of flights including high workload situations such as operations in terminal areas.

Civil Aviation Safety Authority response (received31 January 1996) stated in part:

I refer to BASI Interim Recommendation IR950089 concerning the use of intercom for crew communications. Further to discussions between BASI and CASA staff, the Authority will initiate industry education activities on this issue. These education activities will focus on presenting industry with information on the value of using intercom in multi-crew operations as an aid to clear communications. With your agreement we will call on the expertise of BASI staff in developing this education material.

Response status: CLOSED - ACCEPTED

IR950101 (issued 31 January 1995)

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority require operators involved in multi-crew, air transport operations to ensure that pilots have received effective training in crew resource management (CRM) principles. To this end, the Authority should publish a timetable for the phased introduction of CRM training to ensure that:

(i) CRM principles are made an integral part of the operator's recurrent check and training program and where practicable, such training should be integrated with simulator LOFT exercises;

(ii) the Civil Aviation Safety Authority provides operators and/or CRM course providers with an approved course syllabus based on international best practices;

(iii) such training integrates cabin crew into appropriate aspects of the program; and

(iv) the effectiveness of each course is assessed to the satisfaction of the Civil Aviation Safety Authority.

Civil Aviation Safety Authority response (received 14 September 1995)

I refer to your Interim Recommendation No IR950101 concerning the B747-312 accident at Sydney on 19 October 1994.

CASA fully endorses the principles of and accepts the benefits flowing from CRM and similar training as well as strongly encouraging such training for flight crew, cabin crew and other operating crew.

However, CASA is not fully convinced that mandating CRM or similar training, particularly in relation to high and low capacity RPT operations, will necessarily prevent or reduce the incidence of such accidents in future.

Nonetheless, CASA is willing to further investigate CRM training including the position taken by leading overseas regulatory authorities in this regard, particularly in relation to high and low capacity RPT operations. To this end, CASA intends to consider the issue as part of a major project to commence in the latter part of 1995. This project is to review

all aspects of RPT operations conducted under CAR 217 in relation to Training and Checking organisations and is the first major review of such operations to be carried out for some time.

CASA undertakes to advise BASI of the outcome of that review in relation to CRM and similar training.

Subsequent Civil Aviation Safety Authority response (received 3 January 1996)

Further to [CASA response] of 8 September 1995 in response to your interim recommendation IR950101, I am forwarding the following update on CASA's review of operations conducted under CAR 217.

The project to review CAR 217 has progressed to the stage where a more detailed project definition will include numerous issues, one of which is to consider the extent to which CRM or similar training, mandatory or otherwise, should be included as part of an operator's checking and training, particularly with respect to high and low capacity RPT operations.

CASA undertakes to advise BASI of the outcome of that review in relation to CRM and similar training.

Response status: OPEN

4.2 Safety actions by operator

Ansett Australia has advised the Bureau that it has taken the following action since the occurrence:

The landing of an Ansett Australia Boeing 747 at Sydney Airport with its nosewheel retracted on October 1994 has prompted a rigorous ongoing safety review and improvement process throughout the airline.

The process began immediately following the incident when Ansett initiated its own independent inquiry and safety audit into its international operations.

It has developed over the past 18 months into a proactive program of continuous safety evaluation and enhancement across all areas of the airline.

Since the incident, Ansett has conducted two external audits of its Boeing 747 international operations - one in January, 1995, and another in April, 1996.

An external audit of all flight operations, maintenance and engineering, operations, flight attendant and ramp areas was completed in May 1996.

Twice-yearly safety audits of all operational areas are now built into the airline's new Operational Safety Department.

The new department, staffed with expertise from flight operations, maintenance and engineering, flight attendant, ramp and customer services, reports to the General Manager Technical and to the Chief Executive and the Board.

It is charged with maintaining a seamless "safety first" policy across the airline.

Ansett has also restructured its Flight Operations Department to split management responsibilities for flight standards from general department management.

The Director of Flight Operations is now a 'non-flying' position, charged with managing the business, while the Chief Pilot is accountable for flight standards and compliance.

This reorganisation has also transferred fleet managers away from Ansett's head office to airport offices to improve day-to-day communication with line flight crews.

Further, a Flight Operations Quality Assurance position has been established to provide a continuing audit function within the department and an audit link between Flight Operations and suppliers to the Department.

Additional measures taken by Ansett since the incident include:

- upgrading of Crew Resource Management (CRM) training
  - –all B747 crew have undertaken additional Line Oriented Flight training (LOFT);
  - –consultants designed a new series of training programs to further develop use of CRM procedures into Ansett's daily operations;
  - –CRM training has been added to communication training between cockpit crew and flight attendants;
- amendment of the selection process and training of contract crew to allow the selection of pilots and flight engineers suited to the airline's operational culture, and to improve appropriate training levels to their needs.
- review of procedures for introducing new aircraft and new routes
  - –including formalising criteria for a standard project plan;
  - –and drawing together all aspects of the airline to ensure a coordinated approach is maintained;
- review of all emergency procedures used by technical and cabin crews
- review of all operating manuals
- establishment of a procedures committee and a separate Emergency Procedures Committee within Flight Operations to control the implementation or change of any procedure.

In summary, in the aftermath of this occurrence, Ansett has re-examined every aspect of operational safety to ensure that not only is its house in order now, but also that there are permanent mechanisms in place to ensure that this is always so.

Its new systemic and seamless approach to safety, with ongoing quality assurance and coupled with a more open management environment, provides the basis for continuous review and improvement to achieve and maintain world's best safety practice.

4.3 Final recommendations

The following final recommendations are issued:

R960058

The Bureau of Air Safety Investigation recommends that Ansett Australia review flight crew training, aircraft endorsement and line training as part of the safety audit of their operations.

R960074

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority review the training of their regulatory staff to ensure that they are adequately trained to apply legislation, regulation and administrative procedures relevant to their employment and delegations.

R960073

The Bureau of Air Safety Investigation issued interim recommendation, IR950061, to the Civil Aviation Authority on 21 April 1995 regarding the issue of Air Operators Certificates to low capacity regular public transport operations. This recommendation, stated:

> The Bureau of Air Safety Investigation recommends that the Civil Aviation Authority review its standards, practices and procedures, with a view to ensuring that its officers comply with CAO 82.3 in regard to Low Capacity Regular Public Transport Air Operators Certification.

The Civil Aviation Authority response received on 14 August 1995 stated:

> Manual of Air Operator Certification (MAOC) procedures are presently being extensively revised with particular emphasis on the Low Capacity Regular Transport (LCRPT) sector. In addition the Authority is closely monitoring proposals by the NTSB and FAA to raise the aircraft, flight crew and operating standards for this sector of the industry. Any changes which the Authority may propose in respect to entry standards will be the subject of industry consultation.

As a result of this investigation and the deficiencies identified in this occurrence, the Bureau of Air Safety Investigation issues the following recommendation:

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority review the practices and processes associated with the issue of Air Operator Certificates (AOC) to high capacity regular public transport operators.

4.4 Safety advisory notice

The following Safety Advisory Notice is issued:

SAN960056

The Bureau of Air Safety Investigation suggests that operators of Australian registered B747-200 and B747-300 series aircraft consider placing a fine border line around the five landing gear annunciators located on the flight engineer panel to better define the annunciators as a group.

APPENDIX 1

Explanation of human factors concepts relevant to this report

(a) Confirmation bias

Confirmation bias refers to the phenomena whereby having formed an assessment of an ambiguous situation, a person will sometimes treat information which does not fit their assessment as though it were less reliable than information which does fit their situation assessment. For example, it has been observed that when diagnosing a fault in a system people commonly develop a theory of what is wrong and then search for information which will confirm their theory. People however, are less likely to attempt to dis-prove their suspicions and may disregard information which would contradict their ideas.

While originally a concept drawn from cognitive psychology, confirmation bias has been highlighted as a risk in aviation environments by several authorities including Green et al 1991 and Campbell and Bagshaw (1991).

(b) Mindset

Mindset, also known as expectancy refers to a common bias which can affect the information people perceive from the environment. Although mindset can affect all forms of perception, it is commonly a problem with speech communication. One result of mindset is that a person may hear what they expect to hear and not notice a difference between their expectation and the actual message. For example, a pilot who expects to hear a particular checklist item called by a co-pilot may believe that the item has been correctly called, when in fact other words have been spoken. Frank Hawkins (1993) wrote "the more of the speech content which is lost through clipping, distortion, noise or personal hearing loss, the greater is the risk of mindset playing a role in the interpretation of an aural message". Mindset errors have been implicated in numerous air accidents and incidents, particularly where communication misunderstandings have occurred.

(c) Non-auditory effects of noise

Extensive research has been conducted on the effects of noise on task performance. It has been demonstrated that performance may be affected due to the narrowing of attention and the making of tasks appear more difficult. It has also been shown that noise tends to increase errors and variability rather than directly affect the work rate. Intermittent and impulsive noise is more disruptive than continuous noise at the same level and the higher frequency components of noise generally have more adverse affects on performance than the lower frequency content. Identical levels of noise will affect individuals in different ways, depending upon variables such as previous experience in task performance under noisy conditions, levels of arousal, motivation and the individual's level of anxiety.

(d) System design

Design manuals on system design such as "Human Engineering Guide for Equipment Designers" Woodson and Conover(1964) and "Human Factors in Engineering and Design" McCormick and Sanders (1983) describe in detail the use of lights for warnings and system status displays, but do not consider the possibility that a significant status indication could be signalled by the absence of an indication. Such logic is reversed from other warning lights where the presence of a light indicates a problem.

(e) Anxiety and channelised attention

It is accepted by many psychologists that the breadth of attention diminishes as task stress increases (e.g. Hartley, Morrisson and Arnold 1989). The narrowing of attention with increasing stress has been advanced as an explanation for the familiar inverted U relation between arousal (stress) and task performance. At moderate levels of task stress, task performance may improve as attention becomes focused on primary tasks and irrelevant stimuli are filtered out. As task stress increases however, attention narrows and task relevant stimuli are neglected. The effect of task stress on attention can be expected to be particularly debilitating if the person's stress state is elevated before attempting the task.

While the effect of stress on task performance is not well understood, there is some evidence to indicate that a raised level of anxiety or worry about task performance can reduce general cognitive effectiveness. A particular source of anxiety is previous failure at the task in question (Eysenck 1984).

(f) Non-verbal cues in communication

A significant proportion of information exchanged in the course of normal communications is conveyed by non-verbal cues, such as facial expressions, gestures and tone of voice. In discussing cockpit communications, Kanki and Palmer write: "When operations are normal and repetitive, the entire information exchange can become more like a verification of expectations....intonation and many other contextual features contribute to the functional interpretation of a statement" (p 114).

(g) Situational awareness

Crew members must maintain an awareness of the location of the aircraft in time and space and of its current performance state. Inadequate situational awareness has emerged as a significant factor in many overseas airline accidents and incidents. For example, research has indicated that in 60% of crew related incidents experienced by a US carrier, there was a failure on the part of the crew to recognise the existence of a problem.

(h) Trans-cockpit authority gradient

The term trans-cockpit authority gradient is used to describe the interface between cockpit crew members. If the gradient becomes too steep, such as when the experience and authority of the PIC is significantly greater than the rest of the crew, deference to that authority or experience may result in stifled communications and in errors going undetected or uncorrected. This would be especially true, if other crew members were unassertive.

Problems in this area have been identified in a number of aircraft accident reports. Techniques to manage poor gradients are presented in CRM programs.

(i) False hypothesis

The term false hypothesis has been used to refer to the phenomenon whereby an idea, once formed, can become very resistant to challenge, even when information is available that would contradict the idea. This phenomenon can seriously disrupt fault diagnosis because a premature, incorrect diagnosis of the problem may become unconsciously entrenched, even when it is contradicted by the available evidence. Pilots are particularly susceptible to this phenomenon 1) in ambiguous situations; 2) when a particular outcome is expected; or 3) when workload is high, time is limited or the pilot is distracted. Common scenarios or ideas have a strong tendency to become default assumptions. The concept of false hypothesis is closely related to the issues of confirmation bias and mindset.

APPENDIX 2(A)

APPENDIX H

CHECKLIST FOR ISSUE OF AIR OPERATORS CERTIFICATE

APPLICANT: ..... LOCALITY: .....

	ITEM	CONDITIONS (YES/NO)	SIGNATURE
1.	**Facilities**		
	Despatch	.....	.....
	Crewrooms	.....	.....
	Managerial	.....	.....
	Ops planning	.....	.....
	Traffic	.....	.....
	Loading	.....	.....
	Servicing	.....	.....
	Scheduling	.....	.....
	Training	.....	.....
	Records	.....	.....
	Outports	.....	.....
	Aircraft	.....	.....
	Maintenance	.....	.....
2.	**Manuals**		
	Maintenance	.....	.....
	General Operations	.....	.....
	Operations	.....	.....
	Training	.....	.....
	Security	.....	.....
	Flight Attendant	.....	.....
	Dangerous Goods	.....	.....
	Airworthiness Program	.....	.....
3.	**Training Courses**		
	Technical Crew		
	Indoctrination	.....	.....
	Groundschool	.....	.....
	Simulator	.....	.....
	Aircraft	.....	.....
	Recurrent	.....	.....
	Flight Attendant		
	Indoctrination	.....	.....
	Recurrent	.....	.....

Checklist proforma for air operators certificate issue from the Manual of Air Operators Certification.

APPENDIX 2(B)

ITEM		CONDITIONS (YES/NO)	SIGNATURE
	All flight crew		
	Emerg Procedures	.....	.....
	Dangerous Cargo	.....	.....
	Security	.....	.....
	Traffic	.....	.....
	Loading	.....	.....
	Servicing	.....	.....
	DG handling staff	.....	.....
	Cargo acceptance staff	.....	.....
4.	**Surveillance**		
	Training Courses	.....	.....
	Proving Flights	.....	.....
	Emergency Evacuation	.....	.....
	Ditching	.....	.....
5.	**Operations**		
	Routes	.....	.....
	Terminals	.....	.....
6.	**Administrative**		
	Final Compliance Statement		.....
	Operations Specifications		.....
	Preparation of Certificate		.....

7. **Recommendation**

This is to certify that: .....

trading as: .....

has met all requirements for the issue of an Air Operators Certificate permitting regular public transport operations as follows:

Aircraft Type	Routes	Limitations or Conditions
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....

Project Manager: .....Date: .....

Checklist proforma for air operators certificate issue from the Manual of Air Operators Certification.