# CRACK ATTACK

It is two years since Ansett Australia's last flight. Mark Wolff and Martin Aubury report on the lessons learnt from the airline's collapse.


AP/ROB GRIFFITH

FLIGHTS OPERATED by the Ansett Australia Group ceased on March 5, 2002 when the once-great Australian airline flew its last flight, from Perth to Sydney.

Days later, Ansett's leased Airbuses departed for the US to go into storage in Mojave, California, leaving 32 aircraft for sale.

The firm of accountants appointed to wind up the group after its financial collapse, KordaMentha, embarked on a fire sale in an attempt to pay out staff entitlements and creditors. KordaMentha sold off aircraft, spare parts, subsidiary airlines, airport terminal slots, property and equipment. Even the giant head office kitchen sink was sold when the administrators auctioned remaining goods from the airline's Melbourne headquarters.

All that is physically left of the aviation company Sir Reginald Ansett started in 1936 at Hamilton, in the western districts of Victoria, is a flight simulator business, some regional subsidiaries now run by other companies, some unsold aircraft and the Sir Reginald Ansett Museum in Hamilton.

So what is the legacy of Ansett's demise? There have been big personal and financial costs, but perhaps the key legacy has been heightened awareness in the aviation sector of the importance of control of airworthiness data, particularly for ageing aircraft. Other consequences are new rules, expected to go to the Federal Government for approval this year, putting more responsibility on operators to act on manufacturers' safety advice.

A series of safety problems beset Ansett before its financial collapse. There were two key events: in December 2000 and in April 2001, a number of Ansett B767 aircraft were withdrawn from service because fatigue damage inspections of the aircraft structure had been missed. In both cases undetected fatigue cracking had the potential to eventually lead to structural failure.

On December 23, 2000 Ansett grounded seven of its 767-200s after discovering the aircraft had not undergone structural inspections that, in some cases, should have been carried out much earlier.

The aircraft were out of service for a short time while general safety inspections were performed. CASA allowed them back in the air under strict conditions.

Ansett blamed the error on a single technical officer who allegedly received a service bulletin from Boeing two years earlier notifying the airline that the 767s needed to undergo the inspection on reaching 25,000 cycles. Ansett said the officer somehow mistook the figure for 50,000 cycles and filed the bulletin, thinking it would be some time before it would apply.

The error was noticed by Ansett engineers on one aircraft on which they were working. Further checks revealed another six B767s had exceeded the 25,000 cycles mark. CASA launched an investigation into the airline's quality assurance systems following this and other incidents that occurred in quick succession.

The groundings came at the Christmas travel peak, disrupting some services.

But what happened in the lead up to the following April was worse.

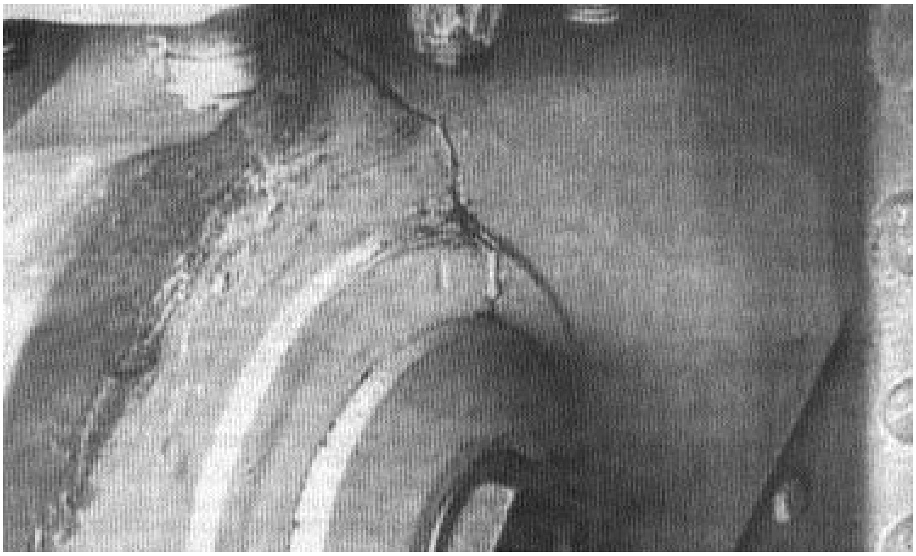
The story starts with the issue by Boeing on March 2, 2000 of an alert service bulletin (No 767-57A0070 revision 1) covering inspections of early model B767-200s for fatigue cracks in the fittings which connect the engine support structure to the wing (*see diagram*). Boeing recommended the inspections be performed within 180 days. An alert is the highest level of Boeing SB, and although it is not compulsory to comply (as it is with an airworthiness directive), any airline not doing so could be regarded as foolish at best and, at worst, derelict in its duty of care to passengers.

The bulletin applied to B767-200s up to serial number 101 off the line. Ansett's original five B767s were serial numbers 24, 28, 32, 35 and 100, delivered between March 1983 and September 1984. In addition, a former Britannia Airways aircraft (serial number 79, built in early 1984) was in the fleet, along with some later models.

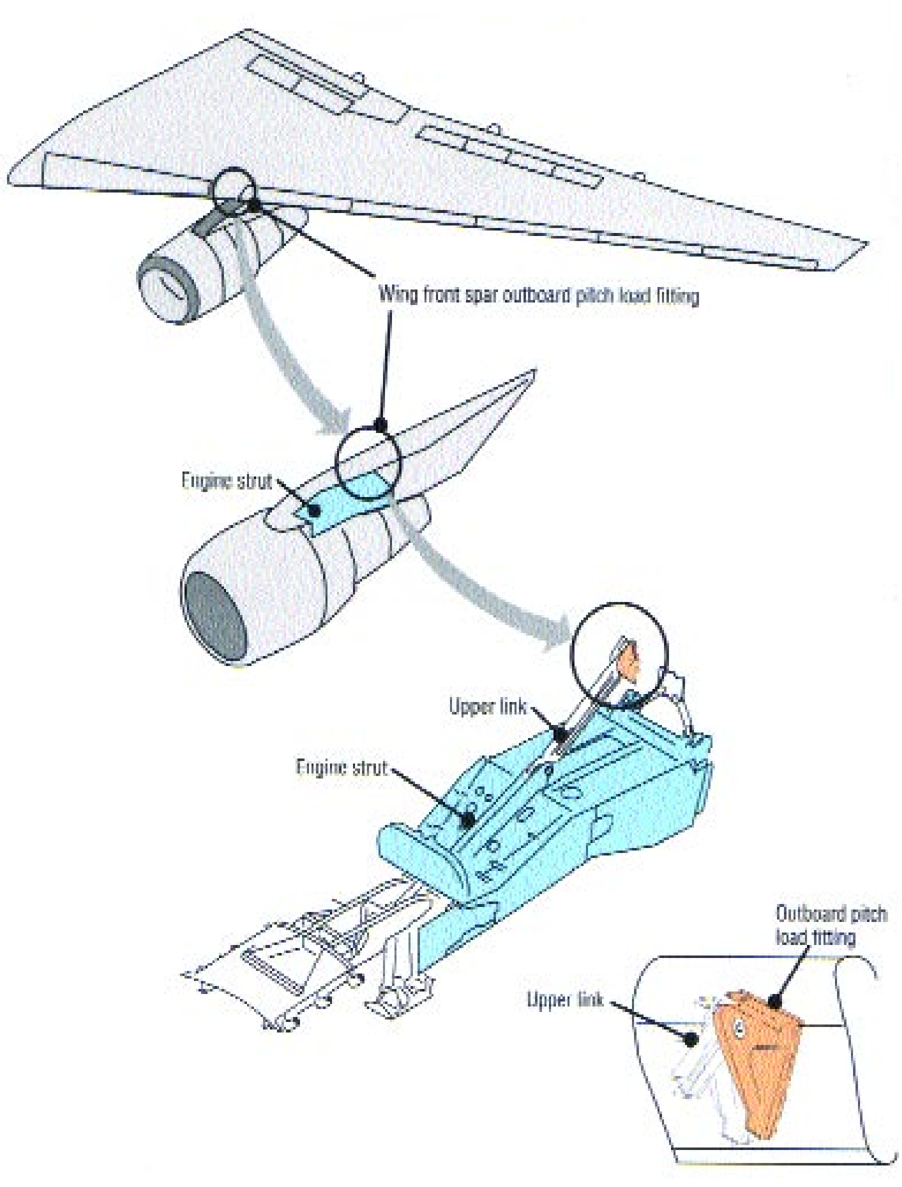
**Systemic problems** In December 2000, Ansett discovered that engine pylon inspections covered by the Boeing alert service bulletin had been overlooked, although this information did not enter the public domain until April 2001. Ansett consulted CASA and Boeing on the best way of making up the inspections. The end of April was the deadline to complete them.

The nightmare continued into the first days of 2001 when hairline cracks were found in the tail support structure of one of the 767s undergoing the delayed 25,000 cycles check. Although the cracks presented no immediate safety problem, the resulting publicity further damaged Ansett's public image.

The situation for Ansett worsened later in January 2001 when it was discovered that a B767-300 had been incorrectly fitted with a leading edge slat from a B767-200. Although the slats are the same size



**Critical condition** Fatigue crack in an Ansett B767 wing front spar outboard pitch load fitting. Location of the fitting (below).



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**Grounded** Ansett B767s parked at Tullamarine Airport, Melbourne.

and work on both models, the 767-300 slat is strengthened and is technically a different part. The error was discovered shortly before the aircraft was due to leave Melbourne for Hong Kong.

CASA announced it was expanding its investigation into Ansett to include the latest incident and to discover if the mix-up was "indicative of wider, systemic problems at Ansett that had not been understood fully by CASA or the airline".

Also in January, the Australian Transport Safety Bureau said it was conducting its own inquiry into Ansett and also "CASA's systems for compliance, including procedures for delegating responsibilities to airlines for regulatory compliance".

CASA ordered changes to procedures within Ansett in February, with the airline required to record in detail its handling of recommendations by aircraft manufacturers for changes to maintenance and inspection procedures.

Details were required to be provided when manufacturers' recommendations were acted upon and a full technical justification recorded when they were not. Until then, only recommendations that had been adopted were fully documented. CASA said the changes would allow it to carry out safety audits more effectively.

CASA's initial investigations revealed shortcomings in the airline's maintenance systems in several areas. It planned a major audit of Ansett's maintenance activities for early March. In the meantime, there was some good news for Ansett as the B767-200s affected by the original problem had now met all the necessary inspection requirements and were clear to resume normal operations.

**The last straw** Things settled down for a month or so, but the worst was yet to come.

On April 10, 2001 inspections of seven Ansett 767-200s covered by the Boeing engine pylon SB of March 2000 revealed that three aircraft had cracks in the pylons which required grounding and repair. A fourth 767 was quickly repaired and returned to service.

CASA recognised the seriousness of the Boeing alert service bulletin. While the US Federal Aviation Administration at that time had not issued an airworthiness directive mandating the alert service bulletin, CASA took action to mandate the service bulletin in Australia. The FAA followed suit.

As a result of CASA's action, another three 767s were immediately grounded for inspection.

The situation deteriorated on April 12 when the ATSB revealed that the airline had flown a 767 with an incorrectly stowed – and therefore inoperative – emergency exit slide on eight sectors before the fault was discovered. The implications were serious. With an unserviceability of this kind, an airliner cannot legally fly with passengers.

This was the last straw for CASA. It grounded Ansett's entire fleet of ten Boeing 767s, saying the aircraft would not be able to fly again until it was satisfied they all met relevant safety standards. CASA announced it would undertake safety checks on all the 767s, inspecting the aircraft and auditing recent maintenance work. The checks would begin over the Easter weekend.

CASA warned Ansett of its intention to issue a notice giving Ansett 14 days to show cause why its air operators certificate and certificate of approval should not be withdrawn. The forewarning of a possible notice was based on a pattern of ongoing structural, management and personnel problems. Ansett would have to prove to CASA that it could lift its game in these areas quickly and reform its maintenance systems.

On April 15, CASA gave Ansett approval to charter six aircraft from overseas operators to relieve the capacity shortage caused by the 767 grounding. Air New Zealand provided a 767-300 and 747-400, Singapore Airlines a 747-400, Air Canada a 767-300 and Emirates two 777s.

The next day, Ansett and CASA struck a deal to "work together … to reach mutual agreement on the structure of the engineering organisations within Ansett; and the internal control systems relating to the planning and implementation of airworthiness directives and service bulletins".

Singapore Airlines (now a 25 per cent shareholder in Air New Zealand) agreed to help Ansett compile the data required by CASA.

On April 18, the physical inspection of the first 767 started. Meanwhile, Ansett managers began a busy two days convincing CASA management that the airline did not deserve to have its AOC withdrawn. On April 20, CASA announced that Ansett would not be issued with a formal "show cause" notice.

Ansett had undertaken to perform a wide-ranging review of its maintenance division, including staff, training and spares management. It had also agreed to introduce better maintenance planning and control measures and a system that properly tracks documentation. Undertakings were given to implement quality control in all areas through a special new unit to ensure work met the desired standards.

Ansett management also promised to introduce a safety education campaign for all staff. The company said it would ensure all 767 service bulletins were assessed, and full technical justification recorded where SBs were not implemented. In addition, the company said it would provide a strong and ongoing commitment to apprenticeships, and would bring in additional resources from Boeing for specific aircraft repair planning issues. A new risk management review process would also be put into place.

An important structural change was the moving of maintenance control from the engineering organisation to the airline.

The first of the grounded Boeing 767s returned to service on April 20 on completion of its paperwork and physical inspections. All the affected 767s were back in service by early May.

That Ansett had serious problems managing its maintenance programs is an inescapable fact. Four months later, in September 2001, the full extent of Ansett's and Air New Zealand's financial problems was revealed, putting the events of the previous year into perspective.

**Managing structural fatigue** Ansett's problems in maintaining its diverse and ageing fleet have thrown the spotlight on the management of structural fatigue.

Structural fatigue is a threat that cannot be avoided, because aircraft designers must always strike a compromise between weight and strength. Many variables make accurate prediction of structural failure very difficult.

The problem used to be managed by estimating an approximate life, cutting it by a safety factor and after that discarding the structure.

This "safe life" approach is still used for small aircraft and helicopters.

Another approach was to duplicate critical structure so that if one part failed prematurely another structure was there to take the load. This is "fail safety", the methodology used to design aircraft throughout the 1960s, up to and including the Boeing 747.

Implicitly, fail safety depended on detecting the first failure before the backup structure also failed. That did not always happen. In 1977 a 14-year-old Boeing 707 crashed in Zambia when its tailplane separated, because failure of its main spar had gone unnoticed.

The big advance in managing structural fatigue has been the science of fracture mechanics, which has made so-called "damage tolerance" possible.

## An ageing fleet

ANSETT WAS ONE of the first airlines in the world to operate B767 aircraft, and did so largely for domestic operations within Australia from 1983.

Certified under damage tolerance design criteria, the B767 requires periodic inspections of the aircraft structure. As in-service experience with the type grows, additional inspection requirements are notified to operators.

As aircraft age, the need to inspect, repair or replace parts increases.

Specific needs for ageing aircraft include the detection of fatigue cracks under fasteners; small cracks associated with widespread fatigue damage; hidden corrosion; cracks and corrosion in multi-layer structures; and stress corrosion cracking.

The average age of the fleet of Western-built jets is 12.9 years, according to aviation consultant, GAB Robins. There are 4,489 Western jets over 20 years old. The average age of Western turbo-prop aircraft is 15.5 years.

Advances in computer technology have cleared the way for more accurate stress analyses on three-dimensional crack configurations, more realistic simulations of fatigue and fatigue cracking in structural components, and better fracture mechanics concepts to assess the residual strength and fail-safe capability of aircraft structures.

NASA's airframe structural integrity program is trying to develop a computational methodology to predict fatigue crack growth and fatigue life, and to simulate stable tearing for residual strength prediction of thin shell structures, including aircraft fuselages, for large single cracks or multiple cracks.

New alloys, materials, and processing technologies, developed since older aircraft were originally designed, are being used to produce better components with significantly lower life-cycle costs.

# Examples of fatal fatigue accidents

**De Havilland Canada DHC-2 Beaver, near Armidale, NSW, Australia**
10 September 1963
The aircraft was at the end of a superphosphate spreading run when the left wing was seen to separate from the aircraft at around 150 ft above the ground. The aircraft immediately rolled to the left and struck the ground. The pilot died. Investigators determined that the left lift strut upper attachment fitting failed in flight due to a fatigue crack allowing the left wing to separate.

**Vickers Viscount, 720C, VH-RMQ, near Port Hedland, WA, Australia**
*31 December 1968*
The aircraft was on a scheduled flight from Perth to Port Hedland, when it went down 28nm south of its destination. Witnesses saw the aircraft descend rapidly and steeply, but did not see it hit the ground.

The investigation found that the right wing outboard of the number three engine had separated from the aircraft, with the primary failure at the lower boom of the main spar. The failure was due to fatigue cracking of the right inner wing main spar lower boom, adjacent to the outer edge of the number three engine nacelle.

**Boeing 707-321C, G-BEBP, near Lusaka, Zambia**
*14May 1977*
The accident occurred on approach to landing, in daylight and in good weather. Shortly after the selection of landing flap, the right horizontal stabiliser and elevator detached. The aircraft pitched rapidly nose down and collided with the ground about two miles short of the runway.

The investigation was conducted by the UK at the request of the Zambian authorities. It concluded that the accident was the result of a loss of pitch control following the in-flight separation of the right-hand horizontal stabiliser and elevator. The failure wa due to a combination of metal fatigue and inadequate fail-safe design in the rear spar structure. Shortcomings in design assessment, certification and inspection procedures were significant factors.

**McDonnell Douglas DC-10, N110AA, Chicago, Illinois, USA**
*25 May 1979*
During take-off rotation the left engine and pylon assembly and about three feet of the leading edge of the left wing separated from the aircraft and fell to the runway. The aircraft collided with the ground. 271 people on board and two people on the ground died. Investigation revealed that damage by improper maintenance procedures resulted in an overload fracture and fatigue cracking of the pylon aft bulkhead upper flange.

**Boeing 747, JA-8119, Mount Ogura, Japan**
*12 August 1985*
The aircraft experienced an explosive decompression while climbing through 23,900ft. The flight data recorder indicated the aircraft began to oscillate and roll. After around 40 minutes it crashed into a mountain. 524 people were killed. The investigation found that a failure of the rear pressure bulkhead caused part of the vertical stabiliser and tail to blow away, rupturing all main hydraulic fluid lines. The bulkhead ruptured as its strength had been reduced by inadequate repair and fatigue cracks.

**Boeing 737, N73711, Maui, Hawaii, USA**
*28 April 1988*
The aircraft experienced an explosive decompression and structural failure at 24,000ft. Despite the loss of 18ft of the aircraft cabin skin, the aircraft landed safely. One flight attendant died. Investigation determined that the maintenance program failed to detect significant disbonding and fatigue damage of the fuselage lap splice.

**Bell 206B Jet Ranger, N213AL, South Marsh 275, Gulf of Mexico, USA**
*23 April 1991*
The pilot did not make a required radio check after departure from an offshore oil rig, so a search was initiated. Two hours later, debris was found floating three miles from the departure point. Two people died. A metallurgic examination found that the vertical fin attachment fittings had separated due to fatigue induced by corrosion and corrosion pitting.

**Cessna 402C, N819BW, Goldsby, Oklahoma, USA**
*27 April 1999*
The aircraft hit the ground in an uncontrolled descent following in-flight separation of the right wing during a normal descent.

Metallurgical examination revealed that the right wing front spar failed due to fatigue that started at an area of mechanical damage and rough machining marks. The presence of primer covering the mechanical damage suggested that the damage was produced during the manufacturing process.

Damage tolerance involves analysis and tests to estimate how quickly cracks grow, their maximum length before the structure fails and then scheduling inspections scientifically.

In some places, the critical crack length is microscopic and sophisticated inspection techniques are needed. Elsewhere, cracks can be a metre long and visual inspections suffice.

Airliners have been designed to damage tolerance principles for more than 20 years, with earlier aircraft revalidated and their inspection programs revamped.

Knowing where to look for cracks is difficult. Manufacturers usually test a complete airframe to simulate several lifetimes of airline service to see where cracks start.

But the best aids are reports from routine inspections on hundreds of aircraft around the world. Findings are reported to the manufacturer, and operators notified.

**Causes and conclusions** The ATSB concluded that Ansett failed to do the 25,000-flight-cycle inspections, recommended by Boeing in June 1997 and updated in June 2000 to include fatigue crack inspections.

It also failed to act within the recommended six months on a March 2000 Boeing alert SB relating to possible cracking in B767 engine mount fittings.

There is no single cause for Ansett's demise, and commentators have noted several major factors at play.

The first relates to strategic adjustment in a service organisation during times of significant change. Also at play was the purchase of too many aircraft types during the 1980s, which led to unsustainable maintenance costs, large inventories and, as the fleet aged, increased running costs.

In addition to errors and omissions by individuals in Ansett, the ATSB found there were deeper systemic and resource weaknesses in the group.

The actions by Ansett and CASA to ground the B767 aircraft until safety could be assured protected the flying public.

The ATSB investigation also found that the Australian and international systems for continuing airworthiness of Class A aircraft were not as robust as they could have been.

To strengthen the Australian system, new regulations will force operators to take more responsibility for assessing SBs. Operators will have to implement the recommendations or record their reasons for not doing so.

CASA continues to review service bulletins, and takes a close interest in the management and information systems that support continuing airworthiness.

AAP Image/Julian Smith

## On continuing airworthiness

Manufacturers designing new aircraft, engines or propellers are required by the applicable certification regulations to develop and publish instructions for ensuring the continued airworthiness of the aircraft, engine or propeller in service.

A type certificate is not generally issued until the manufacturer has developed continuing airworthiness instructions and published them in documents, such as maintenance manuals, overhaul manuals and service instructions.

Once an aircraft, engine or propeller has entered service, the operator's regulator requires the operator to report defects that might compromise the airworthiness of the aircraft.

The aircraft manufacturer is also required to pass on to the certifying regulatory authority (for Boeing, that is the FAA) reports of problems that have occurred in the operation or maintenance of its aircraft.

Reports suggesting the safety of the aircraft has been compromised are typically called major defect reports (MDR) in Australia.

To address the reports, the manufacturer develops service instructions. Those dealing with MDRs are typically called service bulletins.

The role of the certifying regulator does not end with the issue of the new type certificate. The regulator is required to monitor the continuing airworthiness of the product, a role that continues until the type certificate is cancelled. It reviews and assesses both the defect reports as received by the manufacturer and the manufacturer's response. Its review is carried out by specialists qualified in design, certification and maintenance.

When the regulator deems a condition unsafe, it issues an airworthiness directive mandating corrective action. Most ADs mandate a service bulletin addressing an unsafe condition.

ADs issued by a foreign government are not mandatory in Australia unless they are detailed in an Australian airworthiness directive.

*Sources: Investigation into Ansett Australia maintenance safety deficiencies and the control of continuing airworthiness of Class A aircraft,* Department of Transport and Regional Services, Australian Transport Safety Bureau, November 2002; *Ansett: the Story of the Rise and Fall of Ansett,* Stewart Wilson, Aerospace Publications (2002).