AUSTRALIAN TRANSPORT SAFETY BUREAU

AVIATION SAFETY INVESTIGATION

BS/20010005

Investigation into Ansett Australia maintenance safety deficiencies and the control of continuing airworthiness of Class A aircraft

COMMONWEALTH DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES

Department of Transport and Regional Services

Australian Transport Safety Bureau

Investigation into Ansett Australia maintenance safety deficiencies and the control of continuing airworthiness of Class A aircraft

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FRONT COVER:

Ansett B767 VH-RMD at Sydney Kingsford Smith Airport June 1984.

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PREFACE

The Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Commonwealth Department of Transport and Regional Services. ATSB investigations are independent of regulatory or other external influence.

The objective of the ATSB is safe transport. To achieve this objective the ATSB carries out investigations and safety studies to identify possible safety issues, and then recommends safety actions aimed at addressing those issues.

In terms of aviation, the ATSB is responsible for investigating accidents, serious incidents, incidents and safety deficiencies involving civil aircraft operations in Australia, as well as participating in overseas investigations of accidents and serious incidents involving Australian registered aircraft. The ATSB also conducts safety studies of the underlying factors and trends within the aviation system that have the potential to affect safety. A primary concern is the safety of commercial air transport, with particular regard to fare-paying passenger operations.

The ATSB performs its aviation functions in accordance with the provisions of the *Air Navigation Act 192*0, Part 2A. Section 19CA of the *Act* states that the object of an investigation is to determine the circumstances surrounding any accident, serious incident, incident or safety deficiency to prevent the occurrence of similar events. The results of these determinations form the basis for safety advisory notices and recommendations, and ultimately accident prevention programs. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations.

Under the *Air Navigation Act* it is not the object of an investigation to determine blame or liability. However, it should be recognised that an investigation report must include factual material of sufficient weight to support the analysis and conclusions reached. That material will at times contain information reflecting on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation. At all times the ATSB endeavours to balance the use of material that could imply adverse comment, with the need to properly explain what happened, and why, in a fair and unbiased manner.

ATSB investigations are multi-disciplinary. Investigators are drawn from a range of professional backgrounds including pilots, air traffic controllers, human factors professionals†, Licensed Aircraft Maintenance Engineers (LAMEs), professional engineers, and cabin safety and technical analysis specialists.

The ATSB does not adhere only to one 'investigation model', but applies the best methods and techniques appropriate to each situation.

† Human factors is the multi-disciplinary science that applies knowledge about the capabilities and limitations of human performance to all aspects of the design, operation, and maintenance of products and systems. It considers the effects of physical, psychological, and environmental factors on human performance in different task environments, including the role of human operators in complex systems.

The ATSB employs a broadly systemic approach that aims to identify not only what happened, but why it happened. That approach can reveal both immediate and underlying safety issues. A key principle is that human error, though undesirable, is nevertheless both prevalent and pervasive. Hence, recommended safety action is typically aimed at limiting and mitigating the effect of human error.

ATSB investigations include analysis of any relevant human factors or organisational issues. Consideration of these aspects does not, however, in any way diminish the importance and priority given to operational, mechanical, and technical issues. The different aspects are, in fact, very much complementary.

EXECUTIVE SUMMARY

Australia has an excellent air transport safety record. Major Australian airlines have long been regarded as being among the world's safest, and there have been no fatalities involving an Australian high capacity jet aircraft. This enviable record is due, in part, to an aviation safety culture that recognises the need for constant safety awareness.

Given the commercial pressures facing international aviation, the events described in this report should be seen as a learning experience for the aviation industry, regulatory bodies, and all organisations concerned with continuing airworthiness assurance.

In December 2000 and in April 2001, a number of Ansett Australia (Ansett) Boeing 767 (B767) aircraft were withdrawn from service because certain required fatigue damage inspections of the aircraft structure had been missed. As a result there was uncertainty as to the continuing airworthiness status of the aircraft. In December 2000 the concerns related to possible fatigue cracking in the rear fuselage of the aircraft, and in April 2001 the concerns related to possible fatigue cracking of the engine strut fitting on the wing front spar.

On 11 January 2001, the Australian Transport Safety Bureau (ATSB) commenced an investigation into the circumstances surrounding the withdrawal from service of the Ansett B767 aircraft as the situation was regarded as indicative of a potential safety deficiency[i]. On 10 April 2001 the ATSB investigation was extended to include an examination of the continuing airworthiness system for Australian Class A[ii] aircraft such as the B767.

Action by Ansett and the Civil Aviation Safety Authority (CASA) addressed the potential risks to fare-paying passengers. Although Ansett was subsequently placed into voluntary administration in September 2001, the ATSB continued a detailed systemic investigation because of the importance of the issues involved, both in Australia and internationally.

The international continuing airworthiness system, like all complex and safety-critical activities, is dependent on robust[iii] systems to maintain high reliability. The circumstances surrounding the withdrawal from service of the Ansett B767 aircraft revealed, among other things, that the reliability of the continuing airworthiness system was threatened by a number of weak defences.

The B767 aircraft type was among the first in the world to be designed and certified under damage tolerance principles. Damage tolerance certification relies heavily on scheduled inspections to ensure continuing airworthiness. The aircraft structure is designed to maintain integrity until any fatigue or corrosion damage can be detected at a scheduled inspection, and appropriate action taken. Therefore, in itself, the presence of fatigue cracks in the Ansett B767 aircraft was not necessarily a cause for undue concern. However, it was critical that there were robust systems to ensure that the required structural inspections were carried out to detect the cracks before they exceeded acceptable limits.

Withdrawal from service of Ansett B767 aircraft in December 2000

Ansett was the sixth airline worldwide, and the first airline outside North America, to operate the B767. Of the nine Ansett B767-200 aircraft, five were first flown in 1983 and two in 1984. The aircraft accumulated a high number of flight cycles[iv] because they were mostly flown on comparatively short domestic sectors. Ansett had been working with Boeing on fatigue cracking in the area of the Body Station[v] 1809.5 bulkhead outer chord since 1996.

In June 1997, Boeing introduced the Airworthiness Limitations Structural Inspection program[vi] for the B767. The program was an essential part of the damage tolerance requirements and was designed to detect fatigue cracking in susceptible areas that had been identified through testing and in-service experience. Ansett staff did not initially recognise that some Airworthiness Limitations Structural Inspections were required by 25,000 cycles and a period of almost two and a half years elapsed before that error was identified. At the time that the inspection program was introduced, some Ansett B767 aircraft had already flown more than 25,000 cycles. In June 2000, further 25,000 cycle inspections were introduced, including in the area of the Body Station 1809.5 bulkhead outer chord. Ansett did not initially act on this.

In December 2000, Ansett senior management became aware of the missed inspections and the aircraft were withdrawn from service on 23 December 2000, despite the high commercial cost to the company. At that time, both Ansett and CASA were of the belief that compliance with the missed inspections was mandatory. Subsequent legal advice indicated that the regulatory basis for mandating compliance with the Airworthiness Limitations Structural Inspections for Australian operators was unclear. On 29 December 2000, CASA issued a direction to Ansett specifically mandating the inspections for the Ansett B767 aircraft.

The ATSB investigation found that the Ansett system for the introduction and scheduling of the B767 Airworthiness Limitations Structural Inspections was deficient and vulnerable to human error. A mistake or omission by one or two people could potentially result in continuing airworthiness assurance being compromised. In addition, deficiencies existed in resource allocation and in the supporting information management systems.

From October 1998, Boeing also issued a series of service bulletins in relation to fatigue cracks in the area of the B767 Body Station 1809.5 bulkhead outer chord. Service bulletins are issued by aircraft, component, or engine manufacturers to provide operators with relevant service information. Not all service bulletins are safety-related, and compliance with a particular service bulletin can only be mandated by the State of Registry of an aircraft.

Boeing initially notified operators that the service bulletin requirements were primarily commercial in nature. It was not until November 2001 that Boeing indicated that the service bulletin dealt with a potentially major safety issue. The FAA had mandated action by US operators in relation to the service bulletin in April 2001.

Any action to be taken by Ansett in relation to the Body Station 1809.5 service bulletins issued by Boeing was complementary to requirements under the B767 Airworthiness Limitations Structural Inspection program. It was the failure by Ansett to appropriately incorporate the required Airworthiness Limitations Structural Inspections, issued in June 1997 and updated in June 2000, into the B767 system of maintenance that led to the withdrawal from service of six Ansett B767 aircraft in December 2000.

Withdrawal from service of Ansett B767 aircraft in April 2001

In March 2000, Boeing issued an Alert[vii] service bulletin to detect and repair fatigue cracks in the wing front spar outboard pitch load fitting of the B767 engine mounting strut. Boeing recommended that the work be carried out within 180 calendar days. A revision to the service bulletin was issued in November 2000. In March 2001, Ansett became aware that they had not acted on either the original or the revised service bulletins.

During the period from 7–9 April 2001, inspections revealed cracks in the pitch load fittings of three of the Ansett B767 aircraft and they were withdrawn from service. On 9 April 2001 CASA required that a further four Ansett B767 aircraft be withdrawn from service, pending inspection. Those inspections were subsequently carried out, and the aircraft were cleared to fly.

Deficiencies in the Ansett engineering and maintenance organisation

The ATSB investigation found that similar deficiencies within the Ansett engineering and maintenance organisation led to the withdrawal from service of the B767 aircraft in December 2000 and April 2001. Those deficiencies were related to:

- organisational structure and change management
- systems for managing work processes and tasks
- resource allocation and workload.

However, the investigation found no evidence to suggest that Ansett had deliberately breached airworthiness regulations.

Ansett had undergone considerable change over a number of years. Many of the Ansett systems had developed at a time when the company faced a very different aviation environment. Over time, efficiency measures were introduced to improve productivity but the introduction of modern robust systems did not keep pace with the relative reduction in human resources and loss of corporate knowledge.

Risk management and implementation of change within the Ansett engineering and maintenance organisation were flawed. Inadequate allowance was made for the extra demand on resources in some key areas during the change period.

The Ansett fleet was diverse and the point had been reached where some essential aircraft support programs were largely dependent on one or two people. Hence it was possible for an error or omission by a particular specialist to go undetected for a number of years.

Resource allocation and workload issues had been evident within some areas of the Ansett engineering and maintenance organisation for a considerable period of time. The investigation found that measures aimed at achieving greater productivity had been introduced throughout the organisation without sufficient regard to the different circumstances and criticality of the different work areas. Insufficient consideration had been given to the possible consequences of resource constraints on the core activities of some safety-critical areas of the organisation.

People and robust systems are two of the prime defences against error. Therefore, a combination of poor systems and inadequate resources has the potential to compromise safety. If a failure by one or two individuals can result in a failure of the system as a whole, then the underlying problem is a deficient system, not simply human fallibility.

The Australian continuing airworthiness system

The ATSB investigation found that based on the Ansett B767 experience, the Australian system for continuing airworthiness of Class A aircraft was not as robust as it could have been, as evidenced by:

- uncertainty about continuing airworthiness regulatory requirements
- inadequate regulatory oversight of a major operator's continuing airworthiness activities
- Australian major defect report information not being used to best effect.

The investigation identified a need for the regulatory basis for continuing airworthiness requirements of Class A aircraft to be better defined and disseminated to operators.

No evidence was found to indicate that CASA had given formal consideration to monitoring the introduction of the B767 Airworthiness Limitations Structural Inspection program by Ansett from 1997 onwards.

Prior to December 2000, there was apparently little or no awareness among Ansett senior management or within CASA of the underlying systemic problems that had developed within the Ansett engineering and maintenance organisation. The presence of organisational deficiencies remained undetected. In addition, there were delays in adapting regulatory oversight of Ansett in response to indications that Ansett was an organisation facing increasing risk.

The decision by the then Civil Aviation Authority in the early 1990s to reduce its previous level of involvement in a number of safety-related areas did not adequately allow for possible longer-term adverse effects. This included reducing the work done by Authority specialist staff in reviewing manufacturer's service bulletins relevant to Australian Class A aircraft, and relying on operators' systems and on action by overseas regulators in some airworthiness matters.

CASA's central database for major defect reports was incomplete, partly due to deficiencies in reporting, and the information received was not always fully analysed. In addition, feedback to the initiators of major defect reports, and to other operators, was limited. As a result, the potential safety benefit of the major defect reporting system was not fully achieved.

The FAA and ICAO

Delays by the US Federal Aviation Administration (FAA) contributed to a lack of awareness by Ansett and CASA of required B767 Airworthiness Limitations Structural Inspections. This breakdown in FAA process was acknowledged by the US Secretary of Transportation in August 2001. The FAA did not issue airworthiness directives in relation to the June 1997 Airworthiness Limitations Structural Inspection program, or the service bulletins for the Body Station 1809.5 bulkhead outer chord and the wing front spar outboard pitch load fitting, until after the second Ansett groundings in April 2001.

Different views within the FAA as to the importance of airworthiness directives to mandate continuing airworthiness requirements for damage tolerance aircraft types contributed to a lack of timely action by the FAA. The ATSB report includes recommendations that the FAA ensure that such airworthiness directives are processed and released without undue delay, and that affected parties should be informed when delays do occur. The report also recommends that the FAA ensure that the process for determining grace periods for aircraft to comply with airworthiness directives is both systematic and transparent.

The ATSB report outlines where the existing international continuing airworthiness system, as defined by International Civil Aviation Organization (ICAO) standards and recommended practices, could be enhanced by the application of quality assurance mechanisms to the processing and distribution of safety-related information.

The events outlined in this report indicate that there was a breakdown in the continuing airworthiness system within Ansett, the FAA, and CASA. In addition, the possible safety significance of cracks in the area of the B767 Body Station 1809.5 bulkhead outer chord was not initially highlighted by Boeing.

Safety action

On 12 April 2001, the ATSB released two safety recommendations to CASA. The intent of these recommendations was to enhance the robustness of the systems used to manage the continuing airworthiness of Australian registered aircraft such as the B767 by ensuring that:

- action, or lack of action, by another State did not adversely affect the safety of Australian Class A aircraft
- all service bulletins relevant to Australian Class A aircraft were received, assessed and implemented or mandated as appropriate.

CASA subsequently initiated a comprehensive review of its systems to monitor, assess, and act on service bulletins, to ensure that those critical to safety could be readily identified and acted upon appropriately. Recommendations from that review were addressed in an associated implementation plan that detailed the nature and timing of the actions that CASA would take in response to the recommendations. The ATSB is monitoring the implementation of this important safety action.

In response to the circumstances of the events of December 2000 and April 2001, the FAA has included further checks and balances designed to ensure that all service bulletins issued by US manufacturers are properly reviewed and addressed. In addition, the FAA has established an ‘early warning system’ to provide non-US airworthiness authorities with information on pending occurrence investigations that may result in mandatory action by the FAA.

The manner in which events developed highlights the need for organisations to be continually mindful of potential threats to safe operations. Periodic review is needed to ensure that existing systems for maintaining air safety keep pace with the changing environment.

Implementation by the relevant organisations of the recommendations made by the ATSB as a result of this investigation should help to ensure that aviation systems, both within Australia and internationally, are strengthened and that air safety for Class A aircraft is enhanced.

i Section 19AD of the *Air Navigation Act 1920* defines a safety deficiency as any situation related to aviation that can reasonably be regarded as having the potential to affect adversely the safety of aviation.

ii Class A refers to an aircraft with a Certificate of Airworthiness issued in the transport category, or one that is used for regular public transport operations.

iii In the context of this report, a system is robust if, when someone makes an error or a problem occurs for some other reason, the system can detect the deviation and recover without any significant negative effect.

iv A flight cycle is one completed take-off and landing.

v Body Station number is the distance in inches from a datum in front of the nose of the aircraft to a particular point of the aircraft structure.

vi The Airworthiness Limitations Structural Inspections were in addition to zonal inspections and scheduled structural inspections that had formed part of the B767 maintenance program from the time the aircraft entered service.

vii Boeing service bulletins are classified into three categories in order of urgency: Alert, Unusually Significant, and Standard. Alert service bulletins are issued for safety-related issues that require the immediate attention of the operator.

1 INTRODUCTION

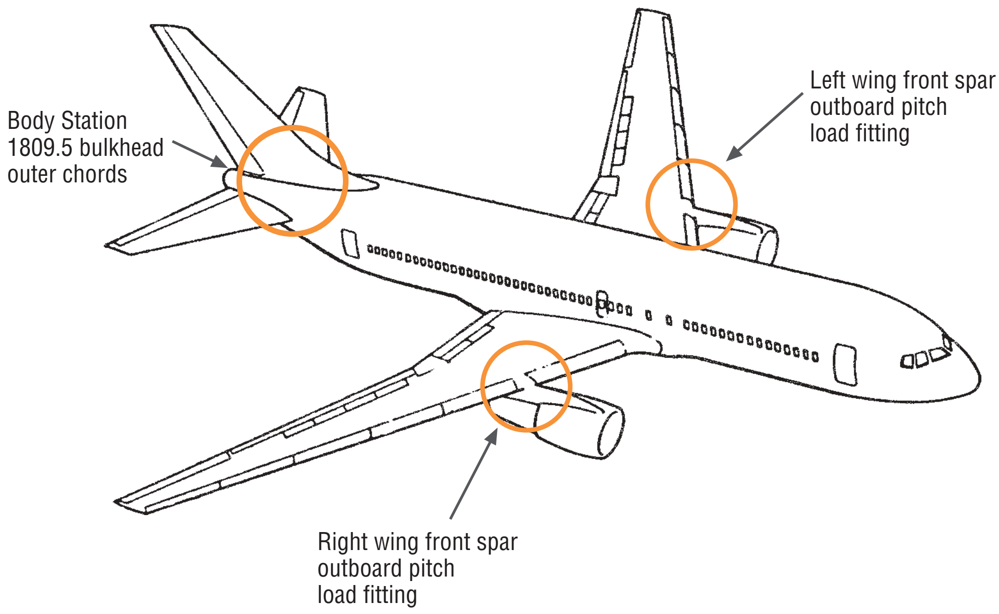
This report examines why there was a loss of continuing airworthiness assurance in relation to Boeing 767 (B767) aircraft operated by Ansett Australia (Ansett), and how that situation came about. The report also details why the international and Australian systems to support continuing airworthiness were, at various levels and to varying degrees, not sufficiently robust. The report concludes with an analysis of the lessons that can be learned to maintain and strengthen airworthiness management.

The events of December 2000 and April 2001

In December 2000 and in April 2001, a number of Ansett B767 aircraft were withdrawn from service because certain required fatigue damage inspections of the aircraft structure had not been carried out. That led to uncertainty that the continuing airworthiness of the aircraft could be assured.

In December 2000 the concerns related to possible fatigue cracking in the Body Station 1809.5 bulkhead outer chord, in the rear fuselage of the aircraft. In April 2001 the concerns related to possible fatigue cracking of the wing front spar outboard pitch load fitting that connected the engine support structure to the wing (see Figure 1). In both cases undetected fatigue cracking had the potential to eventually lead to structural failure.

FIGURE 1:
Location of B767 Body Station 1809.5 bulkhead and wing front spar pitch load fittings



The withdrawal from service of Ansett B767 aircraft in December 2000 and April 2001 attracted wide media coverage and caused significant disruption to Australian domestic aviation. From a safety perspective, however, the principal concern was the possible presence of serious underlying systemic deficiencies within the Ansett system for continuing airworthiness assurance. While the events did not lead to an accident or incident, the inability of Ansett to confirm the airworthiness status of the aircraft raised significant safety concerns. The investigation found no evidence to suggest that Ansett had deliberately breached airworthiness regulations.

Ansett was one of the first airlines in the world to operate B767 aircraft, and did so for domestic operations within Australia. The introduction of that aircraft type into the Ansett fleet in 1983 was significant because the B767 had been certified under the then new damage tolerance design criteria (see page 5).

Ansett was one of a number of airlines that were closely involved with Boeing in the development of the B767 maintenance program. That enabled Ansett to gain a thorough understanding of how damage tolerance philosophy and practice was applied to ensure the continuing airworthiness of the aircraft type.

One of the central aspects of the continuing airworthiness process for aircraft certified to damage tolerance criteria is the requirement for the periodic inspections of the aircraft structure. Hence, as in-service experience with the B767 type grew, additional inspection requirements were notified to operators. This was a normal process for an aircraft certified to damage tolerance criteria and operators' maintenance systems were updated to incorporate the extra requirements as they were identified.

In 1996, Ansett became one of the first B767 aircraft operators to report fatigue cracks in the area of the Body Station 1809.5 bulkhead outer chord and Ansett worked with Boeing to devise and implement a repair scheme. During the period 1996 to 2000, similar cracks were found on four other Ansett B767 aircraft.

In October 1998, Boeing issued a service bulletin relating to Body Station 1809.5 fatigue cracking[1]. Ansett incorporated the inspection procedures detailed in the service bulletin, but subsequently overlooked a later revision of the service bulletin issued in September 1999 that added further inspections. On 21 December 2000, Ansett senior management became aware that certain fatigue-related structural inspections, believed to be mandatory, had not been incorporated into the Ansett B767 system of maintenance. As a result, seven aircraft in the Ansett B767 fleet had exceeded the flight-cycle thresholds specified for those inspections.

Ansett contacted Boeing for advice. Specialist Boeing staff had to be recalled and no immediate response was received. Consequently, due to uncertainties about the continuing airworthiness status of the aircraft, Ansett withdrew the affected aircraft from service from 23 December 2000.

On 11 January 2001, the ATSB commenced an investigation into the circumstances surrounding the omission by Ansett to carry out the B767 inspections, as the situation was regarded as indicative of a potential safety deficiency[2].

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1 A summary of relevant B767 Boeing service bulletins and related FAA and CASA airworthiness directives is given in Appendix 1.

2 Section 19AD of the *Air Navigation Act 1920* defines a safety deficiency as any situation related to aviation that can reasonably be regarded as having the potential to affect adversely the safety of aviation.

Individual aircraft were returned to service after interim inspection arrangements agreed to by the Civil Aviation Safety Authority (CASA). The discovery by Ansett, on 18 January 2001, of additional cracks in the Body Station 1809.5 bulkhead outer chord area of some aircraft necessitated further inspection of those aircraft before they could be returned to service.

Ansett conducted an internal investigation after the grounding of the B767 aircraft. As part of that process Ansett found, in March 2001, that a B767 Alert Service Bulletin for the inspection of the wing front spar outboard pitch load fitting, issued by Boeing on 2 March 2000, had not been implemented. The pitch load fitting connected the engine support structure to the wing. The Alert Service Bulletin had recommended inspection, within 180 days, of the fitting for cracks in a particular location.

When Ansett recognised that the service bulletin had been overlooked, a decision was made to implement it as soon as possible. Boeing was consulted, and it was agreed that the work would be completed by 30 April 2001. However, during the period 7–9 April 2001, inspections revealed cracks in the pitch load fittings of three aircraft, which were then withdrawn from service by Ansett. CASA was informed and later grounded the four remaining Ansett B767 aircraft affected by the service bulletin. On 10 April 2001, CASA issued an airworthiness directive mandating the inspections for all Australian registered B767 aircraft with production line numbers of 1–101 inclusive.

On 10 April 2001, the ATSB investigation was extended to include an examination of procedures for the control of the continuing airworthiness of Class A aircraft such as the Ansett B767s. On 12 April 2001, the ATSB issued two safety recommendations to CASA in that regard. Later the same day, citing further Ansett maintenance problems, CASA suspended the Certificates of Airworthiness of the ten B767 aircraft operated by Ansett, with effect from 10 pm that evening.

The CASA Director of Aviation Safety stated that the suspension of the Certificates of Airworthiness was necessary in the interests of aviation safety, citing a number of issues including a report of an Ansett B767 aircraft operating for eight flights with the door escape-slides not armed[3]. CASA also issued a press release stating that it intended to serve Ansett with a notice on 20 April 2001, giving the airline 14 days to ‘show cause’ why its Air Operator Certificate should not be withdrawn. CASA stated that the notice was based on a pattern of ongoing structural, management and personnel problems, and was not restricted to the Body Station 1809.5 and wing front spar pitch load fitting fatigue cracking issues.

On 20 April 2001, the CASA Director of Aviation Safety advised Ansett that CASA would not be issuing a show cause notice. However, Ansett was required to enter a formal undertaking to address issues of concern to CASA.

Ansett and a number of related businesses were placed into voluntary administration on 12 September 2001, and Ansett ceased flying on 4 March 2002. However, the ATSB investigation was continued as many of the substantive issues related not only to the Ansett system, but also to aspects of the global system for continuing airworthiness assurance. Because of the importance of the issues, both within Australia and internationally, the ATSB conducted a detailed systemic investigation, as described in this report.

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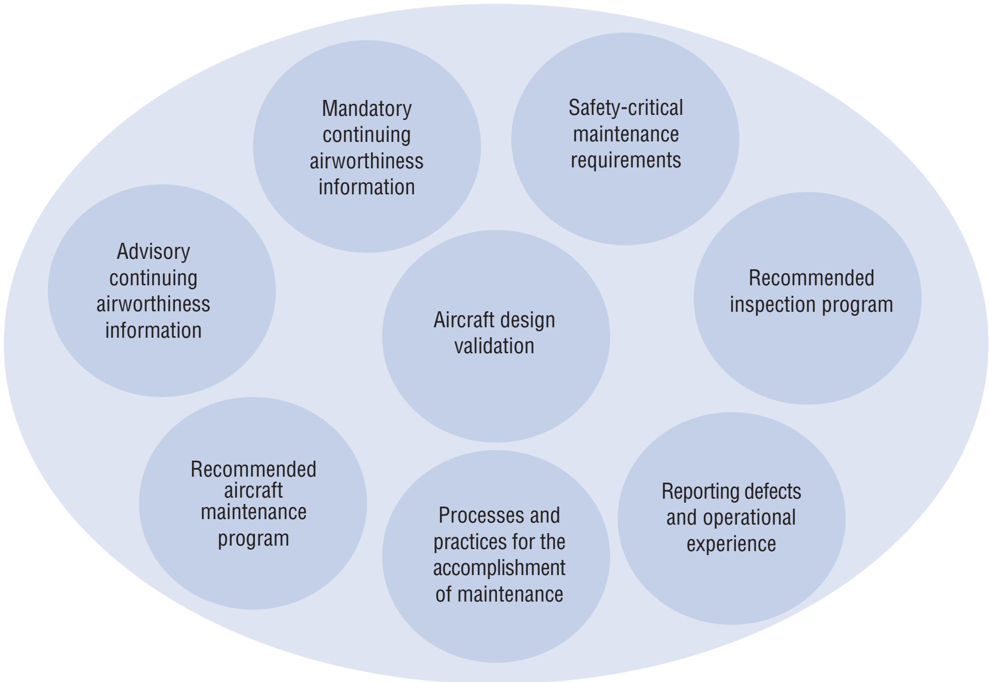
3 The ATSB investigation report into this safety issue (No. 200101606) was issued on 17 November 2001.

Basic elements of the continuing airworthiness system

The international continuing airworthiness system is essentially a complex communication system among all of the organisations responsible for the design, manufacture, regulation, operation, and maintenance of a transport aircraft type. The basic elements of the system that are relevant to this report are outlined in Figure 2.

FIGURE 2:
Basic elements of the continuing airworthiness system



To ensure the maximum reliability of the system, it is necessary to have correct knowledge and control of the system at all levels. It is also necessary to ensure that the procedures that the system depends upon are clear, relevant, workable, and resistant to human error. Finally, as there are many different components to the system, each with their own particular characteristics and complexity, the system requires robust defences to ensure that continuing airworthiness assurance is maintained.

Two important airworthiness concepts in the context of this report are briefly described below.

The concept of continuing airworthiness assurance

This report addresses issues related to the continuing airworthiness assurance of Australian Class A aircraft. The concept of continuing airworthiness assurance can be developed progressively as follows:

- ***Airworthiness*** refers to an aircraft being 'fit to fly' in all environments and circumstances for which it has been designed and certified.
- ***Continuing airworthiness*** refers to the activities necessary to ensure that the aircraft remains airworthy throughout its design life.
- ***Continuing airworthiness assurance*** refers to the confidence that there are robust systems in place to ensure that the continuing airworthiness status of the aircraft is known at all times.

The activities that are necessary for continuing airworthiness are outlined in the ICAO *Airworthiness Manual* (Doc 9760-AN/967, 2001) (see Appendix 2). Some of the main elements include:

- aspects related to design criteria
- the publication of information for the maintenance of the aircraft, and the implementation of that material by operators
- the reporting and analysis of defect, accident and other maintenance and operational information, the transmission of recommended or mandatory action to operators, and subsequent action by the operator
- accomplishment by the operator of all mandatory requirements including fatigue life limits and any necessary special tests or inspections
- preparation of and compliance with Airworthiness Limitations Structural Inspections[4].

The goal of continuing airworthiness assurance is to ensure that all these activities take place in an efficient and timely manner. Thus the airworthiness of the aircraft is assured.

The distinction between *continuing airworthiness* and *continuing airworthiness assurance* is an important one in the context of this report. When, in December 2000, Ansett realised that it had not incorporated required Airworthiness Limitations Structural Inspections into the B767 system of maintenance it withdrew the aircraft from service because continuing airworthiness assurance had been lost.

The subsequent ATSB investigation did not examine the continuing airworthiness of the Ansett B767 aircraft per se. That matter had been dealt with quickly by the actions of Ansett and CASA in grounding and inspecting the aircraft, which were then returned to service. CASA was satisfied that, as a result of those inspections, the structural integrity of the Ansett B767s was maintained. The ATSB investigation did seek to determine why continuing airworthiness assurance for those aircraft had been lost. Initial indications of the presence of a safety deficiency in that regard were reinforced by the Ansett events of April 2001.

The concept of damage tolerance

Anything that can affect the structural integrity of an aircraft is a cause for concern. Metal fatigue is one such process that must be well understood and managed during both aircraft design and in-service maintenance. Undetected fatigue can have a potentially disastrous effect on aircraft structural integrity. In 1968, a major air transport accident in Australia, involving a Vickers Viscount with the loss of 26 lives, was attributed to fatigue (see section 4.1).

The philosophy that underpins the design and maintenance of modern transport aircraft has evolved over time. The most recent approach to the control of fatigue and corrosion in aircraft structures is based on the concept of damage tolerance. The B767 was the first US-designed aircraft certified to damage tolerance standards.

4 The ICAO *Airworthiness Manual* uses the term Supplemental Structural Inspection Programs. As outlined in section 4.2.5.1, the Supplemental Structural Inspection Program is the term used to describe one possible means of compliance with the mandatory Airworthiness Limitations Structural Inspections.

The damage tolerance approach is based on the premise that while cracks due to fatigue and corrosion will develop in the aircraft structure, that process can be understood and controlled. Therefore safety will not be compromised. The key to the effective control of the process is a comprehensive program of inspections of the aircraft structure. Those inspections fall into three broad categories:

- zonal inspection carried out on a routine basis
- specific structural inspections developed from design based criteria
- Airworthiness Limitations Structural Inspections.

It is the third category of inspections, Airworthiness Limitations Structural Inspections, that are of particular relevance to this report. Those inspections are developed after the aircraft type has entered service, largely to address fatigue or corrosion problem areas identified through in-service experience or further testing and research. Because the Airworthiness Limitations Structural Inspections address concerns with a significant potential to affect the structural integrity of the aircraft the inspections are considered mandatory.

In December 2000, the loss of continuing airworthiness assurance for Ansett B767s became apparent when it was realised the inspection thresholds for certain Airworthiness Limitations Structural Inspections in the June 1997 and June 2000 revisions of the B767 *Maintenance Planning Data Document* section 9 were 25,000 flight cycles, and not 50,000 flight cycles. Because the airworthiness status of the aircraft could not be immediately confirmed, the Ansett aircraft were withdrawn from service.

Lessons for the future

The events of December 2000 and April 2001 should be seen as a learning experience for the aviation industry, its supporting organisations, and its regulatory bodies. The resilience of the international continuing airworthiness system could be improved if there was a greater redundancy in the information flows that make up the system. An important lesson for operators is that a combination of inadequate systems and resource constraints can be risky. More generally, the manner in which the events developed over time highlights the need for organisations to be continually mindful of potential threats to safe operations.

The lessons that can be derived from these events can also be applied to other complex, safety-critical systems.

Report structure

Annex 13 to the Convention on International Civil Aviation, *Aircraft Accident and Incident Investigation*, provides guidelines for the format of the final report of an air safety investigation. The ATSB has broadly followed this format with the addition of ‘Observations’ throughout the factual part of the report to provide a brief synopsis and/or analysis, where appropriate, to assist reader comprehension.

The content of the report is described below.

Section 2	Describes the international system for aviation safety management, as described in ICAO documentation.
Section 3	Describes the international continuing airworthiness system and discusses ways of designing resilience into the information flows that make up the system.
Section 4	Describes aircraft structural design and maintenance philosophies, and the nature and relevance of aircraft maintenance systems.
Section 5	Describes the Australian framework for managing the airworthiness of Class A aircraft.
Section 6	Describes the sequence of events surrounding the withdrawal from service of Ansett B767 aircraft in December 2000 and April 2001, and the factors that led to those events.
Section 7	Describes the legislative structure for CASA's activities, and its actions in relation to continuing airworthiness activities for Class A aircraft; both in general, and specifically in relation to Ansett.
Section 8	Describes the administrative procedure and actions taken by the FAA in relation to the oversight and mandating of continuing airworthiness information for B767 aircraft.
Section 9	Analysis of the factual information involving discussion of safety deficiencies identified during the course of the investigation.
Section 10	Conclusions from the discussion developed in the previous section, including lessons that may be of benefit to other operators.
Section 11	Safety actions identified during the course of the investigation.
Appendixes	Other relevant and supporting information.

2 AVIATION SAFETY MANAGEMENT

Aviation safety management is a global concern. The maintenance of the continuing airworthiness of the world's commercial air transport fleet requires coordinated input from all organisations involved in the design, manufacture, operation, and maintenance of aircraft and the regulation of air transport. The reliability and effectiveness of this system is dependent on the consistent and coordinated flow of information among all parties.

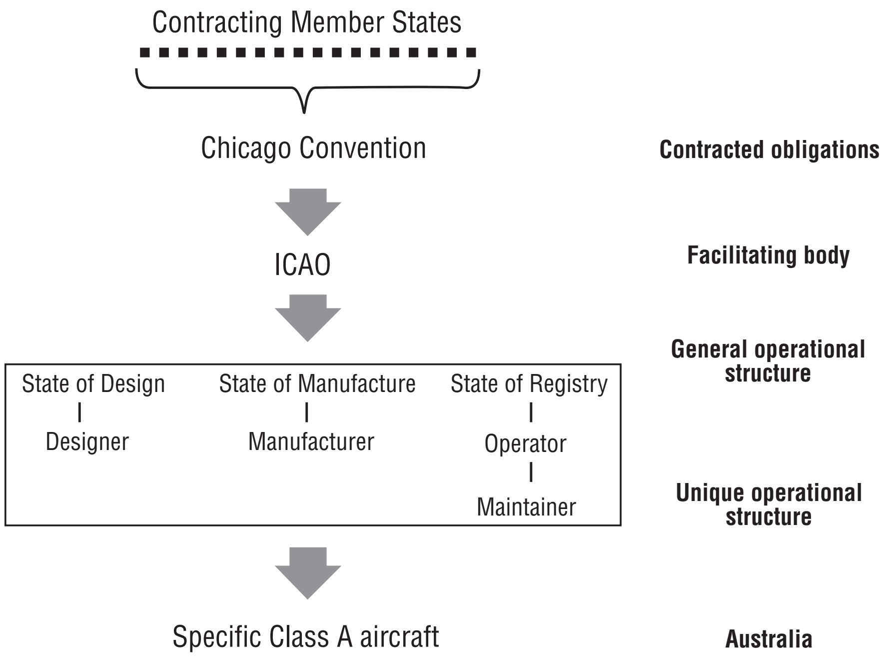
2.1 The International Civil Aviation Organization

The role of the International Civil Aviation Organization (ICAO) is to foster and develop international air transport. ICAO is a specialised agency[5] of the United Nations, and was established by the Convention on International Civil Aviation (Chicago 1944), commonly known as the *Chicago Convention* (see Appendix 3 for the Preamble). Australia is a party to the *Chicago Convention* together with over 180 other 'States', the term used to describe countries under international law.

The *Chicago Convention* is an international multilateral convention which imposes certain obligations on participating States. Under the *Chicago Convention*, ICAO can issue international standards and recommended practices (SARPs) for international aviation through what are termed Annexes to the Convention.

ICAO Annex 8 deals with the airworthiness of aircraft. In Annex 8, ICAO has allocated specific roles and responsibilities to the States of Design, Manufacture, and Registry, and to other involved authorities and parties (see Figure 3).

FIGURE 3:
ICAO framework relevant to Australian Class A aircraft



5 United Nations specialised agencies are autonomous organisations working with the United Nations and each other through the coordinating machinery of the Economic and Social Council.

2.1.1 Standards and recommended practices

The ICAO Annexes contain standards and recommended practices that contracting States are expected to use to develop their own detailed and comprehensive national aviation codes. Annex 6, *Operation of Aircraft*, and Annex 8, *Airworthiness of Aircraft*, are relevant to this investigation, and standards relating to continuing airworthiness from these Annexes are discussed in this report. Relevant excerpts from Annex 6 and Annex 8 are included in Appendix 4 and Appendix 5 respectively.

An ICAO standard is defined as:

> Any specification for physical characteristics, configuration, matériel, performance, personnel or procedure, the uniform application of which is recognized as necessary for the safety or regularity of international air navigation and to which Contracting States will conform in accordance with the Convention. In the event of impossibility of compliance, notification to the Council is compulsory under Article 38.

States agree to undertake all efforts to comply with standards but can notify ICAO of a difference from the standard (see Appendix 3). The lodgement of a difference by a State need not necessarily imply a lower level of safety. ICAO standards are developed through a process of consensus and, in some cases, a particular State may decide to adopt a higher standard. It is possible that the higher standard could be inconsistent with the ICAO requirements, and hence the State would lodge a difference with ICAO.

Australia has notified ICAO that not all the requirements contained in Annex 6, Part I, Chapter 8, concerning continuing airworthiness information are referred to in the Australian Civil Aviation Regulations. No other Australian differences relevant to the continuing airworthiness system have been notified to ICAO.

An ICAO recommended practice is defined as:

> Any specification for physical characteristics, configuration, matériel, performance, personnel or procedure, the uniform application of which is recognized as desirable in the interest of safety, regularity or efficiency of international air navigation, and to which Contracting States will endeavour to conform in accordance with the Convention.

A State is not required to notify ICAO where it chooses not to follow a recommended practice.

ICAO Annexes follow the editorial practice of indicating that a specification is a standard by using the operative verb ‘shall’ when describing the required action, while for recommended practices the operative verb ‘should’ is used.

2.1.2 Continuing airworthiness guidance material

ICAO Annex 8, *Airworthiness of Aircraft*, is the primary document that sets out minimum airworthiness standards[6]. However, the specifications in Annex 8 (and other ICAO Annexes) include only broad standards, which must then be applied by competent State authorities. To aid in this process ICAO Annexes are supplemented by guidance material published in technical manuals. The ICAO *Airworthiness Manual* (Doc 9760-AN/967, 2001) is one such document with relevance to this report.

The ICAO *Airworthiness Manual* consists of two volumes. Volume I, *Organization and Procedures*, outlines the obligations of the State of Registry in matters related to

6 There are only standards, not recommended practices, in Annex 8

airworthiness. It provides detailed guidance on the establishment and operation of an airworthiness organisation, with emphasis on the aircraft inspection division and the aircraft engineering division. It covers issues concerned with Certificates of Airworthiness and Type Certificates, and outlines detailed procedures for the approval of operator's maintenance and reliability programs.

Volume II of the *Airworthiness Manual* is divided into two parts. Part A, *Design Certification*, includes material on aircraft type certification and technical guidance material for aeroplanes and helicopters. It also includes information related to Certification Maintenance Requirements and Airworthiness Limitations. Part B, *Continuing Airworthiness*, provides guidance to States on procedures for maintaining the airworthiness of aircraft. The Foreword to this section of the *Airworthiness Manual* states:

> In addition to providing guidance to the airworthiness authorities of States, the information is also intended to be of use to airline operators who have the primary responsibility for maintaining the airworthiness of aircraft.

Topics covered in the continuing airworthiness section of the *Airworthiness Manual* that are of particular relevance to this report include:

- the maintenance of the validity of the Certificate of Airworthiness
- the exchange and use of continuing airworthiness information
- structural integrity programs.

The ICAO Airworthiness Manual incorporates much of the guidance material previously published in three separate ICAO documents – the *Manual of Procedures for an Airworthiness Organization* (Doc 9389-AN/919, 1983), the *Continuing Airworthiness Manual* (Doc 9642-AN/941, 1995), and the *Airworthiness Technical Manual* (Doc 9051-AN/896, 1987)[7].

Other relevant guidance material published by ICAO includes the *Manual of Procedures for Operations Inspection, Certification, and Continued Surveillance* (Doc 8335-AN/879, 1995), the *Manual of Model Regulations for National Control of Flight Operations and Continuing Airworthiness of Aircraft* (Doc 9388-AN/918, 1987), the *Safety Oversight Manual – Part A – The Establishment and Management of a State's Safety Oversight System* (Doc 9734-AN/959, 1999), and the *Safety Oversight Audit Manual* (Doc 9735-AN/960, 2000).

2.1.3 State of Design and State of Manufacture

The State of Design is defined by ICAO as the State having jurisdiction over the 'Organization Responsible for the Type Design'[8] of an aircraft. Typically the State of Design is also the State of Manufacture[9] and is normally represented by their civil aviation authority.

7 The ICAO *Airworthiness Manual* was first published in December 2001, that is, after the events of December 2000 and April 2001 outlined in this report. However, for ease of future reference, this report refers to the relevant sections of the *Airworthiness Manual* rather than the documents it superseded.

8 The Organization Responsible for the Type Design is primarily referred to as the 'design organisation' in this report.

9 In the context of this report, the design organisation and the manufacturer are treated as the same organisation.

ICAO Annex 8 contains standards that place obligations on the State of Design (see Appendix 5). Those obligations require the State of Design to participate in the flow of information necessary for the international system for continuing airworthiness, and to ensure that specified systems are established and maintained to support those information flows. Those responsibilities include ensuring that:

- a continuing structural integrity program exists for aeroplanes over 5,700 kg maximum take-off weight
- a system exists for receiving all information transmitted to the design organisation about faults, malfunctions and defects related to continuing airworthiness
- a system exists for the promulgation of airworthiness actions such as airworthiness directives and instructions for continuing airworthiness.

The ICAO *Airworthiness Manual* recommends that a State of Manufacture should monitor and assess service bulletins issued by the manufacturer for continuing airworthiness implications (see Appendix 6). To fulfil this role, the State of Manufacture needs to set minimum standards for that system, and to monitor the system to ensure that those standards have been achieved.

2.1.4 State of Registry

The State of Registry is defined by ICAO as the State on whose register an aircraft is entered. A State's civil aviation authority normally undertakes the functions assigned to the State of Registry.

The State of Registry is responsible for setting standards that will enable consistent safe operations, and for ensuring that operators meet those standards. It is responsible for ensuring that aircraft on its register conform in all essential respects with their type design, and that they are maintained in an airworthy condition throughout their service life.

Although the means by which a State of Registry discharges its responsibilities may vary, and in some cases involve the transfer of certain tasks to authorised organisations or other States, such arrangements do not relieve the State of Registry of its overall responsibility.

ICAO Annex 8 places certain specific responsibilities on the State of Registry (see Appendix 5). Those responsibilities include ensuring that appropriate systems exist to:

- develop and maintain information flows relevant to the international system for continuing airworthiness
- develop standards against which the continuing airworthiness of an aircraft can be determined, and to measure compliance against those standards
- assess mandatory information received from a State of Design and take appropriate action.

The State of Registry is the only authority that can legally mandate continuing airworthiness requirements for aircraft on its civil register.

Further details of the responsibilities of the State of Design, the State of Manufacture, and the State of Registry, under the *Chicago Convention*, are given in Appendix 6.

2.2 Civil Aviation Authorities

Under the ICAO structure a State's civil aviation authority is responsible for regulating civil aviation in that State. ICAO documentation also refers to a State's national airworthiness authority. A State's civil aviation authority generally performs the functions of the national airworthiness authority, and some States use the two expressions interchangeably. A State's regulator of civil airworthiness matters is referred to as the civil aviation authority in this report.

Over-regulation by a State's civil aviation authority can impose unnecessary costs on the aviation industry, while under-regulation has the potential to compromise safety. The ICAO *Safety Oversight Manual Part A – The Establishment and Management of a State's Safety Oversight System* (Doc 9734-AN/959, 1999) provides guidance in this area (see Appendix 7).

The manual states that an overly active role could lead to the State dominating and controlling the behaviour of industry to the extent that industry's responsibility and capability to manage its own operations is removed. Conversely, an overly passive regulatory presence will require industry to both interpret and apply the regulations, and the State will not be able to assess the adherence of industry to regulatory requirements. In a balanced safety oversight system, both the State and the aviation community share responsibility for the safe, regular and efficient conduct of civil aviation activities. The manual also points out that certain functions cannot be delegated, lest industry become self-regulating.

The way in which regulation is implemented can also vary. For example, one characterisation contrasts a sanctioning, or deterrence, strategy with a compliance strategy[10]. A sanctioning strategy focuses on the application of punishment for breaking a rule and recourse to legal remedy is a routine response. In contrast, a compliance strategy seeks to secure voluntary adherence to requirements by means such as education and consultation. In practice, the two strategies are complementary and a balanced approach will utilise either of them as appropriate.

The role of regulation, however, remains an important one. In complex areas, such as air transport, it can be difficult for consumers to obtain adequate risk information to make an informed choice. Regulations, which are to a large extent based on specialist expert knowledge, can embody risk information that is not readily available to consumers. Also, in situations where it is not prudent to adopt a strategy of 'learning by mistake', regulations can be formulated to avoid potential problems that are identified by risk analysis, before major accidents occur.

2.2.1 The Civil Aviation Safety Authority

The Civil Aviation Safety Authority (CASA) administers civil air transport in Australia under powers conferred on it by the *Civil Aviation Act 1988*. Section 11 of the Act states that:

> CASA shall perform its functions in a manner consistent with the obligations of Australia under the *Chicago Convention* and any other agreement between Australia and any other country or countries relating to the safety of air navigation.

CASA's powers and responsibilities are described in greater detail in section 7.1 of this report.

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10 Zipser B (1997). *The regulation game: the Civil Aviation Authority and regulatory enforcement.* Australian Journal of Administrative Law, 4, 103–110.

CASA regulates safety-critical aspects of civil aviation involving aircraft on the Australian civil register, or operating in Australian airspace. Of particular interest in this report are CASA's activities relating to systems for supporting the continuing airworthiness of Class A aircraft.

2.2.2 The Federal Aviation Administration

The Federal Aviation Administration (FAA) is the civil aviation authority of the USA. The FAA is part of the US Department of Transportation and has a range of legal responsibilities in relation to US civil aviation. As a mandated responsibility under the *Federal Aviation Act 1958*, the FAA promotes aviation safety both domestically and internationally. Those activities include exchanging aeronautical information with foreign authorities.

The FAA acts for the State of Design and the State of Manufacture for civil aircraft manufactured by The Boeing Company – Commercial Aircraft Group (Boeing).

2.2.3 ICAO Universal Safety Oversight Audit Programme

In 1992, ICAO adopted a resolution to establish a safety oversight program to address concerns that some of ICAO's contracting States were not carrying out essential oversight functions. The first stage of the program, launched in 1996, was voluntary. In October 1998, ICAO endorsed an enhanced program, the Universal Safety Oversight Audit Programme, which replaced the voluntary program in January 1999. By January 2002, ICAO had completed safety system audits in 177 contracting States.

The current objective of the ICAO audit is to measure the degree to which a State complies with the standards and recommended practices of Annex 1, *Personnel Licensing*, Annex 6, *Operation of Aircraft*, and Annex 8, *Airworthiness of Aircraft*. It is envisaged that the audit will be extended to other Annexes in future programs.

An ICAO safety oversight audit was conducted on the Australian civil aviation regulatory system in August 1999. Relevant aspects of the ICAO audit are outlined in section 7.5 of this report.

2.3 Other parties in the ICAO system

2.3.1 Design organisation / manufacturer

The design organisation (Organization Responsible for the Type Design) and the manufacturer are identified as distinct entities in ICAO documentation. However, they are generally either the same organisation, or are closely linked, with similar objectives.

Design organisations need to maintain a comprehensive knowledge of the service experience of their aircraft fleets to be able to provide an effective continuing airworthiness information system. Accordingly, they normally communicate with operators, independently of regulatory authorities. That system enables the receipt and distribution of a substantial volume of information, including safety-critical information.

2.3.2 Aircraft operators

ICAO standards place certain responsibilities on the State of Registry to ensure that operators establish systems for the continuing airworthiness of their aircraft.

In accordance with ICAO Annex 6, an operator must use a documented maintenance control system that is acceptable to the State of Registry. Aspects that Annex 6 stipulates must be covered in the documented system, that are relevant to this report, include a description of the procedures for:

- monitoring, assessing and reporting maintenance and operational experience; and
- assessing continuing airworthiness information and implementing any resulting actions.

To a certain extent operators are reliant on the performance of other agencies within the international airworthiness system for the continued safe operation of their aircraft. Therefore it is prudent for operators to ensure that they are not disadvantaged by any action, or lack of action, by other organisations such as manufacturers or civil aviation authorities. For example, if a State of Design or Registry does not mandate safety action appropriately, then the continuing airworthiness of some aircraft in an operator's fleet may be compromised. If this occurs, the operator is likely to be the most severely affected.

One way that an operator can guard against this situation, and gain the continuing airworthiness assurance that they require, is to continually monitor and assess the performance of those other organisations within the global continuing airworthiness system.

2.3.2.1 Factors influencing aircraft operator safety standards

There are a number of mechanisms that have the potential to influence the behaviour of operators in relation to air safety. Those mechanisms include:

- regulation of civil aviation by the State
- high professional standards upheld by management and senior operational staff
- awareness of the commercial benefits of a reputation as a safe operator
- guidance from aircraft manufacturers
- insurance obligations, and the possibility of legal action after an accident or incident
- the influence of consumers exercising market choice
- the influence of unions or professional associations.

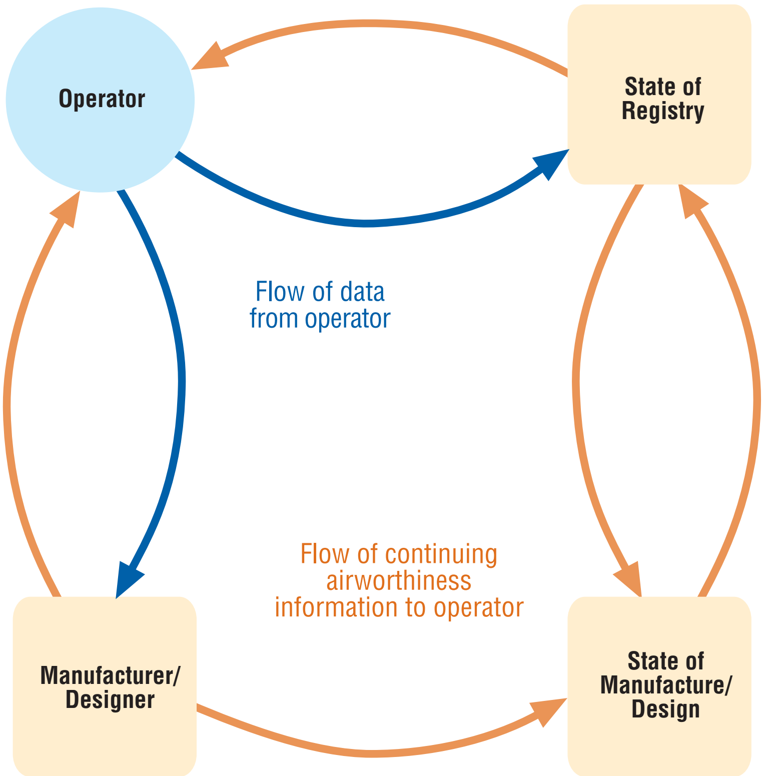
Hence, regulation is by no means the only mechanism that influences air safety, and nor will regulation necessarily be the mechanism that drives the highest level of safety. For example, regulation may provide an acceptable minimum level of safety that many operators with a well-developed safety culture will choose to exceed.

3 THE INTERNATIONAL CONTINUING AIRWORTHINESS SYSTEM

The international continuing airworthiness system is in essence a complex communication system. Good communication between all of the component parts is essential for the overall system to operate effectively and reliably.

The operator is the focus of this communication system. They are both the initial source of much of the raw data that drives the system, as well as being the eventual recipient of the continuing airworthiness information that the system produces. The framework for these information flows between States, manufacturers/designers, and operators is outlined in ICAO Annexes 6 and 8[11]. Figure 4 indicates the flow of raw data from the operator to the State of Registry and the manufacturer/designer (→), and the flow of the resulting continuing airworthiness information back to the operator (→).

FIGURE 4:
Information flows associated with continuing airworthiness

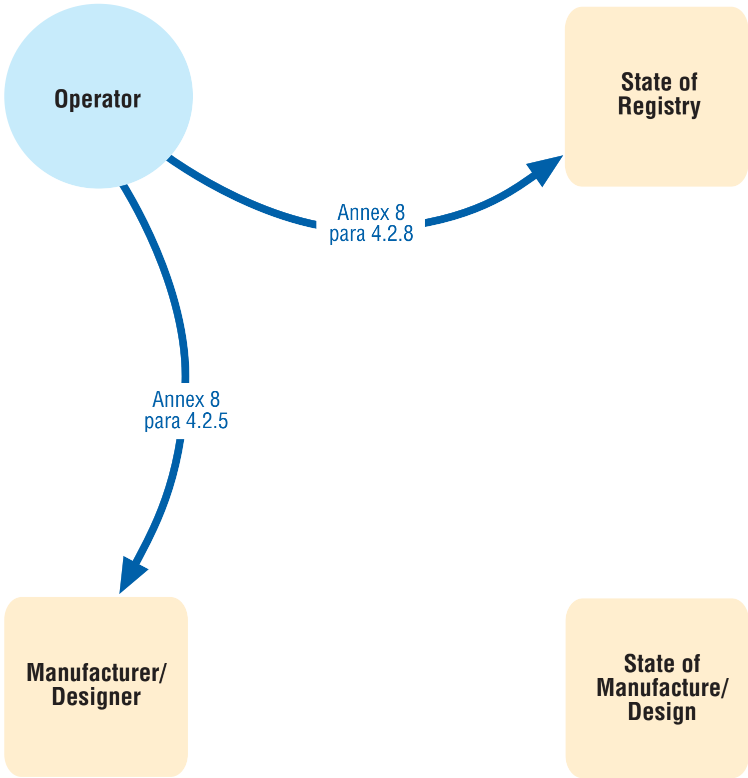


3.1 Transmission of in-service data from operators

The timely and efficient collection of in-service data from aircraft operators is an essential component of the continuing airworthiness system. There are ICAO requirements for this information to be made available to both the design organisation and the State of Registry (see Figure 5).

11 The information flows outlined in ICAO Annexes 6 and 8 may be supplemented by additional information flows required by individual States of Registry.

FIGURE 5:
Transmission of in-service data from operators



Annex 8, Part II, p. 4.2.5 requires the State of Registry to ensure that there is a system for the transmission of in-service data from operators to the design organisation.

ICAO Annex 8, Part II, pp. 4.2.5 states, in part[12]:

> 4.2.5 The State of Registry shall ensure that in respect of aircraft of over 5 700 kg maximum certificated take-off mass, there exists a system whereby information on faults, malfunctions, defects and other occurrences which cause or might cause adverse effects on the continuing airworthiness of the aircraft is transmitted to the organization responsible for the type design of that aircraft.

However, there is no specific Australian requirement for an operator to report matters relevant to the continuing airworthiness of the aircraft type to the manufacturer or the design organisation. In addition, there is no specific mechanism for CASA oversight of that activity, over and above the normal surveillance of operators by CASA.

Safety Recommendation R20020243

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority review the effectiveness of the system for the transmission of information on faults, malfunctions and defects to the organisation responsible for the aircraft's type design, in accordance with ICAO Annex 8, Part II, paragraph 4.2.5.

12 The full text of Annex 8, Part II, section 4 can be found in Appendix 5.

CASA has indicated (16 August 2002) that it supports this recommendation, stating that it will be implemented through the introduction of a database of Type Certificate holders and manufacturers that will link to the CASA service difficulty report system. CASA reported that work had commenced and that the project is planned to be completed in May 2003.

Annex 8, Part II, p. 4.2.8 requires the State of Registry to establish a system for the reporting of in-service information from operators to the State's airworthiness authority.

> 4.2.8 Each Contracting State shall establish, in respect of aircraft over 5 700 kg maximum certificated take-off mass, the type of service information that is to be reported to its airworthiness authority by operators, organizations responsible for type design and maintenance organizations. Procedures for reporting this information shall also be established.

In Australia this system has been known in the past as the major defect reporting (MDR) system. The system has recently been renamed the service difficulty reporting (SDR) system[13].

3.2 Production and distribution of continuing airworthiness information

In-service data from operators, together with manufacturer's test and analysis data, forms the basis from which continuing airworthiness information is prepared. However, the data must first be collated and analysed before the information can be distributed to the world fleet. This process involves the manufacturer and/or design organisation, the State of Design, and the State of Registry.

Each of these bodies has their own specific role to play in the continuing airworthiness system. The manufacturer and/or design organisation has a degree of specific knowledge and expertise in relation to an aircraft type unmatched by any other organisation. The State of Design is in a unique position to monitor the continuing airworthiness activities of the design organisation, and to disseminate information to States of Registry for the benefit of operators worldwide. The State of Registry is in the best position to be aware of the particular environment and issues that operators within its jurisdiction face. It is also the only body that can legally mandate compliance with continuing airworthiness requirements by operators.

It is important that the manufacturer and/or design organisation, the State of Design, and the State of Registry coordinate their activities to produce accurate, effective, and timely continuing airworthiness information to all operators. The framework for this part of the continuing airworthiness system is outlined in ICAO Annex 6 and 8 (see Figure 6).

Annex 8, Part II, p. 4.2.2 sets out the requirement for the State of Design to transmit continuing airworthiness information to the State of Registry. The State of Registry is obliged to act on that information in accordance with its obligations under Annex 8, Part II, p. 4.2.3. The State of Registry can also mandate continuing airworthiness information for aircraft on its register without reference to other States. If it does so, however, it is also required to transmit that information to the State of Design in accordance with its obligations under ICAO Annex 8, Part II, p. 4.2.4.

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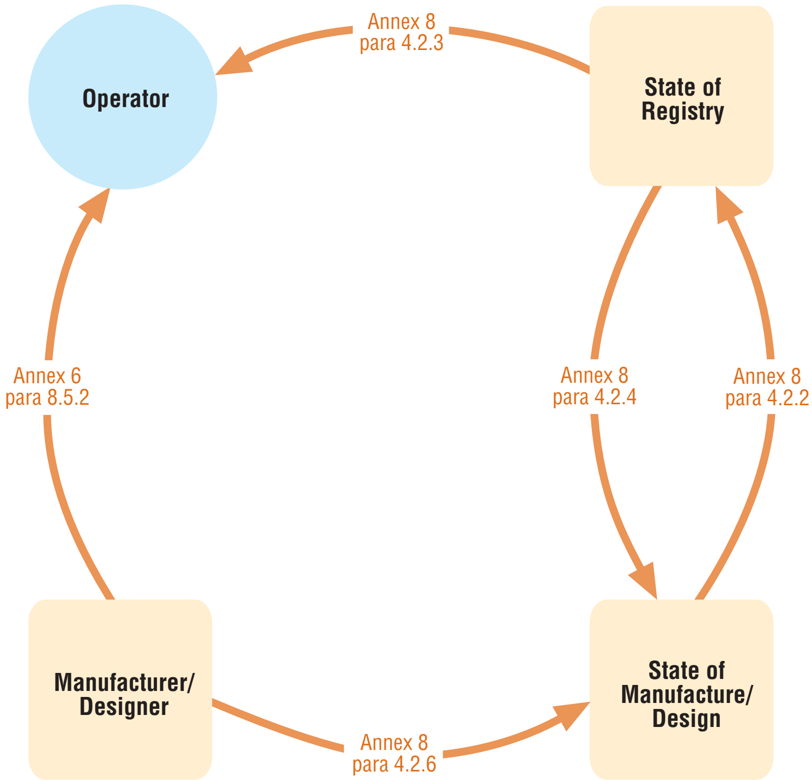
13 See CASA Airworthiness Bulletin AWB 00-4, *Service Difficulty Reporting System*, (May 2001).

FIGURE 6:
Production and distribution of continuing airworthiness information



ICAO Annex 8, Part II, pp. 4.2.2, 4.2.3 and 4.2.4 state, in part:

> 4.2.2 The State of Design of an aircraft shall transmit any generally applicable information which it has found necessary for the continuing airworthiness of the aircraft and for the safe operation of the aircraft (hereinafter called mandatory continuing airworthiness information) as follows:
>
> a) to every Contracting State which has in accordance with 4.2.1 advised the State of Design that it has entered the aircraft on its register: and
>
> b) to any other Contracting State upon request.
>
> 4.2.3 The State of Registry shall, upon receipt of mandatory continuing airworthiness information from the State of Design, adopt the mandatory information directly or assess the information received and take appropriate action.
>
> 4.2.4 Any Contracting State which has entered on its register an aircraft in respect of which that Contracting State is not the State of Design and for which it has issued or validated a Certificate of Airworthiness in accordance with 2.2 of this Part, shall ensure the transmission to the State of Design of all mandatory continuing airworthiness information originated in respect of that aircraft in the former Contracting State.

Under the ICAO defined system, the design organisation receives in-service data from operators. It then develops safety-related service information based on that data. The design organisation has no power to mandate the service information it provides to operators, so that information is, in that respect, advisory. The design organisation can, however, categorise the information with respect to its urgency and relevance to flight safety.

Annex 8, Part II, p. 4.2.6 requires the State of Design to ensure that there is a system for the receipt, assessment, and actioning of the information received by the design organisation from operators. As part of that system, information should be forwarded to the State of Design for the possible issuing of what ICAO terms 'mandatory continuing airworthiness information'.

Annex 8, Part II, p. 4.2.6 states:

> 4.2.6 The State of Design shall ensure that, in respect of aircraft over 5 700 kg maximum certificated take-off mass, there exists a system for:
>
> a) receiving information submitted in accordance with 4.2.5;
>
> b) deciding if and when airworthiness action is needed;
>
> c) developing the necessary airworthiness actions; and
>
> d) promulgating the information on those actions including that required in 4.2.2.

The State of Design then promulgates the information to its domestic fleet, to all States of Registry that have notified that they have the aircraft type on their register, and to other States of Registry on request. It is a matter for a State of Registry to decide what action, if any, it takes on receipt of the information.

Under ICAO Annex 6, Part I, p. 8.5.2, an operator is responsible for ensuring that it receives relevant information from the design organisation:

> 8.5.2 The operator of an aeroplane over 5 700 kg maximum certificated take-off mass shall obtain and assess continuing airworthiness information and recommendations available from the organization responsible for the type design and shall implement resulting actions considered necessary in accordance with a procedure acceptable to the State of Registry.

That standard requires that a system be established for ensuring that operators receive all relevant information from the design organisation and act on it appropriately. The system has to be in accordance with a procedure acceptable to the State of Registry, which implies a degree of oversight by the State of Registry. There is no specific Australian requirement for that activity in Australian civil aviation legislation.

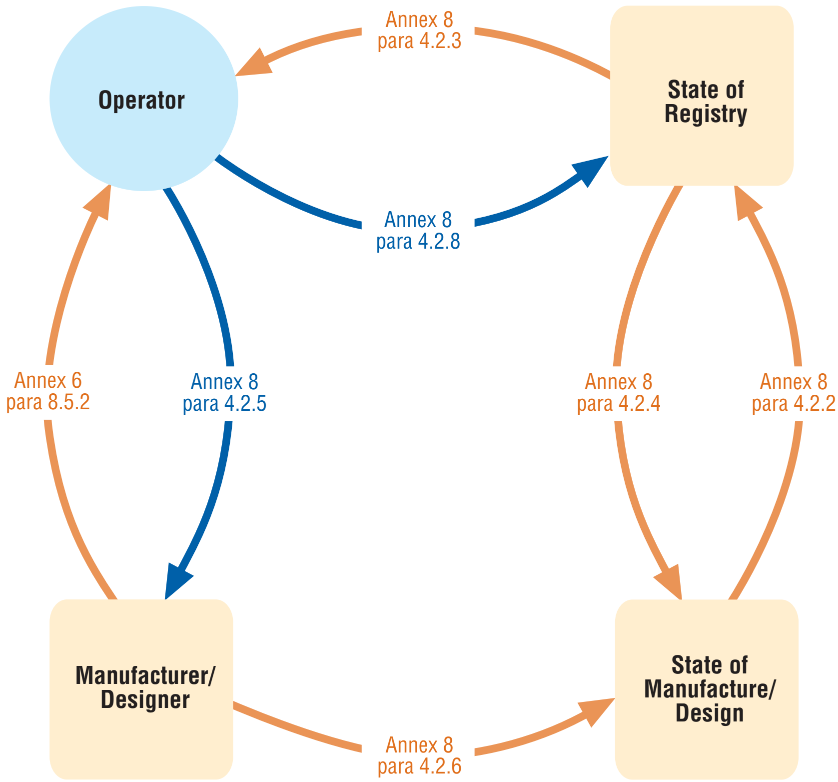
Safety Recommendation R20020244

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority review relevant Australian civil aviation legislation and regulations to ensure that operators of Class A aircraft are required to have an acceptable system for receiving, assessing and actioning safety-related service documentation, in accordance with ICAO Annex 6, Part I, paragraph 8.5.2.

CASA has indicated (16 August 2002) that it agrees in principle with this recommendation. CASA stated that new maintenance regulations to be introduced in early 2003 will provide this outcome. Notices of Proposed Rule Making for these regulations were released for public comment in January 2002.

The complete ICAO framework for the international continuing airworthiness system is shown in Figure 7.

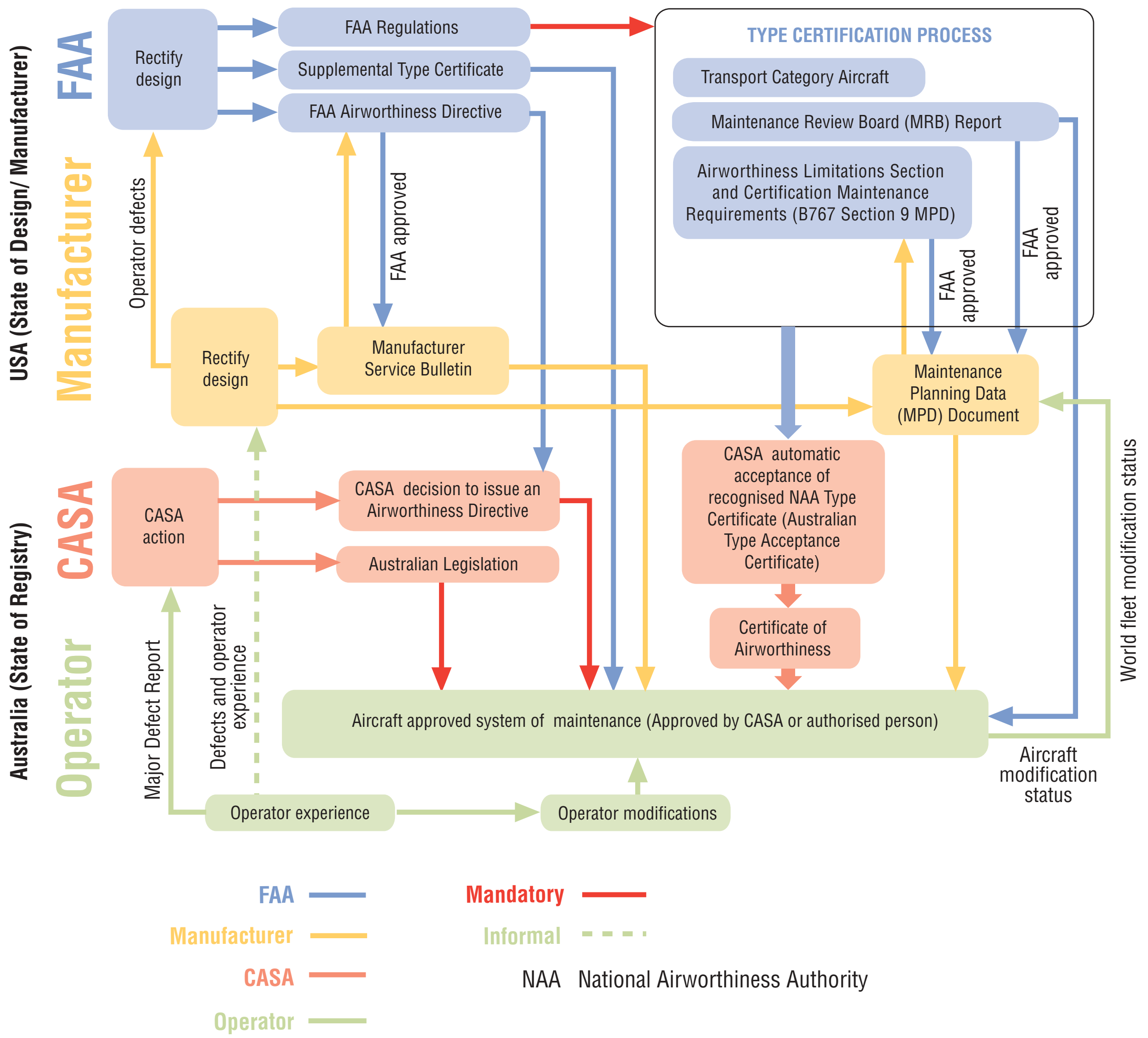
FIGURE 7:
Complete ICAO framework for continuing airworthiness information flows



3.3 Designing resilience into the global continuing airworthiness system

Ensuring the continuing airworthiness of an aircraft is a complex process. There are many different components of the system, each of which has its own particular characteristics and complexity, and in many cases the system must cross national and cultural borders. A basic outline of the continuing airworthiness system components for an Australian registered Boeing 767 aircraft clearly demonstrates the complexity involved (see Figure 8).

FIGURE 8:
Aspects of the continuing airworthiness system for an Australian registered B767



The extent to which particular States comply with ICAO standards and recommended practices is crucial to the reliability of the continuing airworthiness system. However, it is also essential that the different national components of the system function together effectively as a whole. If this is not the case, then the complexity of the system can be compounded.

The aviation industry is continually evolving, with significant changes in aircraft design, the globalisation of aircraft manufacture, and changing airline operations and ownership. These developments impose further pressure on civil aviation authorities to keep pace with the changing aviation environment. One way that the international continuing airworthiness system could potentially be improved is by the application of quality management principles to the system.

A system is resilient if it can tolerate unexpected system deviations and continue to maintain its ability to achieve its required outcomes. Some of the principles behind methods to enhance this capability are outlined in AS/NZS ISO 9001:2000 *Quality* *management systems — Requirements*. For example, systems that operate with elements in parallel offer more redundancy than systems with elements in series[14].

3.3.1 Comparison of information received from different sources

Operators receive continuing airworthiness information from multiple sources. Each of these systems has the potential to identify a deficiency that could affect the continuing airworthiness of an operator's aircraft, and to provide a remedy. To the extent that these systems operate independently in parallel, they provide an opportunity for an operator to compare information it receives from the different sources to check for consistency. That allows an operator to develop resilience in the systems it uses for receiving safety-critical information.

Under current arrangements, information received through the Australian major defect reporting system is not consistently incorporated into other continuing airworthiness systems. The process for an operator to provide major defect reports is independent of the process for information gathering by the design organisation. There is no formal or managed process for information transfer or cross-referencing between the two systems.

Improved integration of information between separate reporting systems would be of particular benefit in cases where, because of the significance of the problem, a single defect report should initiate a timely and thorough investigation.

Observation:

Enhanced integration of the major defect reporting system into the combined continuing airworthiness system would facilitate better use of the information the major defect reporting system generates.

3.3.2 Confirmation of information transfer

When a system relies on the accurate transfer of information, and the consequences of inaccuracies are potentially severe, it is desirable to incorporate a process that checks for accurate, complete and timely transfer of that information. The system must be capable of confirming that information has been received and acted upon as expected. In that way, the potential for different interpretations of the same information will be reduced.

3.3.3 Monitoring of information supply

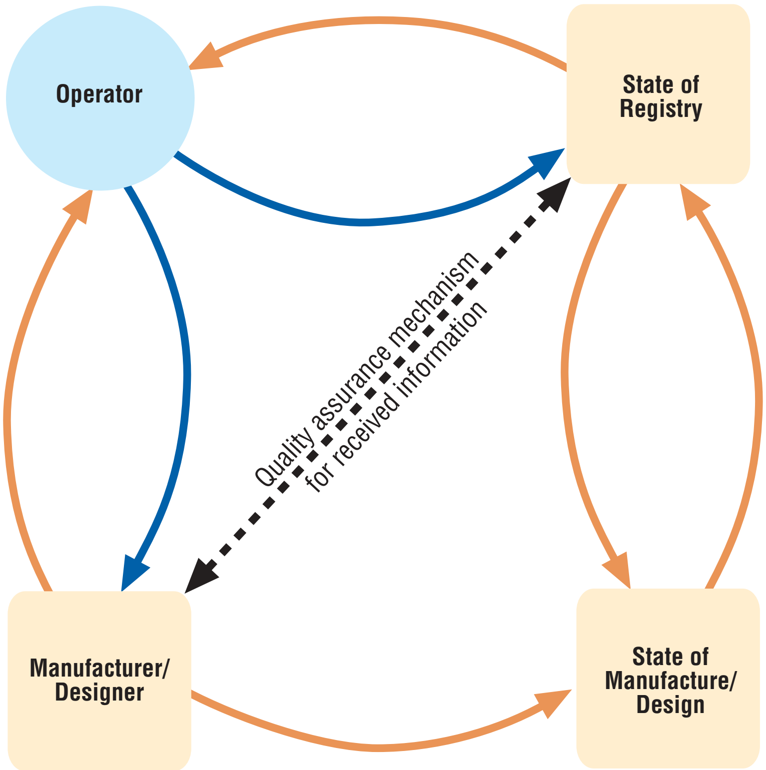
A robust system must monitor the quality of its inputs to be confident that it can produce a high quality output. The continuing airworthiness system is no exception.

If the State of Registry is to be assured that it can provide the necessary mandatory continuing airworthiness information to operators, it needs to be confident that the information it receives from the State of Design is complete, accurate, and timely. The State of Registry can achieve this by monitoring the continuing airworthiness information from the designer/manufacturer that the State of Design uses to prepare its output.

This example is demonstrated in Figure 9, where the dashed line (←━→) indicates a mechanism by which a State of Registry can satisfy itself of the quality of the mandatory continuing airworthiness information it receives from States of Design.

14 There may be a cost associated with the use of parallel systems that must be balanced against the risk and consequences of a system's failure.

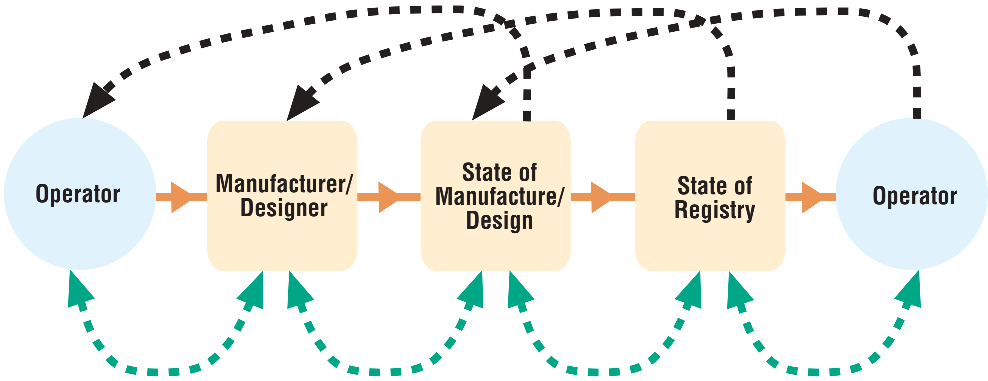
FIGURE 9:
A more robust system for continuing airworthiness information flows



In the same way, a prudent operator can compare continuing airworthiness information received from their State of Registry with similar information promulgated by the State of Design. That would allow the operator to satisfy itself as to the quality of the product generated and disseminated by the State of Registry.

Figure 10 outlines a system with multiple mechanisms to enhance resilience. The flow of information starts from the operator as a service difficulty, and returns to the operator as continuing airworthiness information. The central brown arrows show the flow of information, the green arrows show confirmation of information transfer, and the black arrows show the process of quality assurance of the information received.

FIGURE 10:
Mechanisms that can enhance the resilience of information transfer



The resilience of the system can be enhanced not only by monitoring what information is received, but also by monitoring how an organisation which transmits the received information ensures the quality of its own product. Such a process is in accordance with the principles in AS/NZS ISO 9001:2000 and would enhance the consistency of the system.

Observation:

The resilience of the existing international continuing airworthiness system could be enhanced by the application of quality assurance mechanisms to the processing and flow of information.

Safety Recommendation R20020238

The Australian Transport Safety Bureau recommends that the International Civil Aviation Organization develop standards for States of Registry to ensure that there are appropriate performance measures for continuing airworthiness standards, that take into consideration:

- the process defined in the standard
- a defined outcome that the standard is intended to achieve.

4 DESIGN AND MAINTENANCE SYSTEMS FOR TRANSPORT AIRCRAFT

The design and maintenance philosophy for transport aircraft has evolved over time as a result of operational experience and research and development activities. As the size, complexity, and performance of aircraft has increased, so has the knowledge of design techniques and the control of aircraft maintenance.

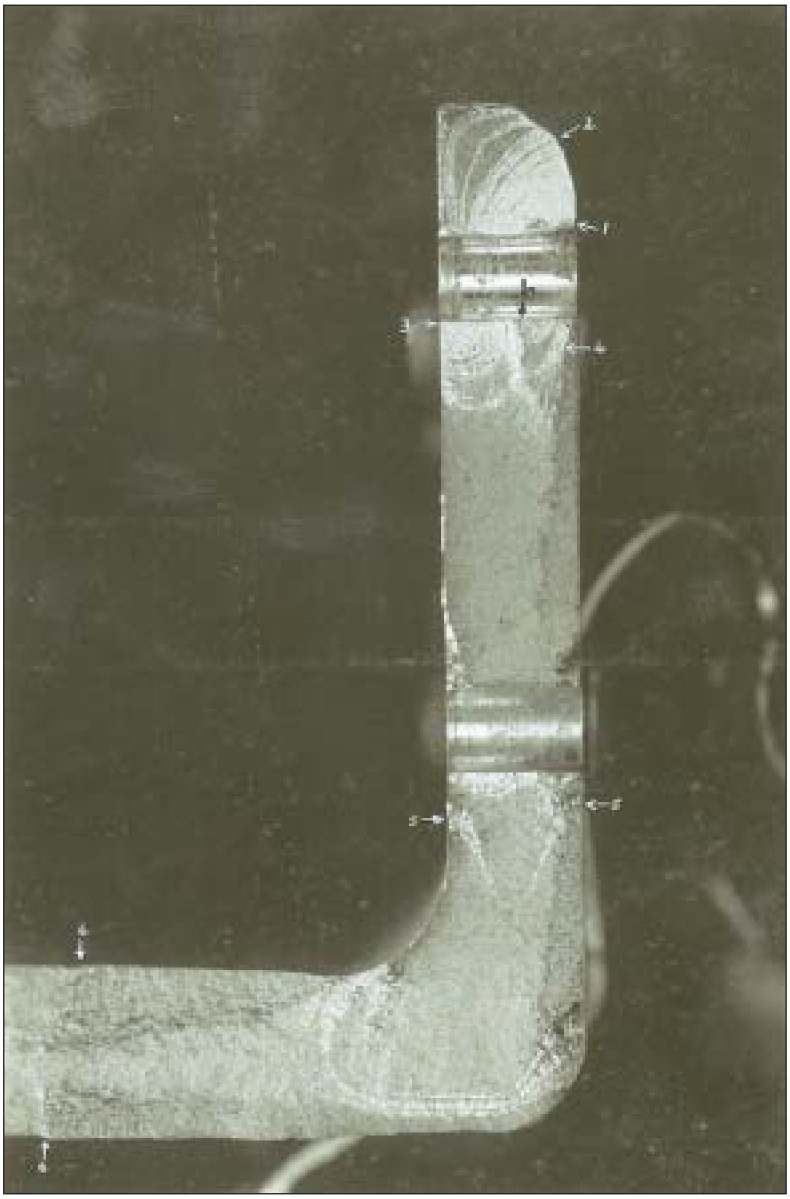
Advances in design, engineering methods, and materials science have led to the production and long service of transport aircraft of increasingly high performance. One of the significant advances in the design and maintenance of aircraft has been a much better understanding of the effect of metal fatigue on the integrity of aircraft structures.

4.1 The effect of fatigue on aircraft structural integrity

Fatigue is the process by which the repeated application of load to a material can cause the material to crack, and potentially fail. When the material is part of a principal element of an aircraft structure then the consequences are potentially very severe. Therefore, it is imperative that the process of fatigue in aircraft structures is well understood and closely controlled.

Fatigue damage from repeated loads can be caused by forces far less than those necessary to break the material with a single load application. For aircraft, the repeated loads can come from atmospheric turbulence, manoeuvres, cabin pressurisation, runway roughness, and simply from the change between being on the ground to being airborne. Figure 11 shows the fracture surface of a fatigue structural failure of an aircraft main spar, the primary load bearing element of the wing.

FIGURE 11:
Fracture surface of an aircraft main spar boom fatigue failure



1. **Primary fatigue crack origin**
2. **Localised area of rapid crack growth**
3. **Secondary fatigue crack origin**
4. **Extent of secondary fatigue cracks**
5. **Small zone of slow growing fatigue cracks**
6. **Small zone of slow growing fatigue cracks**

Fatigue happens more quickly where there are discontinuities, like rivet holes, in the structure. Until the cracks actually start the process cannot be detected, or measured, by any practicable means. Continuing to repeat the loads causes the cracks to grow, and if a crack becomes large enough then the structure will no longer be able to carry the load for which it was designed. It is essential, therefore, that methods are devised for the detection and repair of cracks so that they do not develop to a stage that compromises the structural integrity of the aircraft.

Fatigue in aircraft structures is not a recent phenomenon. The early history of aircraft fatigue failures includes the accident of VH-UYY "Tokana", a Stinson Model A enroute from Essendon to Mildura on 31 January 1945. All ten people on board the aircraft died in the accident. The subsequent public inquiry recommended to the Australian Parliament that aircraft maintenance engineers be given special instructions covering the inspection of vital parts of aeroplanes, that measures for non destructive inspection should be instituted, and that the operational lives of aeroplanes should be limited.

Historically, Australia was at the forefront of research and investigation into aircraft structural fatigue. Pioneering work was undertaken by the Aeronautical Research Laboratories where, between 1947 and 1949, the world's first full-scale fatigue tests of aircraft wings were conducted. This work involved measurement of the repetitive loads to be expected in Australian service. Australian engineers and scientists were prominent in the early development of continuing airworthiness philosophy and practice.

Another early fatigue related accident in Australia was the crash of de Havilland Dove VH-AQO, on 15 October 1951, when the wing separated from the aircraft during a flight from Perth to Kalgoorlie (see Figure 12). All seven people on board died in the accident. VH-AQO and her four sister aircraft were the first Doves in airline service anywhere in the world. The aircraft was four years old at the time of the accident and had accumulated 9,000 flying hours. Had later criteria designed to control fatigue been applied to VH-AQO the aircraft would have been retired after 2,500 hours.

FIGURE 12:
Rear fuselage and empennage of de Havilland Dove VH-AQO

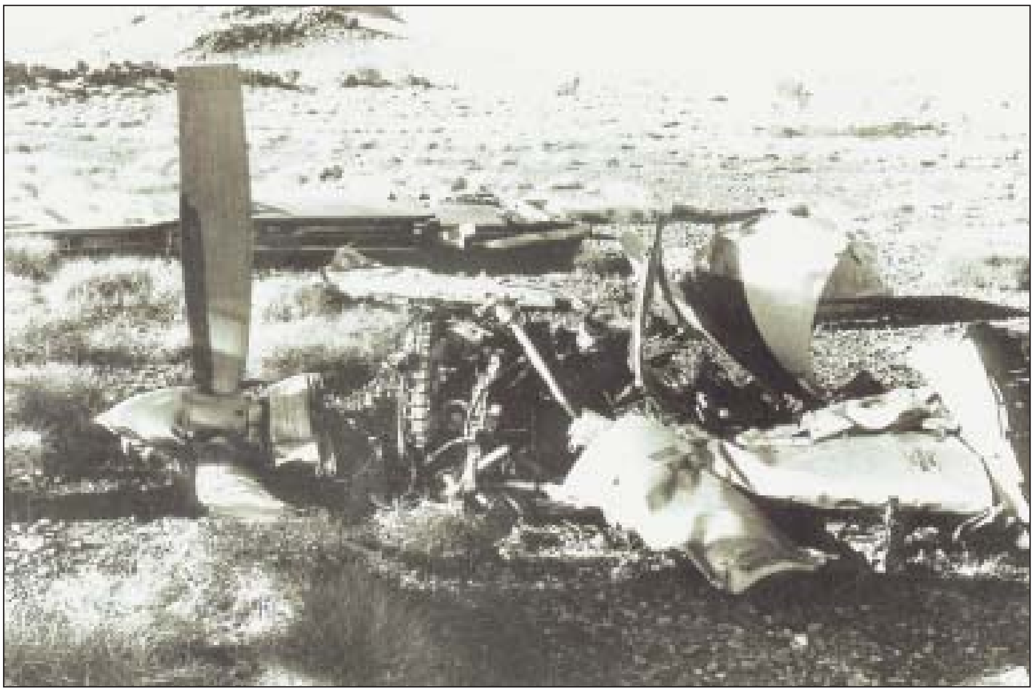
Prior to the VH-AQO de Havilland Dove accident, and similar structural failures in the USA of Martin 202s, structural fatigue was not widely believed to be a significant threat to civil aircraft. The potential effect of in-service operation resulting in fatigue of the aircraft structure was not fully realised.

Structural fatigue failure was responsible for two de Havilland Comet accidents in succession in 1954. This aircraft type was the first airliner with a pressurised cabin to enter service. On 10 January 1954 Comet G-ALYP broke-up at high altitude after departing Rome for London, with the loss of 35 lives. Three months later, on 8 April 1954, Comet G-ALYY experienced a similar in-flight break-up on a flight from Rome to Cairo, with 21 fatalities. On the 12 April 1954 the UK Certificate of Airworthiness was withdrawn from all Comet aircraft.

Following these accidents, the UK Royal Aircraft Establishment conducted ground tests to simulate the conditions of a series of pressurised flights. The tests established that the initiating point of the fatigue failure was in the area of the more highly stressed corners of the windows and other cut-outs, leading to the rupture of the pressure cabin.

Australia last experienced a fatigue related major air transport accident in 1968. During a flight from Perth to Port Hedland on 31 December 1968, Vickers Viscount VH-RMQ broke up in flight and crashed with the loss of 26 lives (see Figure 13).

FIGURE 13:
No. 4 engine and wing wreckage of Vickers Viscount VH-RMQ



The investigation into the VH-RMQ accident found that the right wing of the aircraft had separated in flight due to fatigue cracking of the inner wing main spar lower boom. The fatigue endurance of the boom had been substantially reduced by an incorrect maintenance procedure. Following the accident, similar cracks were found in other Viscount aircraft and at least three aircraft were at significant safety risk. Revised fatigue calculations required the immediate replacement of the booms in a large number of Viscount aircraft in many countries.

From the mid–1950s, the failure rate due to aircraft structural fatigue decreased significantly. However, fatigue related crashes continued to occur. For example, during the late 1960s and the 1970s aircraft types involved included the Fokker/Fairchild F27, Hawker Siddeley 748, Boeing 707, and the Douglas DC10.

The most recent development in the history of aircraft structural fatigue began on 28 April 1988, when a Boeing 737, US registration N73711, enroute from Hilo to Honolulu, Hawaii, experienced an explosive decompression and structural failure at 24,000 feet. Approximately one third of the aircraft cabin roof separated in flight from the aircraft structure aft of the cabin entrance door. The crew performed a successful emergency descent and landing. A flight attendant lost overboard during the decompression was the sole fatality.

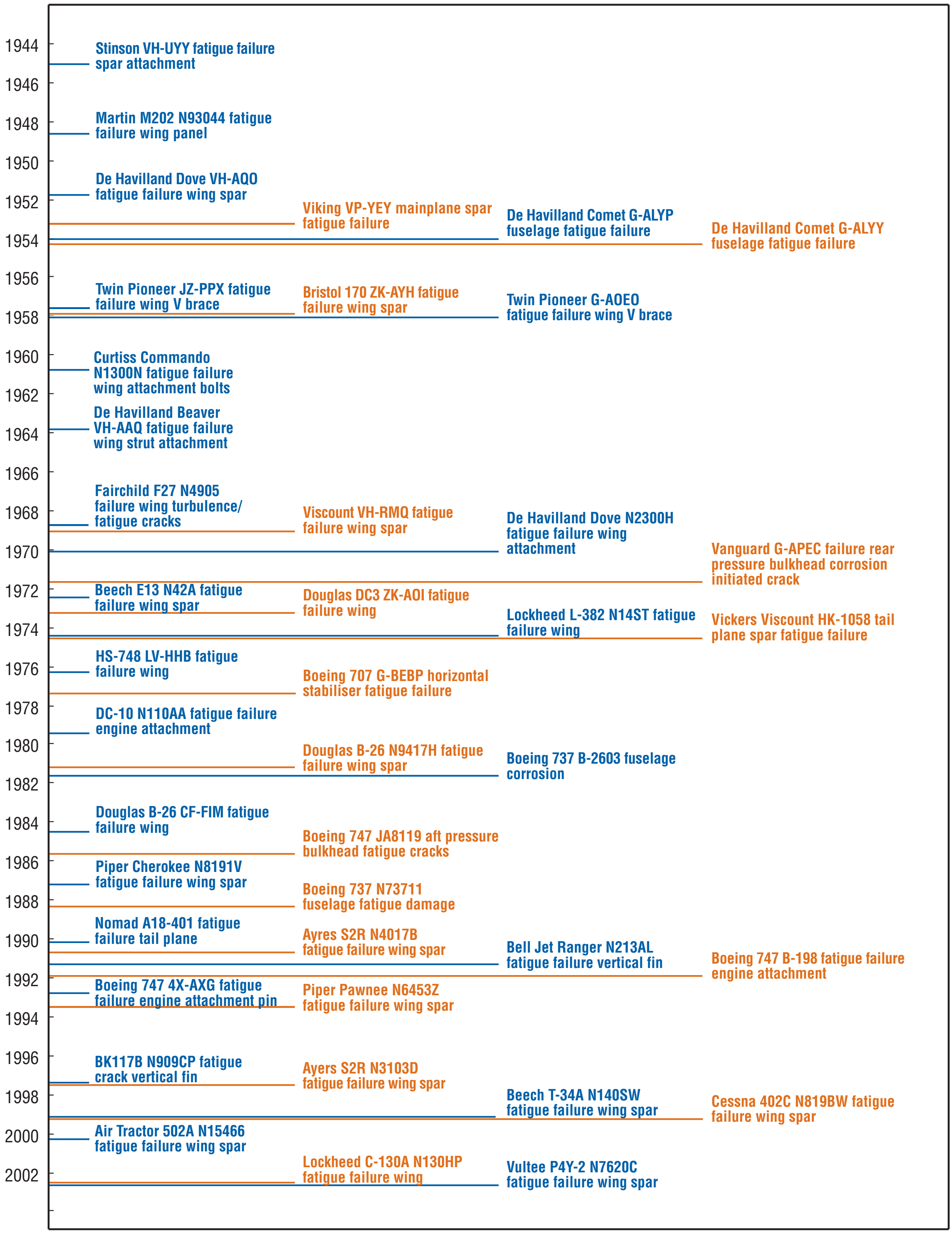
The N73711 accident was pivotal in highlighting the issue of susceptibility of aircraft structures to widespread fatigue damage and resulted in a major effort to ensure the continuing airworthiness of ageing aircraft. The US Congress passed the *Aging Aircraft Safety Act in 1991*, and subsequently the FAA issued an *Aging aeroplane safety* Notice of Proposed Rule Making (NPRM 93-14) in 1993. Industry comment led the FAA to withdraw and reissue the proposal (NPRM 99-02) in 1999. The FAA also amended the Federal Aviation Regulations to require that damage tolerance repair assessment guidelines exist for fuselage repairs of some large transport category aircraft registered in the US[15]. Guidance material has been produced for manufacturers and operators by organisations such as the FAA[16] and the European Joint Aviation Authorities (JAA)[17].

15 Federal Aviation Regulations ss. 91.410, 121.370, 125.248 and 129.32.

16 FAA Advisory Circular No. 91-56A, *Continuing structural integrity program for large transport category airplanes*, April 1998.

17 JAA Administrative and Guidance Material Leaflet No. 11, *Continued airworthiness of ageing aircraft structures,* March 2001.

FIGURE 14:
Examples of fatal aircraft accidents associated with fatigue damage and structural failure from the period 1944 to 2002



Aircraft structural fatigue has been, and remains, a significant aviation safety issue. As Figure 14 outlines, structural fatigue related accidents can involve all types of aircraft carrying out all types of operations. The details of these accidents are given in Appendix 8.

4.2 Damage tolerance design and certification

Successive standards for ensuring that newly certified aircraft types are adequately protected from fatigue failure have been based on the following concepts:

- safe–life
- fail–safe
- damage tolerance.

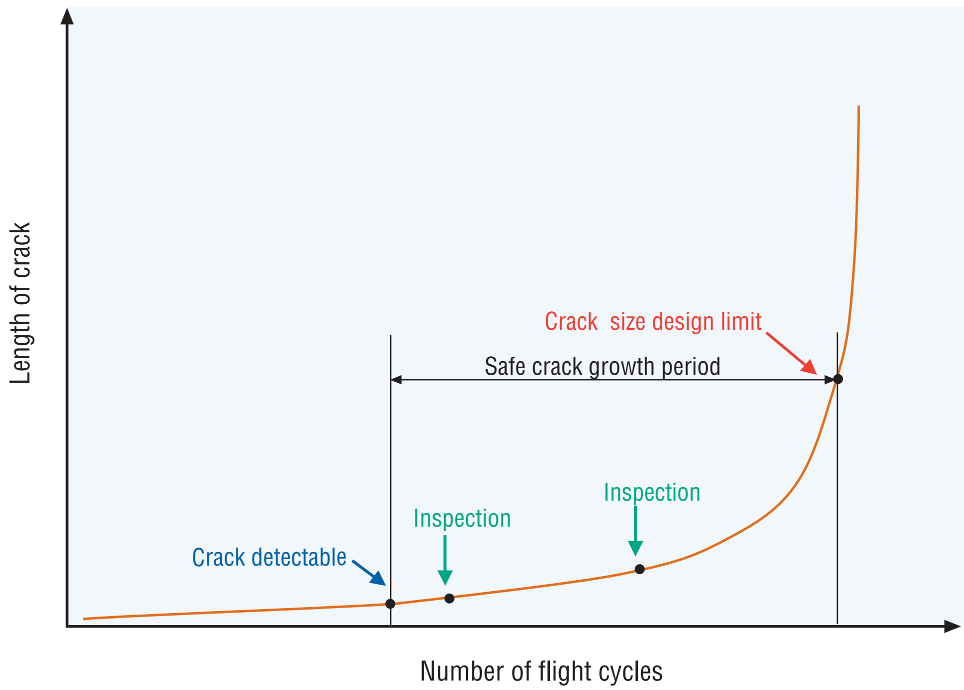
Safe–life certification requirements assign a design safe–life to an aircraft structural component on the assumption that it will retain a pre-determined residual strength during that time. However, critical cracks did develop in structural components before the design safe–life has been reached. An example of this is the in-flight break-up of Stinson VH-UYY in 1943, described above.

In the late 1950s the fail–safe concept was developed. Critical aircraft structures were designed with multiple load paths, so that if a primary element failed the remaining structure would retain sufficient strength to carry the design load. However, hidden cracks could still develop in primary or secondary structures and remain undetected, because no comprehensive scheduled structural inspections were required.

Damage tolerance aircraft type certification was developed in the 1970s. Under the damage tolerance approach a structure is designed to maintain integrity until damage can be detected at a scheduled inspection, and the damaged part replaced or repaired. Hence, the design has to meet specific requirements related to inspectability, predictability of crack growth, and inspection frequency. The underlying philosophy of damage tolerance design is that damage can, and must, be detected before it becomes critical. Therefore, scheduled inspections are a central element of the continuing airworthiness processes for a damage tolerance aircraft type.

Damage tolerance analysis and tests are conducted to gain information about expected damage location, and crack growth and detection. A typical service load spectrum is used, covering flight loads (gust and manoeuvring), ground loads and pressurisation loads. Crack growth predictions and residual strength diagrams are developed for individual structural elements. Using that data, appropriate inspection intervals can be specified to ensure that damage can be detected before it becomes critical (see Figure 15), and structural integrity is maintained throughout the design life of the aircraft.

FIGURE 15:
Theoretical damage tolerance inspection regime to detect cracks before they become critical



Although fatigue testing has not normally been completed at the time of aircraft certification, a plan to produce fatigue test results must have been approved before certification. These results are crucial for the determination of the required inspection program for a damage tolerant aircraft. The aim of an inspection program is to ensure that the detection of any damage will occur while it is still within acceptable limits. Fatigue testing must be conducted to at least twice the design service goal of the aircraft. FAA Advisory Circular 25.571-1C, *Damage Tolerance and Fatigue Evaluation of Structure*, defines a design service goal as:

> Design service goal is the period of time (in flight cycles/hours) established at design and/or certification during which the principal structure will be reasonably free from significant cracking.

Type design change proposals, including those incorporated in service bulletins, modifications and repairs, must show that widespread fatigue damage will not occur within the design service goal of the aircraft, and that damage tolerance requirements will be maintained after the incorporation of the design change.

In any damage tolerance determination, including those involving multiple cracks, it is necessary to establish:

- the damage detection threshold for the inspection techniques to be used
- the residual strength capabilities of the structure, and
- the likely damage growth rate.

Damage growth rates under the repeated loads expected in service provide the basis for development of an inspection program. In addition, the complex interactions of the many parameters affecting damage tolerance must be taken into account. Those factors include operating practices, environmental effects, load sequence, variations in inspection methods, and operational experience with the aircraft type.

4.2.1 Maintenance Steering Group MSG–3 principles

In the early 1960s, a body called the Maintenance Steering Group (MSG) was formed from representatives of manufacturers, operators, and the FAA. The role of the MSG was to determine the guiding principles for the development of maintenance programs of new aircraft types. The first exposition of principles, issued in 1968, was called MSG–1. MSG–2 followed in 1970, and MSG–3 in 1980.

The MSG–3 logic involves a 'consequence of failure' approach. The aircraft's significant systems and components are identified, referred to as Maintenance Significant Items or Structural Significant Items, and the anticipated consequences of their failure determined. On the basis of that analysis, a maintenance activity may be required for a particular item; for example, inspection, servicing or lubrication, operational or functional checks, or restoration or replacement of the item.

The structures logic of MSG–3 follows damage tolerance principles, including the possibility of multiple failures and the effect of failure on an adjacent structure. A clear delineation is made between tasks that are required primarily for safe operation, and those that are only economically advantageous.

4.2.2 FAA type certification

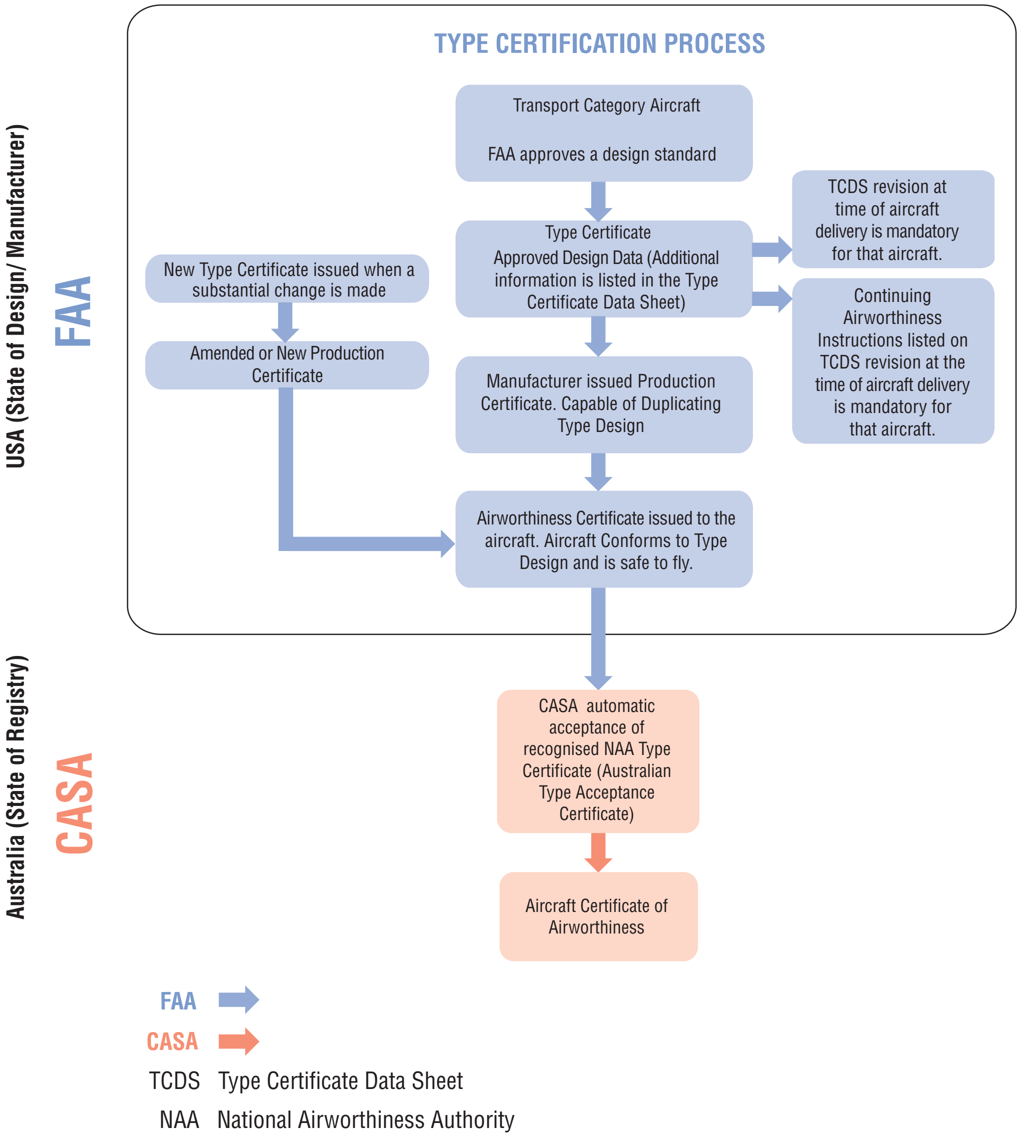
Type certification is the process by which the civil aviation authority of the State of Design approves a new aircraft type, engine or propeller. For US-designed aircraft, type certification is the responsibility of the FAA.

The FAA certifies that the design of a new US aircraft type complies with the applicable sections of the Federal Aviation Regulations and issues a Type Certificate to the design organisation, Boeing in the case of the B767. The Type Certificate includes the Type Certificate Data Sheet, type design data, operating limitations, and other requirements prescribed by the FAA.

Once a US-designed aircraft type enters service, the FAA monitors the design organisation's continuing airworthiness activities for the life of the aircraft. Those activities include the issue of service bulletins by the manufacturer, and revisions to the type design. The FAA responds to that information as it sees appropriate, including by the issuing of airworthiness directives.

Figure 16 outlines the system covering the type certification process for a US-designed aircraft, and the introduction of that aircraft into Australia.

FIGURE 16:
Type certification system for US–designed aircraft registered in Australia



4.2.2.1 FAA certification of damage tolerant transport category aircraft

In 1978, the US FAA adopted the damage tolerance concept for the certification of transport category aircraft. The B767 was the first US-designed air transport category aircraft to be certified under damage tolerance principles.

The B767 was certified in accordance with FAR Part 25 *Airworthiness Standards: Transport Category Airplanes,* s. 25.571 (Amdt. 25-45, effective 1 December 1978), *Damage-tolerance and fatigue evaluation of structure,* which stipulated that a damage tolerance evaluation had to be carried out during design to ensure:

> …that catastrophic failure due to fatigue, corrosion or accidental damage, will be avoided throughout the operational life of the airplane.

FAA damage tolerance standards for type certification require evidence to substantiate, by structural tests and analysis, that the design service goal of the aircraft can be achieved. The design service goal for the B767 passenger aircraft was 50,000 flight cycles.

Fatigue tests and analysis are used to determine the damage tolerance inspection thresholds and frequencies for single and multiple load path structures. That program may be undertaken at the same time as aircraft are in service, so long as the test program remains well in advance of actual in-service operational experience of the fleet.

4.2.3 FAA Instructions for Continued Airworthiness

FAA standards for the certification of a transport category aircraft type require the design organisation to prepare Instructions for Continued Airworthiness (Federal Aviation Regulations, s. 25.1529). The Instructions for Continued Airworthiness contain all the information considered essential for the proper maintenance of the aircraft and must be made available to the operator at the time that the aircraft is delivered.

Specific requirements for the preparation of Instructions for Continued Airworthiness are outlined in Appendix H to Federal Aviation Regulations Part 25 (see Appendix 9 of this report). Appendix H sets out the minimum requirements for the content, distribution and timeliness of the information that must be provided to operators.

The Instructions for Continued Airworthiness include the Certification Maintenance Requirements, Aircraft Maintenance Manual, and other maintenance instructions including troubleshooting information. The Instructions for Continued Airworthiness must also include a specific Airworthiness Limitations section that defines the limits of the type certification with regard to the specific aircraft design characteristics.

The Airworthiness Limitations section must be clearly distinguished from other information and must set forth each mandatory replacement time, structural inspection interval, and related structural inspection procedure for damage tolerance and fatigue evaluation of the aircraft structure (Federal Aviation Regulations, s. 25.571).

The Airworthiness Limitations section typically includes items of the following type:

- Airworthiness Limitations Structural Inspections
- Structural Safe–Life parts.

It is the Airworthiness Limitations Structural Inspection requirements that are of particular relevance to this report.

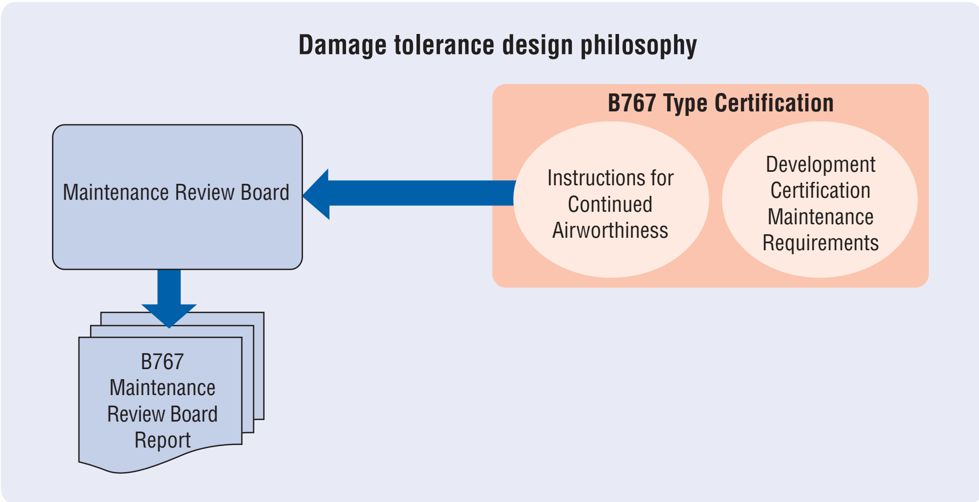
4.2.4 Maintenance Review Board

During the design and development stage of a new transport category aircraft in the USA consideration of operational and maintenance aspects during the type certification process are carried out by the FAA Aircraft Evaluation Group, which is part of the Maintenance Review Board. The Maintenance Review Board has members from the FAA, the aircraft manufacturer and key operators.

The Maintenance Review Board supports the development of the initial minimum maintenance and inspection program based on MSG–3 damage tolerance principles. This program is outlined in the *Maintenance Review Board Report*, which is approved by the FAA as part of the type certification process (see Figure 17). The report forms part of the Instructions for Continued Airworthiness.

The *Maintenance Review Board Report* outlines the initial minimum maintenance and inspection requirements that must be adhered to. Individual operators can then adjust the maintenance program with regard to the unique circumstances and environment of their operations.

FIGURE 17:
Development of the B767 initial scheduled maintenance program



4.2.5 B767 maintenance and inspection program

MSG–3 logic was used to develop the initial minimum scheduled maintenance program for the B767 (see Appendix 10). Maintenance Significant Items and Structural Significant Items were identified by the manufacturer for the aircraft structure, systems and power plants. Inspection tasks were then generated for those items at set frequencies of flight hours, flight cycles and/or calendar time.

The B767 Instructions for Continued Airworthiness were comprised of a suite of Boeing documents including the *Aircraft Maintenance Manual*, component maintenance manuals, the *Maintenance Planning Data Document*, the *Structural Repair Manual*, the *Corrosion Prevention Manual*, the *Non-Destructive Test Manual,* and the *Wiring Diagram Manual.*

The B767 Instructions for Continued Airworthiness included the inspection and maintenance tasks outlined in the B767 *Maintenance Review Board Report,* as well as the Airworthiness Limitations and Certification Maintenance Requirements[18].

4.2.5.1 B767 Maintenance Planning Data Document

The B767 *Maintenance Planning Data Document* lists all Boeing recommended scheduled maintenance tasks, and contains information for each B767 operator to develop their own scheduled maintenance program. Other inputs into an operator's maintenance program include manufacturer's task cards[19], the manufacturer's Aircraft Maintenance Manual, airworthiness directives, service bulletins, service letters, operator's unique requirements, and component manufacturer publications. Requirements of the B767 *Maintenance Review Board Report* were included in the B767 *Maintenance Planning Data Document.*

18 Certification Maintenance Requirements are tasks that are identified during aircraft certification, independently of the MSG–3 analysis. They are tasks identified as critical in ensuring that system failure probabilities and their effects remain within an acceptable range.

19 Boeing task cards list the maintenance procedures to be followed to accomplish a task.

The B767 *Maintenance Planning Data Document* sections include:

Sections 1 to 4	–	General aircraft information
Section 5	–	Recommended lubrication tasks
Section 6	–	System maintenance program
Section 7	–	Zonal inspection program
Section 8	–	Structural inspection program
Section 9	–	Airworthiness Limitations and Certification Maintenance Requirements
Section 10	–	Corrosion prevention program.

The structural inspection program contained in section 8 of the *Maintenance Planning Data Document* is developed using MSG–3 based damage tolerance principles to ensure that structural damage is detected in a timely manner. The program is designed to control environmental deterioration including fatigue damage, corrosion, and accidental damage. Section 8 also contains the Supplemental Structural Inspection Program.

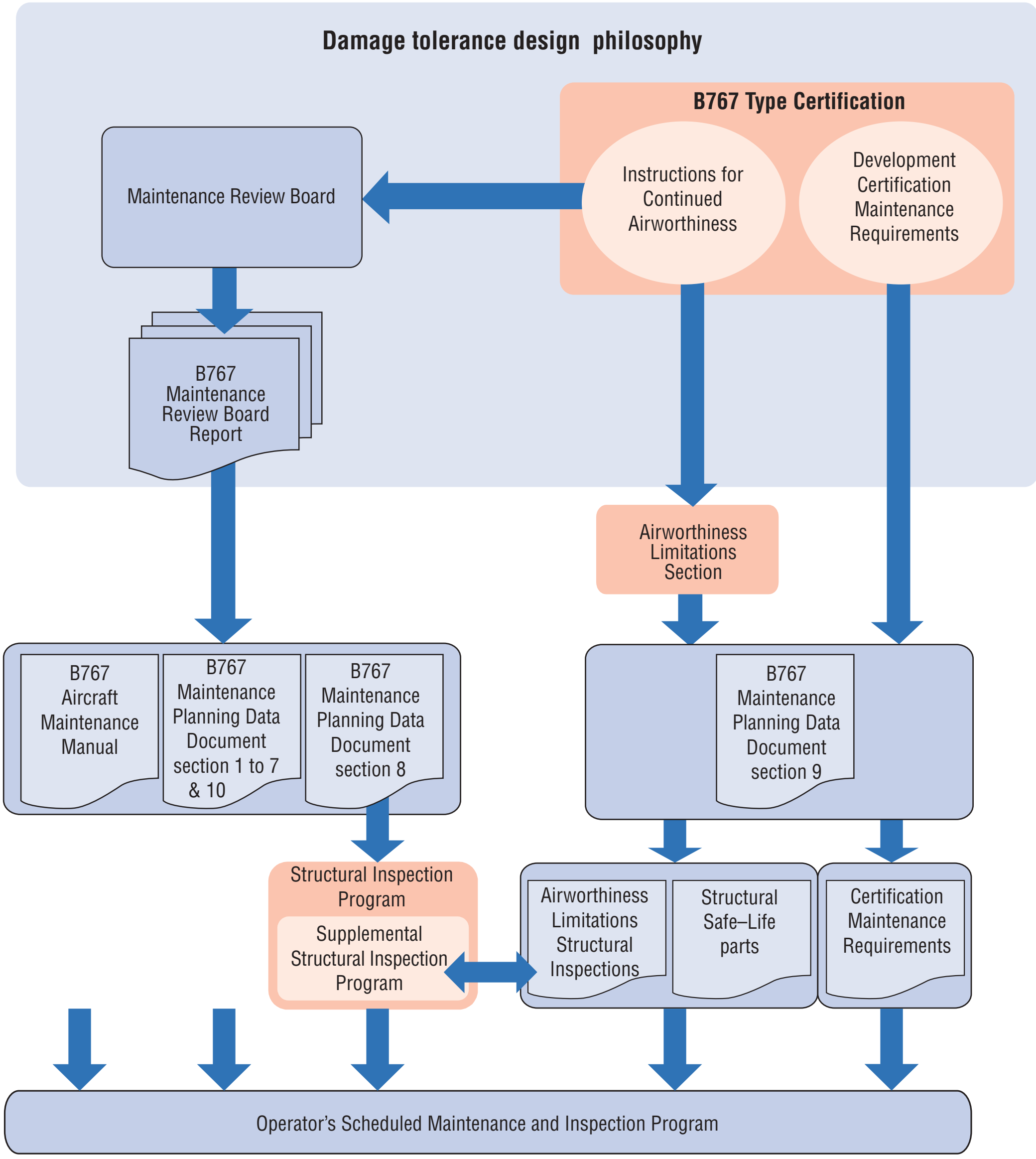
Section 9 of the *Maintenance Planning Data Document* contains the B767 Airworthiness Limitations and Certification Maintenance Requirements. The Airworthiness Limitations section contains mandatory replacement times for Structural Safe–Life parts and Airworthiness Limitations Structural Inspections. The Airworthiness Limitations Structural Inspections relate to those Structural Significant Items found not to have received adequate fatigue damage detection opportunity from the structural inspection program listed in section 8 of the *Maintenance Planning Data Document*. They are subject to change with additional testing, analysis or in-service experience.

Boeing submits section 9 of the *Maintenance Planning Data Document* to the FAA Aircraft Certification Office for approval because it contains mandatory requirements. After approval, the revised section 9 is normally incorporated into the next revision of the B767 *Maintenance Planning Data Document*. The revision date for section 9 is the date it was sent to the FAA for approval, and therefore it may differ from the revision date for the main *Maintenance Planning Data Document*.

The Supplemental Structural Inspection Program included in section 8 of the B767 *Maintenance Planning Data Document* is the Boeing suggested program to meet the mandatory Airworthiness Limitations Structural Inspection requirements outlined in section 9 of the *Maintenance Planning Data Document*. Alternatively, an operator may choose to develop their own program to meet the Airworthiness Limitations Structural Inspection requirements, rather than using the program provided Boeing. For example, an operator might find it convenient to do more frequent visual inspections rather than less frequent non-destructive testing inspections, or vice versa. However, Boeing is not aware of any B767 operator taking this course.

Figure 18 shows the interrelationship between the key B767 continuing airworthiness documents and terminology.

FIGURE 18:
Interrelationship between B767 continuing airworthiness documents



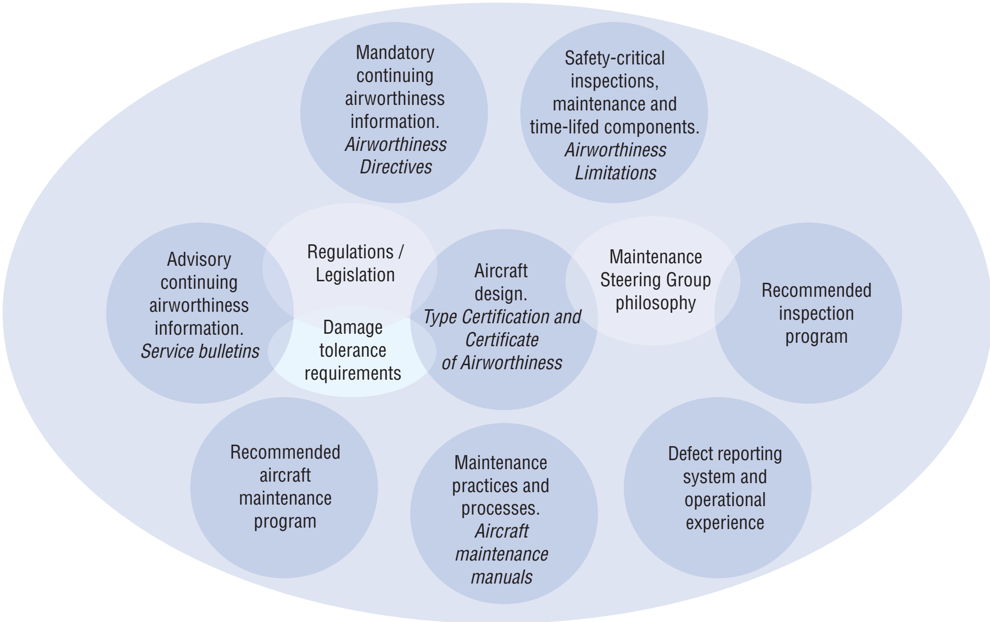
For each task in the B767 maintenance program, a corresponding Boeing maintenance task card is sent to operators. The task cards are intended to be used by the operator to develop their own job cards. The B767 *Maintenance Planning Data Document* states that:

> …every item in the MPD [*Maintenance Planning Data Document*] is covered by a task card.

4.3 Continuing airworthiness activities

The continuing airworthiness system for a damage tolerance aircraft type consists of a number of different elements, each of which is essential to the correct functioning of the system as a whole. The failure of any individual element can potentially lead to the failure of the overall system. Some of the principal components are shown in Figure 19.

FIGURE 19:
Principal components of the continuing airworthiness system



4.3.1 Service bulletins

Service bulletins are issued by the aircraft, component, or engine manufacturers to provide operators with information relevant to a particular aircraft type. Maintenance service bulletins may require action for inspection, repair, rework or modification of the aircraft. While some service bulletins address safety or airworthiness related problems, other service bulletins relate solely to operational or economic matters. A service bulletin may be prompted by problems identified through in-service experience or production, and may introduce product improvements or changes to operational requirements.

Manufacturers typically categorise service bulletins according to the degree of importance or urgency that they believe operators should give to the information provided. Most manufacturers use a three or four-tiered classification system with designators such as: Alert, Mandatory, Recommended, and Optional. However, there is very little standardisation in the way that manufacturers classify service bulletins.

The US Air Transport Association *iSpec 2200: Information Standards for Aviation Maintenance*[20] specification outlines the following three categories for service bulletins: Alert, Standard, and Engine Conversion.

Observation:

Because there is no authoritative standard for the categorisation of service bulletins, the terms that different aircraft and component manufacturers use to alert operators to the importance and urgency of service bulletins vary greatly. This has the potential to lead to confusion and misunderstanding of the relevance and importance of the information based on its categorisation.

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20 The Air Transport Association is the trade organization for the principal US airlines, with some non-US airlines as associate members. *iSpec 2200: Information Standards for Aviation Maintenance* is a specification for technical documentation in support of aircraft maintenance. It includes standards for numbering aircraft systems, and for documentation content and formatting.

Safety Recommendation R20020239

The Australian Transport Safety Bureau recommends that the International Civil Aviation Organization develop standards for the classification and format of service information issued by aircraft, engine, and component manufacturers.

Service bulletins issued by a manufacturer are advisory. Regardless of whether or not a manufacturer uses a term such as Alert or Mandatory to indicate that the bulletin contains safety-related information requiring urgent attention, compliance with the service bulletin is only mandatory in a legal sense if a State of Registry takes specific action to mandate it for aircraft on its register.

Boeing service bulletins are classified into three categories in order of urgency:

- Alert
- Unusually Significant
- Standard.

Alert service bulletins are issued for safety-related issues that require the immediate attention of the operator.

Unusually Significant service bulletins are issued for non-immediate safety matters or for non-safety items that have the potential for significant economic impact on operators. Boeing recommends that operators examine those service bulletins immediately.

Standard service bulletins are issued when an Alert or Unusually Significant service bulletin is not warranted.

Each Boeing service bulletin, including any subsequent revision, is classified by Boeing on an individual basis and can be up-graded or down-graded on its merit. Alert service bulletins are marked with ALERT written in the header of the service bulletin, and are printed on blue colour paper. In addition, a letter 'A' forms part of the service bulletin number (for example 767-57A0070). Subsequent amendments to the service bulletin that are not classified as alert are not marked with ALERT written in the header, but retain the letter 'A' in the number. Unusually Significant service bulletins are marked with SPECIAL ATTENTION in the header, and are printed on white paper. Standard service bulletins are printed on white paper.

Observation:

Revisions to Boeing Alert service bulletins that do not introduce new Alert material do not carry any of the distinguishing marks such as an ALERT banner or printing on blue paper. The retention of an 'A' in the service bulletin number is the only indication of the urgency of the original bulletin. If the revised service bulletin clearly indicated that a previous revision of the bulletin addressed Alert matters, then operators would be provided with an additional reminder of a safety-related issue.

The FAA Seattle Aircraft Certification Office approves either directly, or by designee, all Boeing service bulletins for aircraft produced in the Seattle area, including the B767.

4.3.2 Airworthiness directives

Airworthiness directives are issued by States to mandate safety-critical action by air operators with respect to a particular aircraft type, or certain aircraft within that type. They are designed to address an unsafe condition that exists, or could develop, in other aircraft of that type (see Appendix 11). Airworthiness directives essentially serve as required changes to a previously certificated type design.

An airworthiness directive describes the unsafe condition, the applicability of the directive, the required corrective action and/or operating limitations, and specifies by when compliance must be met. Airworthiness directives are one means by which a State of Design can meet its obligation to publish and exchange mandatory continued airworthiness information, in accordance with ICAO Annex 8, Part II, p. 4.2.2.

The State of Design sends airworthiness directives to those States that have declared the aircraft type to be on their register, and to other States on request. It is then the responsibility of each State to mandate the airworthiness directive, or to take appropriate action as they see fit. ICAO requires that airworthiness directives developed by a State of Registry also be sent to the State of Design (Annex 8, Part II, p. 4.2.4).

4.3.2.1 Airworthiness directive compliance thresholds and grace periods

Two types of analysis are typically necessary when determining compliance times for airworthiness directives: thresholds and grace periods.

A compliance threshold stipulates the time in service of the aircraft by which action should be taken to detect or prevent the unsafe condition. The threshold value is based on engineering analysis, and may be expressed in terms of flight cycles, flight hours, or calendar time or date, or any combination thereof.

Grace periods are included in some airworthiness directives to provide an allowance for aircraft, components, or engines that have already exceeded the threshold at the time the airworthiness directive is introduced. The intent of allowing a grace period is to avoid aircraft being grounded unnecessarily.

A range of factors is considered when determining an appropriate grace period. The degree of urgency of the unsafe condition is balanced against factors such as:

- the amount of time necessary to accomplish the required actions
- the availability of necessary replacement parts
- operators' regular maintenance schedules.

Appendix 12 contains an excerpt from the FAA *Airworthiness Directives Manual (1999)* that describes the determination of thresholds and grace periods. The CASA *Airworthiness Directives Procedures Manual (2000)* does not address this issue.

5 THE AUSTRALIAN AIRWORTHINESS SYSTEM

5.1 Components of the Australian airworthiness system

5.1.1 Class A aircraft

Aircraft such as the B767 are designated in Australia as Class A aircraft. Class A refers to an aircraft with a Certificate of Airworthiness issued in the transport category, or an aircraft which is used for regular public transport operations (Civil Aviation Regulations 1988, rr. 2(1), 2(2C), & 206(1)(c)). Examples of Australian aircraft with a Certificate of Airworthiness issued in the transport category are listed in Appendix 13. The maintenance required for Class A aircraft is more rigorous in its application and control than the maintenance required for other Australian civil aircraft.

5.1.2 Australian automatic type certification

Before 1990, the Civil Aviation Regulations made no provision for the issue of an Australian Type Certificate for aircraft manufactured outside Australia. The conclusion of the Australian acceptance process for a foreign manufactured aircraft type was indicated simply by the issue of the first Australian Certificate of Airworthiness.

In 1990, the concept of automatic type acceptance was introduced, whereby foreign manufactured aircraft that already had a Type Certificate from one of a small number of recognised countries[21] were automatically issued with a Certificate of Type Approval (Civil Aviation Regulations 1988, r. 22A).

This concept was maintained in further amendments to Australian civil aviation legislation in 1998. From 1 October 1998, a Type Acceptance Certificate (Civil Aviation Regulations 1998, r. 21.29A) was automatically issued for an aircraft type that had a current Type Certificate issued to it by a recognised country[22] (Civil Aviation Regulations 1998, r. 21.12). All Certificates of Type Approval issued under the 1988 regulations were allowed to continue under transitional regulations and were, for legal purposes, identical to Type Acceptance Certificates issued under 1998 regulations.

At the time of publication of this report, all the aircraft types over 5,700 kg MTOW[23] operating on the Australian civil register as Class A aircraft had a Type Certificate issued by one of the countries recognised by Australia[24].

5.1.3 Certificate of Airworthiness

A Certificate of Airworthiness for an aircraft that has an Australian Type Acceptance Certificate is issued to the Certificate of Registration holder when CASA, or a person

21 The recognised countries were Canada, France, the Netherlands, the UK, and the USA.

22 The recognised countries were those listed in footnote 21 with the addition of Germany and New Zealand.

23 Maximum certificated Take-Off Weight.

24 Aircraft manufactured in other than a recognised country, such as Sweden or Brazil, had obtained a Type Certificate from a recognised country, for example the USA.

authorised by CASA, is satisfied, in accordance with Civil Aviation Regulations 1998, r. 21.183 (3), that:

(a) the aircraft conforms to the type design; and

(b) any modifications or repairs to the aircraft have been carried out in accordance with approved maintenance data; and

(c) the aircraft is in a condition for safe operation.

Except in certain exceptional circumstances, an Australian registered aircraft is required to have a Certificate of Airworthiness before it can legally be operated.

5.1.4 Approved system of maintenance for Australian Class A aircraft.

Class A aircraft cannot be used in operations unless there is a CASA approved system of maintenance for the aircraft (Civil Aviation Regulations 1988, r. 39(2)(a)). In addition, an operator of a Class A aircraft must prepare a maintenance control manual that details the arrangements under which the approved maintenance program will be met (Civil Aviation Regulations 1988, r. 42ZY(1)(d)(iii)).

The Certificate of Registration holder of a Class A aircraft is responsible for developing a CASA approved system of maintenance that adequately provides for the continued airworthiness of that aircraft. When approving a system of maintenance for a Class A aircraft, CASA, or a person authorised by CASA, must have regard to the manufacturer’s maintenance schedule and any inspection programs or documents issued by the manufacturer (Civil Aviation Regulations 1988, r. 42M (3)). This is also the case when approving any changes to the system of maintenance (Civil Aviation Regulations 1988, r. 42R (3)).

5.2 Responsibilities within the Australian airworthiness system

A number of entities share responsibility for the maintenance system for Australian Class A aircraft:

- the Certificate of Registration holder
- the Air Operator Certificate holder[25]
- the Maintenance Controller
- the Certificate of Approval holder.

CASA, as the safety regulator, is responsible for ensuring that each of these entities carry out the functions required of them.

5.2.1 Responsibilities of the Certificate of Registration holder

A Certificate of Registration is issued by CASA for each individual aircraft. The Certificate of Registration holder is responsible for ensuring that the aircraft has an approved system of maintenance that is appropriate and not defective[26], and that maintenance is carried out on the aircraft when required. The Certificate of

25 In the context of this report, the operator will be the holder of an Air Operator Certificate. However, the operator of a private Class A aircraft would not necessarily be the holder of an Air Operator Certificate.

26 Civil Aviation Regulations 1988, r. 40, *Defective or inappropriate systems of maintenance.*

Registration holder must also ensure that obligations relating to the major defect reporting system are carried out.

The Certificate of Registration holder's obligations are not simply and readily identifiable in the Australian legislation, as the requirements can be found in many different parts of the Regulations (see Appendix 14).

5.2.2 Responsibilities of Air Operator Certificate holder

An Air Operator Certificate is issued by CASA to an operator to carry out a particular type of commercial operation including scheduled transport services, charter operations and aerial work (Civil Aviation Regulation 1988, r. 206 (1)).

Under Australian legislation, operators of Class A aircraft have a number of responsibilities intended to ensure safe operation of those aircraft. The *Civil Aviation Act 1988*, s. 28BF requires that operators must at all times maintain an appropriate organisation, with a sufficient number of appropriately qualified personnel and a sound and effective management structure, having regard to the nature of the operations (see Appendix 15). That obligation is further supported by the requirements in Civil Aviation Regulations 1988, r. 213, which requires that an operator:

> …shall provide an adequate organisation, including trained staff, together with workshop and other equipment and facilities in such quantities and at such places as CASA directs in order to ensure that airframes, engines, propellers, instruments, equipment and accessories are properly maintained at all times when they are in use.

The *Civil Aviation Act 1988*, s. 28BE requires operators to exercise a reasonable degree of care and diligence and specifically mentions possible failure due to:

- inadequate corporate management, control or supervision of the conduct of any of the body's directors, servants or agents; or
- failure to provide adequate systems for communicating relevant information to relevant people in the body.

An operator of a Class A aircraft is also responsible for ensuring compliance with the maintenance control manual, and that the functions of the maintenance controller are carried out properly (Civil Aviation Regulations 1988, r. 42ZY (2)).

5.2.3 Responsibilities of the Maintenance Controller

The Maintenance Controller is appointed by the operator of a Class A aircraft, and approved by CASA, to be responsible for the control of maintenance for that aircraft. Civil Aviation Advisory Publication[27] 42ZV-1(0), *Maintenance Control Manual*, lists the responsibilities of the maintenance controller as:

- the control of all maintenance, whether scheduled or unscheduled
- the development, organisation and supervision of all activities and procedures specified in the maintenance control manual
- the transfer of maintenance records to a new Certificate of Registration holder
- the investigation of all defects raised by the aircraft's maintenance organisation.

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27 Civil Aviation Advisory Publications (CAAPs) are published by CASA to provide guidance and information in a designated subject area, or to show a method acceptable for complying with a related Civil Aviation Regulation. CAAPs relate to the Civil Aviation Regulations 1988 and are advisory only. The Civil Aviation Regulations 1998 are supported by similar Advisory Circulars.

5.2.4 Responsibilities of the Certificate of Approval holder

CASA grants Certificates of Approval for specified aircraft maintenance tasks. The Certificate of Approval holder is responsible for ensuring that there are adequate facilities and equipment for the activities permitted in accordance with the certificate, that those activities are carried out in accordance with a system of quality control, and that employees receive appropriate and adequate training (Civil Aviation Regulations 1988, r. 30(2C)).

5.2.5 Summary of responsibilities within the Australian airworthiness system

The division of responsibilities within the maintenance system for Australian Class A aircraft is summarised in Figure 20. CASA is responsible for ensuring the safety regulation of the entities.

FIGURE 20:
Division of responsibilities within the Australian Class A aircraft maintenance system

Entity	Responsibility
Certificate of Registration holder	Specify system of maintenance
Air Operator Certificate holder/ Maintenance Controller	Control maintenance
Certificate of Approval holder	Perform maintenance

6 ANSETT AUSTRALIA

6.1 Ansett Boeing 767 aircraft

6.1.1 Introduction to service of Ansett Boeing 767-200 aircraft

Production design of the Boeing 767 began in 1978. The aircraft made its initial flight in September 1981 and the first Boeing 767 entered service with a US operator in September 1982. The B767 was the first US-designed transport aircraft certified to damage tolerance standards.

In March 1981, Ansett ordered five Boeing 767-200s, and the aircraft first entered service with Ansett in June 1983. Ansett was the sixth airline worldwide, and the first airline outside North America, to operate the B767. Four aircraft, VH-RMD, VH-RME, VH-RMF, and VH-RMG, entered service during 1983. VH-RMH followed in 1984. A further four B767-200 aircraft, VH-RMK, VH-RML, VH-RMM, VH-RMO, entered service with Ansett during 1995 and 1996. These aircraft were not new at the time, having first flown between 1983 and 1991 (see Table 1).

FIGURE 21:
Ansett B767 VH-RMG at Sydney Kingsford Smith Airport June 1984

Table 1:
Ansett Boeing 767-200 aircraft

Aircraft registration	*Model number*	*Engine type*	*Production line number*	*First flown*	*First registered in Australia*
VH-RMD	767-277	CF6-80	24	May 1983	June 1983
VH-RME	767-277	CF6-80	28	May 1983	June 1983
VH-RMF	767-277	CF6-80	32	June 1983	June 1983
VH-RMG	767-277	CF6-80	35	July 1983	August 1983
VH-RMH	767-277	CF6-80	100	August 1984	September 1984
VH-RMK	767-204	CF6-80-A2	79	January 1984	November 1994
VH-RML	767-204	CF6-80-A2	71	September 1983	November 1995
VH-RMM	767-216	CF6-80A	347	January 1991	March 1996
VH-RMO	767-204	CF6-80-A2	184	August 1987	May 1996

6.1.2 Certification basis for Ansett Boeing 767-200 aircraft

The five original Ansett B767 aircraft, VH-RMD/E/F/G/H, did not receive an Australian Type Certificate because they were introduced into Australia prior to 1990. Between 1990 and 1998, CASA issued a Certificate of Type Approval for each new type of aircraft accepted in Australia from one of a small number of recognised countries (see section 5.1.2). The USA, the State of Design and Manufacture of Boeing transport aircraft, was one of those countries. Ansett B767 aircraft VH-RMK and VH-RML received a (then) Civil Aviation Authority Certificate of Type Approval issued on 4 November 1992.

6.1.3 Maintenance requirements for Ansett B767 aircraft

An operator of Australian Class A aircraft is required to have a CASA approved system of maintenance that adequately provides for the continued airworthiness of the aircraft (see section 5.1.4). The framework under which the approved maintenance program is required to be met is documented in a maintenance control manual.

Under the Civil Aviation Regulations 1988, CASA has the power to issue delegations and authorisations to individuals to enable them to act in matters that would otherwise be performed by CASA. The use of delegations and authorisations can have a number of advantages (see section 7.1.1).

Certain senior staff of the Ansett engineering and maintenance organisation were authorised by CASA to both approve 'new' systems of maintenance, and to approve changes to existing systems of maintenance. That was in accordance with CASA's standard practice. Consequently, approval for the system of maintenance for the Ansett B767 aircraft was handled entirely within the Ansett organisation.

Under those arrangements, formal documentation for the approval of a new system of maintenance was held internally by Ansett. CASA involvement in the process was limited to any auditing of Ansett authorisation holders it might carry out to ensure that they were performing their functions adequately.

> **Observation:**
>
> The ability of an operator of a Class A aircraft to approve a new system of maintenance created a situation where there was no independent review of an important function related to continuing airworthiness.
>
> Direct CASA involvement in the approval process for new systems of maintenance for Class A aircraft would have provided an added opportunity for CASA to be involved in matters related to continuing airworthiness of Class A aircraft.

6.1.4 Ansett involvement in the Boeing 767 Maintenance Review Board

As an early operator of the B767, Ansett was involved in the development of the systems for the ongoing maintenance and continuing airworthiness of the aircraft type.

A member of staff from the Ansett Maintenance Development section, the B767 Maintenance Development engineer, was part of the steering group that created the *Maintenance Review Board Report* for the B767 in 1981/2. The staff member spent approximately a week each month at Boeing in the USA, and his input to the process was acknowledged by Boeing.

6.2 Boeing 767 *Maintenance Planning Data Document*

The B767 *Maintenance Planning Data Document* (Boeing Document D622T001) listed all Boeing recommended scheduled maintenance tasks for the B767 and formed the basis on which a B767 operator could develop its own scheduled maintenance program (see section 4.2.5.1).

6.2.1 Boeing 767 *Maintenance Planning Data Document* section 9

Sections 1 to 8 and 10 of the *Maintenance Planning Data Document* contained general B767 maintenance information, as well as information specific to lubrication, system maintenance, the zonal and structural inspection programs, and the corrosion prevention program (see section 4.2.5.1).

Section 9 of the *Maintenance Planning Data Document* set out items that were mandatory for compliance with the continuing airworthiness requirements for the B767. The Scope section (June 1997, page 9.0-9) of that document states:

> The scheduled maintenance requirements described in this section result from Model 767 airplane certification activities with the U.S. Federal Aviation Administration (FAA). Accordingly, this FAA approved Airworthiness Limitations and Certification Maintenance Requirements document is cross-referenced in the Model 767 Type Certificate Data Sheet . These maintenance actions are mandatory.

Section 9 carried a separate document number (Boeing Document D622T001-9) and unlike the remainder of the document, had to be approved by the FAA because it mandated maintenance requirements.

The cross-reference referred to in Section 9 of the *Maintenance Planning Data Document* was to Note 3 appended to the B767 Type Certificate Data Sheet (A1NM, revision 15, 1 August 1997). Note 3 stated:

> The FAA-approved Airworthiness Limitations Section (Section 9) of the Boeing Document D622T001-9 lists the required inspection thresholds for certain structural items, the retirement times for safe–life parts, and the Certification Maintenance Requirements. All Boeing Model 767 airplanes must fully comply with this section.

> However, regarding the damage tolerance structural inspections contained in Chapter (B) of this section, all Boeing 767s, production line number 669 and on, must comply with a particular revision of this section, namely Revision June 1997, or later FAA-approved revision. FAA intends to issue an Airworthiness Directive (AD) mandating compliance with the June 1997 Revision (or later FAA-approved revisions), applicable to all 767 aircraft with production line numbers lower than 669. In addition, all Boeing Model 767-300F (freighter) airplanes must also comply with the October 1995 Revision to Section 9 (or later FAA-approved revision), regardless of production line number.

Ansett B767-200 aircraft were below production line number 669 (see Table 1).

6.2.2 Revisions to the Boeing 767 *Maintenance Planning Data Document* section 9

Boeing issued revisions to the B767 *Maintenance Planning Data Document* on a four monthly cycle, concurrent with Aircraft Maintenance Manual amendments. However, most revisions related only to Sections 1-8, and not section 9.

Revisions to section 9 typically had a revision date two months earlier than the revision date of the overall *Maintenance Planning Data Document* in which they appeared. The reason for that was that amendments to section 9 had to be approved by the FAA. For example, the August 1997 *Maintenance Planning Data Document* revision contained a section 9 revision dated June 1997.

Each *Maintenance Planning Data Document* revision was distributed to operators by Boeing as a complete new document. Revisions included a ‘highlight of changes’ section at the front of the document and the actual changes were also indicated by a change bar beside the text in the body of the document. Staff of the Ansett Maintenance Development section reported that while theoretically all changes were shown, sometimes a change might appear only in the highlight section, or only in the main body of the document. Changes to the document were also reflected in changes to the Aircraft Maintenance Manual, and to changes in the task cards that detailed the work to be performed.

Revisions to the *Maintenance Planning Data Document* that included a revised section 9 were less frequent than the four-monthly cycle and, up to August 2001, were issued as follows: May 1990, February 1993, May 1995, October 1995, February 1996, June 1997, August 1997, and June 2000.

6.2.3 Cycle threshold for B767 *Maintenance Planning Data Document* section 9 Airworthiness Limitations Structural Inspections

The Airworthiness Limitations Structural Inspection program for the B767 was developed during the period from 1981 to 1997. Before June 1997, section 9 of the *Maintenance Planning Data Document* did not list inspection items with specific flight cycle thresholds. Boeing documentation (23 June 1997) explained:

> Currently section 9 of the MPD [*Maintenance Planning Data Document*] contains an example listing of 50-series MPD items considered to be airworthiness limitations with a commitment that this information will be revised upon a reassessment of the analytical data and service experience.

The Airworthiness Limitations Structural Inspection program for the B767 was initially released in the June 1997 *Maintenance Planning Data Document* section 9 revision. The initial program listed 164 inspection line items. However, many of those items were applicable to only some variants of the B767 aircraft, for example 300 series aircraft, ER (extended range), or freighter aircraft. Of the Airworthiness Limitations Structural Inspections relevant to passenger aircraft with less than 60,000 flight hours, approximately three quarters had a threshold of 50,000 flight cycles[28] (see Appendix 16). However, the remaining inspections had thresholds of either 40,000 cycles or 25,000 cycles. Eleven of the 25,000 cycle Airworthiness Limitations Structural Inspections (see Table 2) were potentially applicable to the Ansett B767 aircraft VH-RMD/E/F/G/H/K/L.

Table 2:
June 1997 *Maintenance Planning Data Document* revision Airworthiness Limitations Structural Inspections

Structural Significant Item Number	*Damage Tolerant Rating (DTR) check form title*	*Threshold (flight cycles)*
53-50-I13B	Fuselage rear spar bulkhead	25,000
53-50-I14C	Aft wheel well bulkhead STA 1065	25,000
53-80-I25	Horizontal stabilizer hinge pin and support structure	25,000
55-10-I13B	Horizontal stabilizer pivot fitting upper and lower attachments	25,000
55-10-I13C	Horizontal stabilizer pivot fitting upper and lower attachments	25,000
57-10-I16	Lower surface side-of-body splice	25,000
57-20-I15A	Outboard wing lower surface splice stringer	25,000
57-20-I15B	Outboard wing lower surface splice stringer	25,000
57-20-I15C	Outboard wing lower surface splice stringer	25,000
57-20-I16A	Rear spar lower chord and skin	25,000
57-20-I16D	Rear spar lower chord and skin	25,000

When the details of the B767 Airworthiness Limitations Structural Inspections were released in the June 1997 revision of the *Maintenance Planning Data Document* section 9, the Ansett Maintenance Development section was not aware that some inspections had been assigned thresholds of less than 50,000 cycles (see section 6.6.1).

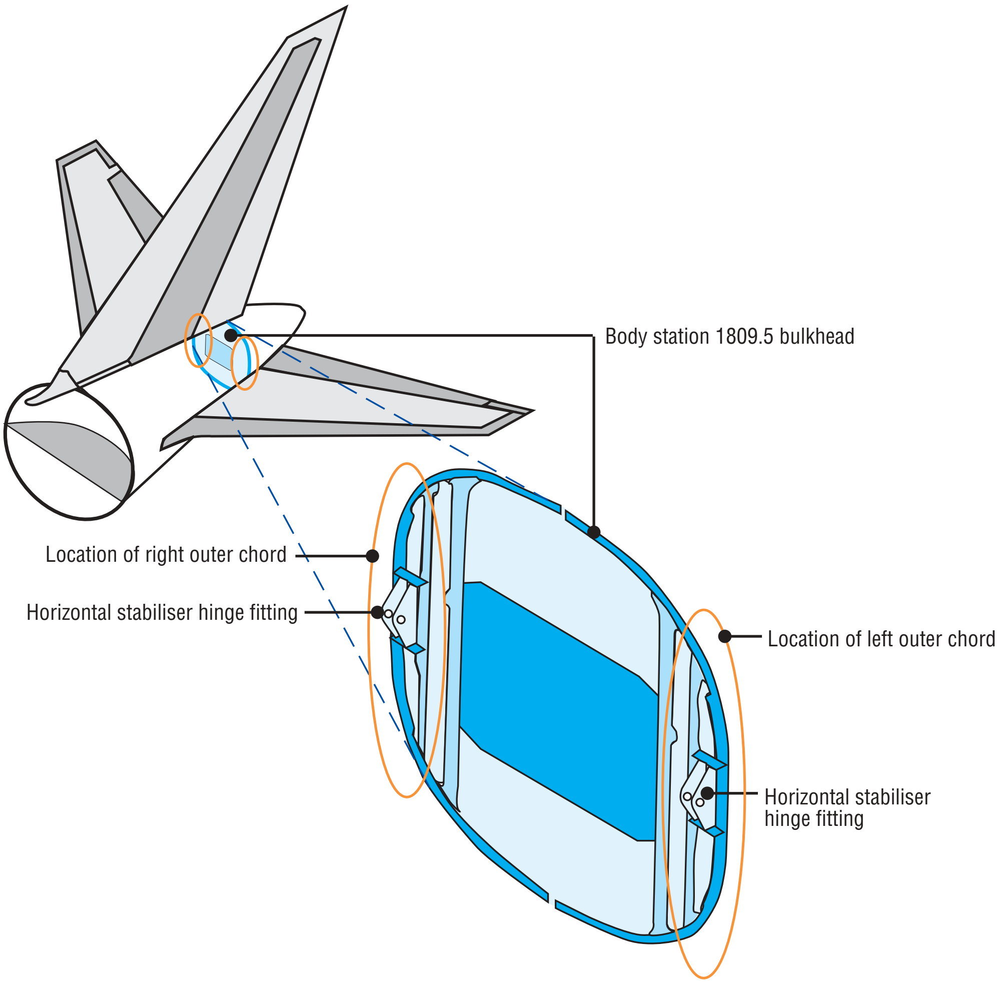
The June 2000 revision of the *Maintenance Planning Data Document* section 9 included three further Airworthiness Limitations Structural Inspections with thresholds of 25,000 cycles that were potentially applicable to the Ansett B767 aircraft VH-RMD/E/F/G/H/K/L (see Table 3). All three of those inspections related to the Body Station 1809.5 bulkhead outboard chord (see Figure 22).

28 A flight cycle is a completed take-off and landing sequence.

Table 3:
June 2000 *Maintenance Planning Data Document* revision additional Airworthiness Limitations Structural Inspections

Structural Significant Item Number	*Damage Tolerant Rating (DTR) check form title*	*Threshold (flight cycles)*
53-80-I15	Body Station 1809.5 bulkhead outboard chord	25,000
53-80-I16	Body Station 1809.5 bulkhead outboard chord	25,000
53-80-I17	Body Station 1809.5 bulkhead outboard chord	25,000

Figure 22:
Location of B767 Body Station 1809.5 bulkhead



6.3 B767 Body Station 1809.5 bulkhead outer chord fatigue cracks

The B767 was designed under the MSG–3 damage tolerance philosophy (see section 4.2.2.1), and therefore operators understood and expected that, over time, routine inspections would reveal that cracks had developed in the airframe during service.

In January 1996, a crack was found in the area of the Body Station 1809.5 bulkhead outer chord of Ansett B767 aircraft VH-RMG. During the period 1996 to 2000, cracks were found in the area of Body Station 1809.5 on other Ansett B767 aircraft (see Table 4).

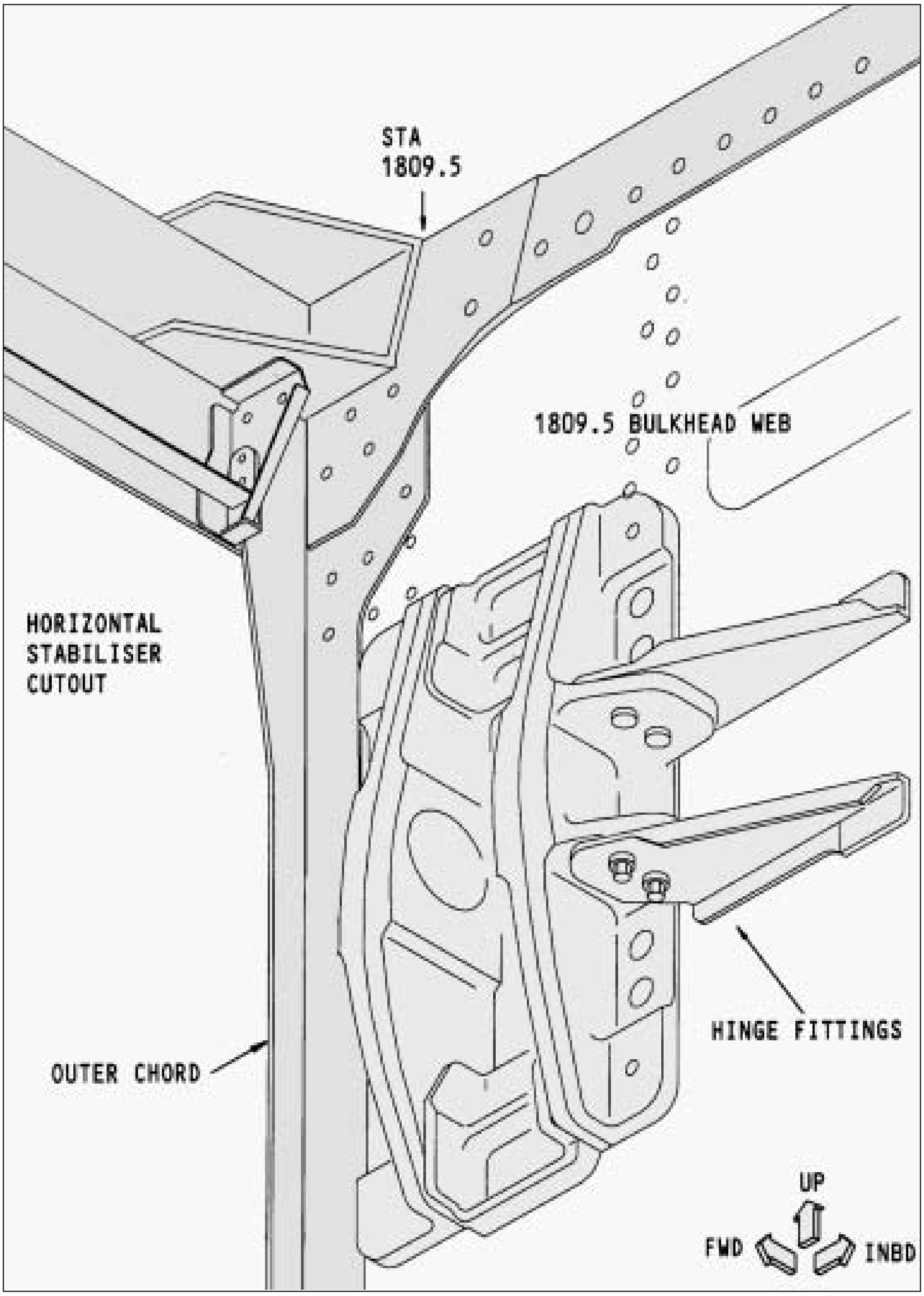
Table 4:
Ansett B767 aircraft with Body Station 1809.5 bulkhead outer chord fatigue cracks

Aircraft Registration	*Date*	*Flight hours*	*Flight cycles*	*Side*
VH-RMG	19 Jan 1996	33,113	23,934	right side
VH-RMD	20 Jan 1997	37,220	27,093	left side
VH-RMF	13 Feb 1998	39,746	29,185	both sides
VH-RMK	4 Nov 2000	57,296	28,447	both sides
VH-RMH	23 Dec 2000	48,373	34,086	right side

The Ansett aircraft had accumulated a high number of flight cycles because they were early production aircraft and had mostly flown comparatively short domestic sectors.

Other B767 operators reported similar Body Station 1809.5 bulkhead cracks to Boeing, and cracks were also found in that area on the B767 fatigue test aircraft. The cracks were in the outer chord of the bulkhead, just above the horizontal stabiliser hinge fitting (see Figure 23). Fatigue cracks occurred in this area because the horizontal stabiliser flight loads in the upper corner of the bulkhead were higher than allowed for during design.

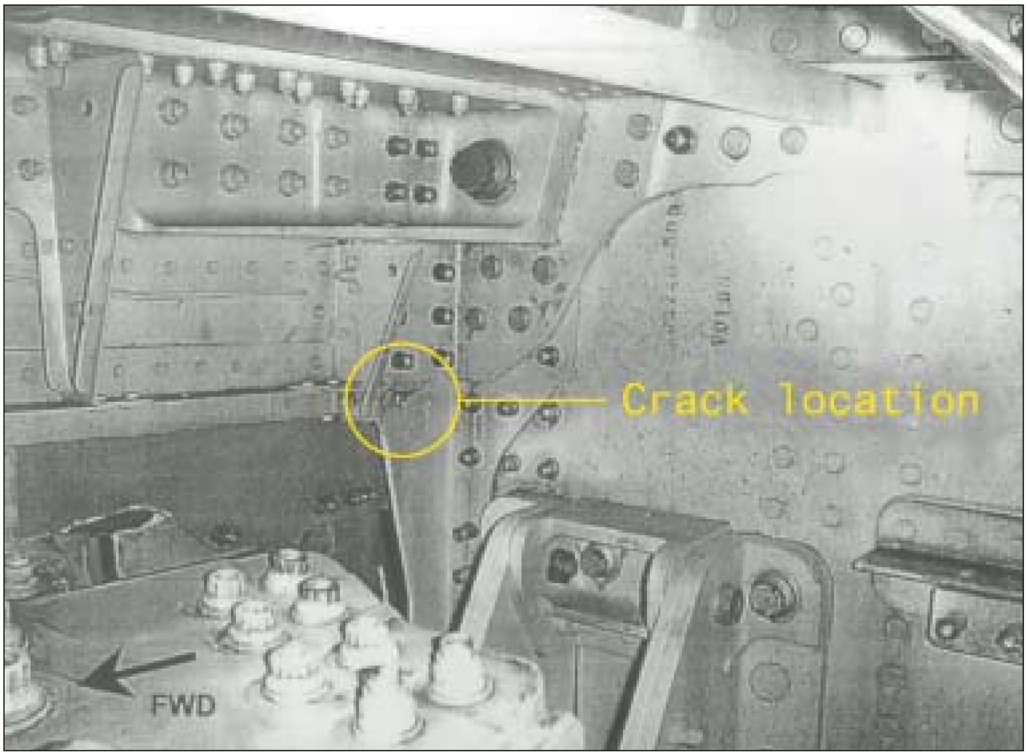
FIGURE 23:
Construction detail of B767 Body Station 1809.5 bulkhead area



Boeing analysis at the time indicated that if the fatigue cracks in the bulkhead chord were not found and repaired, then cracks could develop in the adjacent structure. Adjacent structure cracks could result in expensive repairs and unscheduled removal of the aircraft from service (see section 6.4.1).

The Body Station 1809.5 bulkhead area was a difficult area in which to work (Figure 24). Ansett structural engineers contacted Boeing for advice and a repair scheme was subsequently devised and implemented. Ansett submitted major defect reports to CASA concerning the cracks identified in VH-RMG on 19 January 1996 and VH-RMD on 20 January 1997.

FIGURE 24:
Fatigue crack in an Ansett B767 Body Station 1809.5 bulkhead outer chord



Ansett did not submit further major defect reports on subsequent Body Station 1809.5 bulkhead defects as it was of the opinion that CASA had already been alerted to the problem with the initial reports (see section 7.7).

The design of the B767 Body Station 1809.5 bulkhead outer chord was changed after aircraft production line number 710, to improve durability.

Observations:

- The manner in which fatigue cracks in the Body Station 1809.5 bulkhead outer chord of B767 aircraft were initially found by Ansett and other operators, and reported to Boeing, was in accordance with the design philosophy for damage tolerant aircraft.
- It was reasonable to expect that the Ansett B767 aircraft would be among the first in the world fleet to show evidence of cracking in the Body Station 1809.5 area as the Ansett aircraft had accumulated a relatively high number of flight cycles.
- An incorrect understanding of the requirements of the major defect reporting system by Ansett reduced the potential for safety-related information to be disseminated to other bodies within the continuing airworthiness system.

6.4 B767 Body Station 1809.5 bulkhead outer chord service documents

During the period from 1998 to 2001, Boeing issued information about fatigue cracking in the area of the Body Station 1809.5 bulkhead outer chord to all operators of B767 aircraft. That information was contained in a service bulletin and also a revision to the B767 *Maintenance Planning Data Document* section 9, that listed Airworthiness Limitations Structural Inspection items.

6.4.1 Boeing service bulletin related to Body Station 1809.5 bulkhead outer chord fatigue cracks

On 15 October 1998, Boeing issued Service Bulletin number 767-53-0078, titled *Fuselage – Section 48 – Body Station 1809.5 Bulkhead Outer Chord Inspections, Repair, and Modification*. The service bulletin described cracks in the Body Station 1809.5 bulkhead outer chord area involving six B767 aircraft from four different operators in the world fleet (see Table 5). One of the aircraft from which the data were derived was Ansett B767 VH-RMG. The service bulletin contained instructions applicable to inspection intervals, inspection methods, repair, and modification, of that part of the B767 structure.

Table 5:
Service history of B767 aircraft with Body Station 1809.5 bulkhead outer chord fatigue cracks (October 1998)

Model	*Flight hours*	*Flight cycles*	*Crack length Left side*	*Crack length Right side*
-200	18,412	18,016	no crack found	0.4 inch
-300	13,494	8,823	no crack found	2.8 inch
-200	33,045	23,886	no crack found	more than 2.5 inch
-200	29,033	27,952	1.8 inch	no crack found
-300	16,229	14,754	no crack found	2 inch
-300	15,680	12,601	0.5 inch	2 inch

Service Bulletin 767-53-0078 logic diagram stated:

> Start to do the inspections at or before the last to occur of:
>
> 10,000 total flight-cycles, or
>
> 3,000 flight-cycles after you get this service bulletin, or
>
> 18 months after you get this service bulletin.

Ansett was one of the first operators to find and report fatigue cracks in the Body Station 1809.5 bulkhead area, and had worked with Boeing to devise and implement a repair scheme. Ansett did not action the service bulletin as it considered that the matter was under control, and compliance with the requirements of the service bulletin was not mandatory.

On 9 September 1999, Boeing issued a revision to Service Bulletin 767-53-0078 that added instructions for visual and surface high frequency eddy current inspections of the aft outer chord at Body Station 1809.5. Ansett did not recognise that the service bulletin revision added further inspection instructions and the service bulletin revision was not actioned. Staff in the Ansett Technical Services department reported that their workload was very high at the time (see section 6.13.3).

6.4.1.1 Reclassification of Boeing Service Bulletin 767-53-0078

The initial release of Boeing Service Bulletin 767-53-0078 on 15 October 1998, and subsequent revisions issued on 9 September 1999 and 19 April 2001, were Boeing Standard service bulletins, not Alert or Unusually Significant service bulletins (see section 4.3.1). Initially, neither the FAA nor CASA issued airworthiness directives to mandate compliance with the bulletins in their respective jurisdictions.

Prior to November 2001, information from Boeing indicated that the primary reason for the service bulletin was to detect and repair damage that, if left unchecked, could result in the need for further expensive repairs. That is, the reason given was primarily commercial, rather than safety.

The Background section of the October 1998 Service Bulletin 767-53-0078 explained the need for action in the following terms:

> Fatigue cracks in the STA [station] 1809.5 bulkhead chord that are not found can cause cracks in adjacent structure. Adjacent structure cracks could result in expensive repairs and unscheduled removal of the airplane from revenue service.

A Boeing communication to Ansett dated 17 January 2001, stated:

> Previous analysis has shown that there is sufficient residual strength to justify an economic based Service Bulletin.

However, as further information became available, the FAA, CASA, and Boeing upgraded the status of their response, as outlined below.

A FAA communication to Ansett on 12 January 2001 stated in part:

> …the 1809.5 bulkhead structure is a 'multiple load path' structure in an unpressurized area of the fuselage, and can be analytically shown to withstand all limit load conditions with the forward outer chord completely severed. (There are no reports to date that the outer chord has ever been severed.)
>
> Nevertheless, …considering that the outer chord has now been added to the MPD [*Maintenance Planning Data*] Airworthiness Limitations Section, we are re-evaluating whether SB 767-53-0078 should be made the subject of separate AD [airworthiness directive] action.

On 27 April 2001, the FAA issued Airworthiness Directive 2001-09-13 that mandated compliance with revision 2 of Boeing Service Bulletin 767-53-0078 for US registered B767 aircraft, effective from 24 May 2001. The FAA airworthiness directive set out the following requirements for initial inspections:

> Prior to the accumulation of 8,000 total flight cycles, or within 90 days after the effective date of this AD, whichever occurs later, perform detailed visual, surface high frequency eddy current (HFEC), and low frequency eddy current (LFEC) inspections, as applicable, for cracking of the forward and aft outer chord, aft mid chord, and upper and lower intercostals of the Station 1809.5 bulkhead.

On 15 November 2001, Boeing issued revision 3 of Service Bulletin 767-53-0078, and upgraded the service bulletin to Alert status with the revised number 767-53A0078. The reclassification of the service bulletin indicated that it addressed a safety-related matter requiring the immediate attention of the operator. The Background section of the revised service bulletin stated:

> Fatigue cracks in the STA [station] 1809.5 bulkhead chord that are not found can cause cracks in adjacent structure. Adjacent structure cracks could result in the inability of the 1809.5 bulkhead structure to carry horizontal stabilizer flight loads.

On 5 December 2001, CASA issued Airworthiness Directive AD/B767/146 that mandated Boeing Service Bulletin 767-53-0078, revision 2 or 3, for Australian registered B767 aircraft, effective from 27 December 2001. The CASA airworthiness directive stated in part:

> The FAA received reports that fatigue cracking of the horizontal stabiliser pivot bulkhead has been found on several Model 767-200, -300, and -300F series aircraft. Analysis indicates that these fatigue cracks occur because the flight loads on the horizontal stabiliser in the upper corner of the Station 1809.5 bulkhead are higher than expected. Undetected fatigue cracking in this area could result in loss of the horizontal stabiliser.

Observation:

Over a period of three years, from 1998 to 2001, the emphasis of the required inspection and repair of the B767 Body Station 1809.5 bulkhead outer chord changed from the commercial avoidance of costly repairs of adjacent structure to ensuring that fatigue cracking of adjacent structure did not result in a major loss of structural integrity.

6.4.2 B767 *Maintenance Planning Data Document* revision related to Body Station 1809.5 bulkhead outer chord fatigue cracks

The August 2000 revision to the B767 *Maintenance Planning Data Document* contained a revised section 9 (dated June 2000) that included three items related to the Body Station 1809.5 bulkhead outer chord, each with a 25,000 cycle threshold (see Table 3). However, the Boeing task cards outlining the method by which the inspections should be carried out were not issued until April 2001. Normal practice would be for the task cards to be made available concurrently with the *Maintenance Planning Data Document* revision. This would have permitted operators to perform the work without delay if necessary.

Observation:

The availability of maintenance task cards concurrent with the issue of the *Maintenance Planning Data Document* may have provided Ansett engineering and maintenance with an improved understanding and awareness of the maintenance requirement.

FIGURE 25:
Ansett B767 VH-RME at Melbourne Tullamarine Airport March 1995

6.5 Release of the B767 Airworthiness Limitations Structural Inspection program

The *Maintenance Planning Data Document* is one of the primary means by which Boeing disseminates information relating to the continuing airworthiness of B767 aircraft. In particular, section 9 of the *Maintenance Planning Data Document* lists mandatory items of three types; Airworthiness Limitations Structural Inspections, Structural Safe–Life parts and Certification Maintenance Requirements.

Prior to June 1997, section 9 of the *Maintenance Planning Data Document* did not list Airworthiness Limitations Structural Inspections with specific flight cycle thresholds. This was in accordance with the principle and practice of the MSG–3 philosophy, where fatigue and corrosion information from operational experience were important factors in setting specific flight cycle thresholds. Boeing correspondence (23 June 1997) provided a status report on the development of this work. The status report stated in part:

> A draft of section 9 of the MPD [*Maintenance Planning Data Document*] is being forwarded to the FAA and once signed will be provided to all operators as a temporary revision to the MPD. It is anticipated that Notice of Proposed Rule Making [NPRM] to mandate the inspection requirements of section 9 will follow the release of section 9.... The intent is that all operators will have this information ... in a timely manner such that informed comment on the NPRM may be made.

The FAA Notice of Proposed Rule Making (see section 8.2.1) concerned a proposed airworthiness directive mandating compliance with the June 1997 *Maintenance Planning Data Document* section 9 revision for all B767 aircraft with production line numbers lower than 670. These included the Ansett B767-200 aircraft VH-RMD/E/F/G/H/K/L/M/O. However, the airworthiness directive proposed a 'grace period' (see section 4.3.2.1) of up to three years for operators of aircraft that were approaching, or had already passed, the flight cycle thresholds for the inspections.

Because of delays in the FAA Notice of Proposed Rule Making process, it was not until 19 April 2001 that the FAA issued the relevant Airworthiness Directive (FAA AD 2001-08-28), effective from 1 June 2001. By that time CASA had already issued a specific directive to Ansett that mandated the inspections for the Ansett B767 aircraft. A similar directive was not issued to other Australian operators of B767 aircraft at the time.

The FAA airworthiness directive to mandate the B767 Airworthiness Limitations Structural Inspections was the first of its type and involved numerous policy issues which had to be resolved to pave the way for future such airworthiness directives (see section 8.2).

6.6 Ansett handing of revised B767 Airworthiness Limitations Structural Inspections

6.6.1 Ansett handling of B767 *Maintenance Planning Data Document* section 9, June 1997 revision

The August 1997 revision of the *Maintenance Planning Data Document* included a revised section 9 (dated June 1997) that introduced individual thresholds for the Airworthiness Limitations Structural Inspections for the first time. The document was sent from Boeing to Ansett by mail and received a date-stamp indicating that it was processed by the Ansett library in October 1997.

When the August 1997 *Maintenance Planning Data Document* revision was issued, four Ansett B767 aircraft had already exceeded the 25,000 flight-cycle limit for some of the inspections.

It was not the intention of the FAA or Boeing that aircraft already over the 25,000 cycle threshold would be subject to any immediate sanction. That was in accordance with the usual practice of allowing a grace period for older or higher cycle aircraft to conform to new requirements.

Whether the four Ansett B767 aircraft that had already flown more than 25,000 cycles were, from that time on, non-compliant with a mandatory requirement under Australian law was a matter of interpretation (see section 7.2.1).

The processing of *Maintenance Planning Data Document* revisions in Ansett was primarily the responsibility of the Ansett Maintenance Development section. After receipt by the Ansett library, the August 1997 *Maintenance Planning Data Document* revision was sent to the Maintenance Development section and passed to the Maintenance Development Engineer responsible for B767 maintenance development work. Although it was usual practice for such documents to be marked with the names of staff to whom the document would be circulated, it was not done in this case.

The Maintenance Development Manager and the B767 Maintenance Development Engineer were aware that the Airworthiness Limitations Structural Inspection program for the B767 had been released. However, they were unaware that, contrary to their expectation, some of the Airworthiness Limitations Structural Inspections had been introduced with thresholds of less than 50,000 cycles.

In November 1999, there was further discussion within the Maintenance Development section in relation to the B767 Airworthiness Limitations Structural Inspection program, and the Maintenance Development Manager asked the B767 Maintenance Development Engineer to review the work and to discuss it with him. It was reported that the pressure of work in the Maintenance Development section at the time was high (see section 6.13.3) and the Maintenance Development Engineer did not review the work for some time.

In February 2000, the B767 Maintenance Development Engineer discussed the work with the Maintenance Development Manager. The Manager reported that this was the first time that he was aware of the significance of the 25,000 cycle items. Between February and April 2000, meetings were held between staff of the Maintenance Development section and the Technical Services department. The staff determined that the inspections were mandatory and had been missed. It was decided that the inspections would be carried out at the next scheduled check. A structures engineer from the Ansett Technical Services department was given a file of information relating to the inspections in order to develop an appropriate work program.

The structures engineer noted that there were no directions from Boeing as to how the work program was to be managed for aircraft that were already over the threshold number of flight cycles at the time the program was released. The structures engineer contacted Boeing for information.

On 7 June 2000, a telex was sent from Ansett to Boeing in Seattle, through the Melbourne Boeing Field Service Representative. The correspondence said in part:

> With regard to the 25,000 cycle inspection threshold on several SSI [Structural Significant Item] tasks, Ansett have several aircraft beyond that threshold. The implementation instructions [in the B767 *Maintenance Planning Data Document*] would indicate that Ansett are already out of compliance... Ansett intention is to introduce the necessary inspections into its maintenance program in time for the next check layup appropriate to that specific inspection...
>
> Ansett requests that Boeing confirm the proposal is acceptable... They ask for a Boeing contact/telephone number and a time for a call... Ansett asks for a reply by 11 July 2000.

The reply to Ansett from Boeing in Seattle, through the Melbourne Boeing representative, was dated 12 July 2000 and read in part:

> Per DER [Designated Engineering Representative], we confirm that the ANS [Ansett] proposal is a reasonable approach to achieving conformance to the SSIP [Supplemental Structural Inspection Program] for their airplane fleet. However, we are not authorized by the FAA to approve deviations to the SSIP as described in the MPD. We recommend that ANS request approval from their regulatory agency to deviate from the SSIP as they have described.

Boeing also provided the names and contact details of three Boeing engineers in Seattle for further contact, as requested by Ansett.

The Ansett structures engineer in Technical Services reported that he did not make further contact with the Boeing engineers because of the high workload that he was under. Also, it was his belief that the matter was primarily the responsibility of the Ansett Maintenance Development section.

The Maintenance Development section was unaware that the structures engineer had contacted Boeing in relation to the Airworthiness Limitations Structural Inspections. The Maintenance Development section did not contact Boeing.

The Maintenance Development Manager and the B767 Maintenance Development Engineer reported that they later spoke to the structures engineer about the work. However, there was no formal record of the communication and coordination between the Maintenance Development section and the Technical Services department. In general, there was no formal procedure for recording and monitoring workflow between the two work areas (see section 6.13.2).

The Maintenance Development section was not aware that the Technical Services department had not proceeded with preparation for the B767 Airworthiness Limitations Structural Inspection program. Staff in both the Maintenance Development section and the Technical Services department reported that their workload was very high and that they were under-resourced in both equipment and manpower (see section 6.13.3).

Ansett Maintenance Development staff reported that they did not feel that Ansett was overly at risk, as they expected that there would be a grace period for Ansett to comply with the inspection requirements (see section 6.9.3). Staff indicated that they were waiting for information and direction from Boeing or the FAA on a time frame for the inspections. Allowing a grace period would have been consistent with similar previous programs for the B747 Supplemental Structural Inspection Program and the Corrosion Prevention and Control Program.

Maintenance Development section staff took no action to verify their assumption that a grace period would be allowed for the completion of the Airworthiness Limitations Structural Inspections on high-cycle B767 aircraft.

6.6.2 Ansett handling of B767 *Maintenance Planning Data Document* section 9, June 2000 revision

When the August 2000 revision of the B767 *Maintenance Planning Data Document* (section 9 revision date June 2000) was released, section 9 included three Airworthiness Limitations Structural Inspection items related to the Body Station 1809.5 bulkhead outer chord, each with a 25,000 cycle threshold. Ansett received the August 2000 revision of the *Maintenance Planning Data Document* in September 2000.

The Ansett B767 Maintenance Development Engineer was not aware of the *Maintenance Planning Data Document* Body Station 1809.5 Airworthiness Limitations Structural Inspections. It is possible that the engineer was relying on the issue of Boeing tasks cards related to particular work items to bring the introduction of new tasks to his attention. Task cards for the Body Station 1809.5 work were not provided by Boeing until the April 2001 *Maintenance Planning Data Document* revision.

In early December 2000, a Ansett structures engineer visited IBM in the USA for work related to the testing of the new TIMS information management system that IBM was developing with Ansett (see section 6.13.2.2). As a result of working with the B767 *Maintenance Planning Data Document*, he was reinforced in his view that certain inspections had been missed. On return to Ansett late in December 2000, he discussed the issue with the Maintenance Development Manager who confirmed that the inspections had not been incorporated into the B767 maintenance program. The file related to that work could not be found.

6.7 Withdrawal from service of Ansett B767 aircraft on 23 December 2000

On the evening of 21 December 2000, staff from the Ansett Technical Services department and the Quality Assurance section discussed the potential *Maintenance Planning Data Document* section 9 compliance problem. A meeting was convened for 10 am on 22 December 2000, where it was confirmed that there were 14 Airworthiness

Limitations Structural Inspection items from the *Maintenance Planning Data Document* section 9 June 1997 and June 2000 revisions that had been overlooked. It was believed that the inspections were mandatory under the Australian system of airworthiness compliance. The 14 Airworthiness Limitations Structural Inspections had flight cycle thresholds of 25,000 flight cycles. At the time, seven Ansett B767 aircraft had exceeded that limit (see Table 6).

Table 6:
Ansett B767 aircraft VH-RMD/E/F/G/H/K/L flight hours and cycles as of 22 December 2000

Aircraft Registration	*Flight hours*	*Flight cycles*
VH-RMD	49,309	35,504
VH-RME	49,530	35,301
VH-RMF	49,233	35,447
VH-RMG	48,241	34,569
VH-RMH	48,373	34,078
VH-RMK	57,327	28,466
VH-RML	58,894	27,690

Ansett notified CASA of the situation at about midday on 22 December 2000. CASA was told that Ansett had missed the inspections in two *Maintenance Planning Data Document* section 9 revisions that involved airworthiness limitation items. Ansett requested a variation to the system of maintenance under Civil Aviation Regulations 1988, r. 42ZS, *Granting of exemptions and approval of variations*. CASA rejected the proposal as it considered that it was in effect a request for a temporary exemption from the inspection requirement. CASA asked that more information be obtained, including a response from Boeing.

A meeting was held between Ansett and CASA at 8 pm on 22 December 2000. It was agreed that the affected aircraft should be grounded before the first flight the next morning unless Ansett was able to gain Boeing approval to extend the time allowed for the inspections.

Ansett sent an urgent AOG (Aircraft on Ground) fax to Boeing with a proposal that the inspections be carried out at the next heavy maintenance C check. Ansett asked Boeing to:

> …review the proposed implementation of the SSIP [Supplemental Structural Inspection Program] inspections, and provide a 'No Technical Objection' to support Ansett's proposal of the program to CASA.

Specialist Boeing staff who could access the required engineering data had to be recalled and no immediate response was received from Boeing. As there were uncertainties about the continuing airworthiness status of the aircraft, Ansett withdrew six B767 aircraft VH-RME/F/G/H/K/L from service with effect from 23 December 2000. One other aircraft, VH-RMD, was also affected, but the aircraft was undergoing heavy maintenance at the time and was not in service.

Discussions between Ansett and CASA were based on an agreed understanding that the missed inspections were mandatory (see section 6.9.2) and the negotiations in relation to the return to service of the B767 aircraft were based on that assumption. The negotiations between Ansett and CASA did not involve legal issues, but centred on how the affected aircraft could be inspected without delay and returned to service.

On 23 December, Boeing replied to Ansett recommending that:

> ...all of the required visual and NDI [non-destructive inspection] inspections at 25,000 cycles be performed on airplanes [VH-RMD] and [VH-RME] at this time with the exception of the [three Body Station 1809.5 items] which need to be accomplished within the next 12 months.

Boeing considered that if no defects were found in VH-RMD and VH-RME then there could be a high level of confidence that VH-RMF, VH-RMG and VH-RMH could be returned to service and then inspected within the next 500 cycles (approximately two months). CASA chose to impose more stringent conditions, requiring the inspections to be undertaken after every 80 flights and all the aircraft to be returned to a normal inspection schedule within 90 days.

6.8 Return to service of Ansett B767 aircraft

Meetings between Ansett and CASA continued throughout the day of 23 December 2000. It was agreed that the two aircraft with the lowest number of flight cycles (VH-RMK and VH-RML) be released back into service with a plan that involved visual inspections. As the necessary non-destructive testing tooling had not been developed, the procedure employed was to inspect for secondary damage as an indication of underlying primary damage. If no secondary damage was found, then the aircraft could remain in service. However, if the inspections revealed cracks on an aircraft, then the interim arrangements would cease and the aircraft would be required to complete the normal Boeing inspection program before further flight.

On 25 December 2000, VH-RMF and VH-RMG were also returned to service. VH-RME followed on 28 December 2000.

On 29 December 2000, CASA issued a Direction[29] for Ansett to verify that all B767 Airworthiness Limitations Structural Inspections and Certification Maintenance Requirements were being achieved, and that systems were in place to ensure the integrity of those processes in the future. CASA also issued a Direction which mandated Boeing Service Bulletin 767-53-0078 (*Body Station 1809.5 Bulkhead Outer Chord Inspection, Repair, and Modification*) for Ansett B767 aircraft. That action was intended to remove any doubt that individual aircraft were not permitted to fly until the inspections and repairs required by Service Bulletin 767-53-0078 had been incorporated. Ansett B767 aircraft VH-RMM and VH-RMO were also affected by the direction. No cracks were found during the inspections of those aircraft.

CASA was satisfied that as a result of the inspection program that was carried out, the structural integrity of Ansett's aircraft never fell below international regulatory standards.

29 Civil Aviation Regulations 1988, r. 38, *Maintenance directions*. (1) "CASA may give directions relating to the maintenance of Australian aircraft for the purpose of ensuring the safety of air navigation".

During January 2001, Ansett received further communication from Boeing in reply to questions it had raised in relation to VH-RMD/E/F/G/H/K/L. In commenting on the situation in which some Ansett B767 aircraft had already exceeded the 25,000 cycle threshold, Boeing on 7 January 2001 stated in part:

> The NPRM [Notice of Proposed Rule Making] indicates a grace period of 3 years will provide operators of airplanes that are approaching or have already reached the 25,000 cycle inspection threshold with a reasonable amount of time to plan and perform the inspections. Some operators in this situation have approached Boeing for guidance and our recommendation has been to schedule the threshold inspections at the next major visit.

On 11 January 2001, the ATSB commenced an investigation into the circumstances surrounding the omission by Ansett to carry out the B767 inspections, as the situation was regarded as indicative of a potential safety deficiency.

On 18 January 2001, non-destructive testing revealed cracks in VH-RMH and VH-RMG and as a consequence all aircraft that had not completed the normal Boeing inspections were required to do so before returning to service. Temporary repairs had to be carried out as there was no guidance material available from Boeing.

The FAA did not issue the Airworthiness Directive (AD 2001-08-28) mandating the B767 Airworthiness Limitations Structural Inspections for aircraft with production line numbers 1–669 inclusive, as contained in section 9 of the June 1997 *Maintenance Planning Data Document* revision, until 19 April 2001 (see section 8.2.1). CASA issued a corresponding airworthiness directive, AD/B767/145 on 5 December 2001 (see section 7.2.4).

FIGURE 26:
Ansett B767 VH-RML at Melbourne Tullamarine Airport August 2001

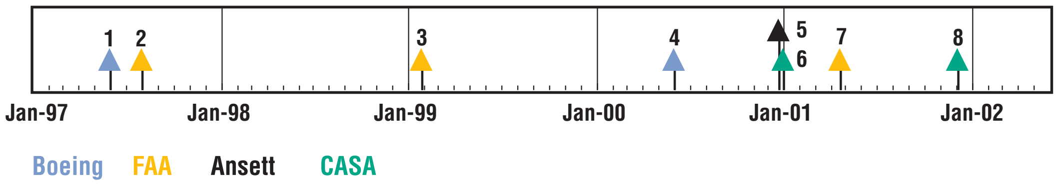
6.9 Issues related to Ansett B767 Airworthiness Limitations Structural Inspections

6.9.1 Sequence of events related to B767 *Maintenance Planning Data Document* section 9 revisions

Ansett B767 aircraft were withdrawn from service in December 2000 because it was realised that two revisions of section 9 of the *Maintenance Planning Data Document*, June 1997 and June 2000, had not been incorporated into the system of maintenance for Ansett B767 aircraft. As a result, certain Airworthiness Limitations Structural Inspections had not been carried out in accordance with Boeing's prescribed schedule.

Figure 27 outlines the time sequence of events related to the issuing of the relevant revisions to section 9 of the B767 *Maintenance Planning Data Document*, and in particular actions taken by Boeing (▲), the FAA (▲), Ansett (▲), and CASA (▲).

FIGURE 27:
B767 *Maintenance Planning Data Document* section 9 revisions sequence of events



	Entity	Date	Action
1	Boeing	June 1997	B767 *Maintenance Planning Data Document* June 1997 section 9 revision
2	FAA	1 August 1997	B767 Type Certificate Data Sheet revision 15 issued - Note 3 foreshadows airworthiness directive to mandate B767 *Maintenance Planning Data Document* June 1997 section 9 revision
3	FAA	28 January 1999	Notice of Proposed Rule Making issued for Airworthiness Directive 2001-08-28
4	Boeing	June 2000	B767 *Maintenance Planning Data Document* June 2000 section 9 revision
5	Ansett	23 December 2000	Ansett B767 aircraft withdrawn from service
6	CASA	29 December 2000	CAR 38 (1988) Direction issued to Ansett to mandate B767 *Maintenance Planning Data Document* June 2000 section 9 revision
7	FAA	19 April 2001	Airworthiness Directive 2001-08-28 mandating B767 *Maintenance Planning Data Document* June 1997 section 9 revision issued
8	CASA	5 December 2001	Airworthiness Directive AD/B767/145 mandating B767 *Maintenance Planning Data Document* June 2000 section 9 revision issued

Observation:

The B767 Airworthiness Limitations Structural Inspections, outlined in section 9 of the B767 *Maintenance Planning Data Document*, were a significant element of the damage tolerance design of the B767 aircraft type.

The sequence of events following the June 1997 and June 2000 revisions to section 9 of the B767 *Maintenance Planning Data Document* indicate that there was a breakdown in the system for processing the B767 Airworthiness Limitations Structural Inspection program within Ansett, the FAA, and CASA.

6.9.2 Compliance aspects of the B767 Airworthiness Limitations Structural Inspections

Prior to December 2000, there was a general belief both within Ansett and CASA that compliance with the B767 Airworthiness Limitations Structural Inspections for Australian registered aircraft was mandatory. It is likely that this belief was based principally on the knowledge that the inspections formed part of the Airworthiness Limitations section of the B767 Instructions for Continued Airworthiness (see section 4.2.3), as set out in section 9 of the *Maintenance Planning Data Document*.

The preface to section 9 of the B767 *Maintenance Planning Data Document* noted that the maintenance requirements described in the section were the result of certification activities with the FAA, and that the requirements were therefore mandatory. However, compliance by B767 operators outside the USA would have only become mandatory when the relevant State of Registry took the necessary legal action to mandate the requirements for aircraft on its register.

It was most likely that a general awareness of intent, rather than a detailed knowledge of the legal basis under Australian legislation, led to the belief that when released, the B767 Airworthiness Limitations Structural Inspections were a legal requirement for Australian operators.

Ansett senior staff were of the opinion that the inspections were an essential part of the system for ensuring the continuing airworthiness of the aircraft and that they were mandatory in terms of Ansett policy and procedures.

Discussions between Ansett and CASA in the days immediately after 22 December 2000 were based on an agreed understanding that the missed inspections were mandatory, as noted in a record of meeting between Ansett and CASA dated 28 December 2000.

However, when the events of December 2000 focussed attention on the Airworthiness Limitations Structural Inspections it became apparent to CASA and Ansett that the legal situation was far from clear (see section 7.2.1). Preliminary CASA legal advice outlined in the CASA interim report, *Review of Ansett Maintenance Control*, dated 31 January 2001, indicated that none of the possible regulatory mechanisms mandated compliance with the inspections with any certainty.

Observations:

In December 2000, both Ansett and CASA were of the belief that compliance with the B767 Airworthiness Limitations Structural Inspections, when released, was mandatory. Subsequent legal advice indicated that the regulatory basis for mandating compliance with the inspections was unclear.

6.9.3 Lack of a grace period for compliance

A number of senior Ansett staff in both Maintenance Development and Technical Services expressed a view that when the B767 Airworthiness Limitations Structural Inspection program was introduced, it was expected that a grace period would be allowed for the work to be completed on aircraft that had already flown more flight cycles than specified for the initial inspection threshold. They reported that the expectation of a grace period contributed significantly to the lack of a timely response by Ansett.

Grace periods were an important part of other similar programs such as the Corrosion Prevention and Control Program and the B747 Supplemental Structural Inspection Program. In these cases, when the programs were introduced for Australian operators, CASA typically issued an airworthiness directive that required operators to comply within a certain time period.

A grace period of three years was proposed for the introduction of the B767 Airworthiness Limitations Structural Inspections in the FAA Notice of Proposed Rule Making, 97-NM-276-AD, issued 28 January 1999:

> This proposed AD allows operators up to three years after the effective date of this AD to accomplish the ALI [Airworthiness Limitations Instructions] revision required by this AD. This period provides operators of airplanes that are approaching or have already reached the 25,000-flight-cycle inspection threshold with a reasonable amount of time to plan and perform the inspections. The FAA notes that only a few PSE's [Principal Structural Elements] in the ALI [Airworthiness Limitations Instructions] have an initial inspection threshold of 25,000 total flight cycles. The majority of PSE's in the ALI have an initial inspection threshold that corresponds to the design service objective of the affected airplane (i.e., 50,000 total flight cycles for passenger airplanes). In addition, the Model 767 Structures Working Group, whose membership is composed of many of the major operators worldwide and almost all U.S. operators, has been aware of the specific contents and requirements of this ALI revision since August 1996. These facts have led the FAA to determine that three years is an appropriate and reasonable grace period for operators to perform the earliest PSE inspections.

One of the respondents to the Notice of Proposed Rule Making argued for a four year grace period. In support of their argument they referred to a Boeing communication in relation to the B767 Airworthiness Limitations Structural Inspections, dated 16 October 1997, that stated in part:

> Our [Boeing's] discussions with the FAA indicate a five year implementation frame is provided for operators with airplanes exceeding the 25,000 flight cycle threshold. The beginning of the five year implementation period is expected to begin in mid 1998, with the release of an airworthiness directive mandating the program.

Communication from Boeing to Ansett dated 7 July 2000 again reiterated that the FAA Notice of Proposed Rule Making indicated that a grace period of three years would provide operators of aircraft that were approaching or had already reached the 25,000 cycle inspection threshold with a reasonable amount of time to plan and perform the inspections. Boeing went on to state:

> Some operators in this situation have approached Boeing for guidance and our recommendation has been to schedule the threshold inspections at the next major visit.

Observations:

- It was common practice for operators to be allowed a grace period when new structural inspections were introduced. In the case of Ansett, this had occurred with programs such as the Corrosion Prevention and Control Program and the B747 Supplemental Structural Inspection Program.
- Boeing and the FAA intended that a three year grace period would be allowed for operators to comply with the requirements of the B767 Airworthiness Limitations Structural Inspection program.
- The assumption by Ansett staff that a grace period would be allowed for compliance with the B767 Airworthiness Limitations Structural Inspection program was reasonable in the circumstances.

6.9.4 '50-series' name

Ansett Maintenance Development staff reported that their belief that the flight cycle threshold for the B767 Airworthiness Limitations Structural Inspections would be 50,000 cycles stemmed in part from the term '50-series' to refer to the B767 Supplemental Structural Inspection Program. None of the Ansett B767 aircraft had reached a threshold of 50,000 cycles.

The '50-series' Supplemental Structural Inspection Program, outlined in section 8 of the B767 *Maintenance Planning Data Document*, provided a Boeing developed inspection program that operators could follow to comply with the Airworthiness Limitations Structural Inspections contained in section 9.

The term '50-series' was widely used in Boeing documentation and communications. However, the term did not refer to an inspection threshold of 50,000 cycles. It referred to the last two digits of the Supplemental Structural Inspection item number – a series sequence number between 50 and 99 that identified the specific task (see Appendix 17). For example, for item number 5350-143-50E, the '-50' identified the task as a Supplemental Structural Inspection Program item. It did not refer to the cycle threshold for that inspection.

Observation:

Staff in the Ansett Maintenance Development section reported that they believed the term '50 series' used in some Boeing documentation indicated that the B767 Airworthiness Limitations Structural Inspections would be introduced with 50,000 flight cycle thresholds. However, section 9 of the B767 Maintenance Planning Data document clearly indicated that a number of items had been assigned thresholds of less than 50,000 cycles (see Appendix 16). This indicated a poor general understanding of certain essential Boeing documentation for the inspection and maintenance of B767 aircraft by some Ansett staff.

6.9.5 Ansett quality assurance

The activities of the Ansett Quality Assurance section did not uncover any of the systemic deficiencies within the Ansett engineering and maintenance organisation that contributed, in large part, to the withdrawal from service of B767 aircraft in December 2000 and April 2001.

Since 1997, there had been no specific quality assurance audit activities in relation to the processing of maintenance planning data.

There was evidence that the Ansett Quality Assurance section operated more in the way of quality control, rather than quality assurance (see Appendix 18 for a comparison of quality control and quality assurance). It was doubtful whether specific audits with a narrow focus would have uncovered the systemic problems that existed within the engineering and maintenance organisation.

The Ansett Quality assurance audit process was dependent on the experience of the individuals carrying out the audit. However, in many cases audit staff did not have adequate professional engineering background or support to enable them to adequately conduct auditing of the maintenance and engineering area.

As a result of the events of December 2000, management within the Ansett engineering and maintenance organisation became aware of the deficiencies within the Ansett quality assurance system. Work was begun early in 2001 to rectify the situation, including the appointment of new staff with specific quality assurance skills and experience, and additional training for existing staff. The full process was planned to take 12 to 18 months to complete.

Observation:

The Ansett Quality Assurance section was not able to alert Ansett management to the problems that existed within the engineering and maintenance organisation.

6.9.6 Ansett and ANNZES[30] investigations in relation to missed B767 Airworthiness Limitations Structural Inspections

Internal investigations were carried out by both Ansett and ANNZES into the issues associated with the missed B767 Airworthiness Limitations Structural Inspections. Both reports were made available to CASA.

The Ansett report, dated 29 January 2001, listed three recommendations related to:

- the delineation of responsibility for the control of airworthiness documentation between Ansett and ANNZES
- the introduction of a periodic Certification Maintenance Review process for Ansett aircraft
- the development of appropriate communication protocols between Ansett and Boeing and other manufacturers.

The ANNZES report, dated 25 January 2001, listed nine recommendations, mainly in three areas:

- review of the relevant areas within Ansett and ANNZES, and the relationship between them
- review of the quality assurance systems
- staff training associated with the missed inspections and related matters.

30 ANNZES - Ansett Australia and Air New Zealand Engineering Services - was, for some of the period relevant to this report, responsible for some aspects of the Ansett engineering and maintenance function. The formation and development of ANNZES and its relationship to Ansett Australia is outlined in section 6.13.1.

The ANNZES report also listed a number of general findings:

> This Inquiry found that the primary or root cause for the failure to have conducted the required SSIs [Supplemental Structures Inspections] was human error.
>
> - Engineering Planning personnel were found to have received the subject MPD [Maintenance Planning Data Document] revisions, however erroneously assumed that the inspection threshold was 50,000 cycles, instead of the actual 25,000-cycle limit.
>
> This Inquiry also made a number secondary findings relating to this failure, including:
>
> - The existing provisions of the documented Quality Management System applicable to the Engineering Planning functions do not provide adequate checks and balances in the event of personnel failure (as occurred in this case).
> - The Quality Assurance Audit program failed to identify the failure.
> - A lack of effective communications between Engineering Planning and Technical Services personnel was found to have existed.

Observation:

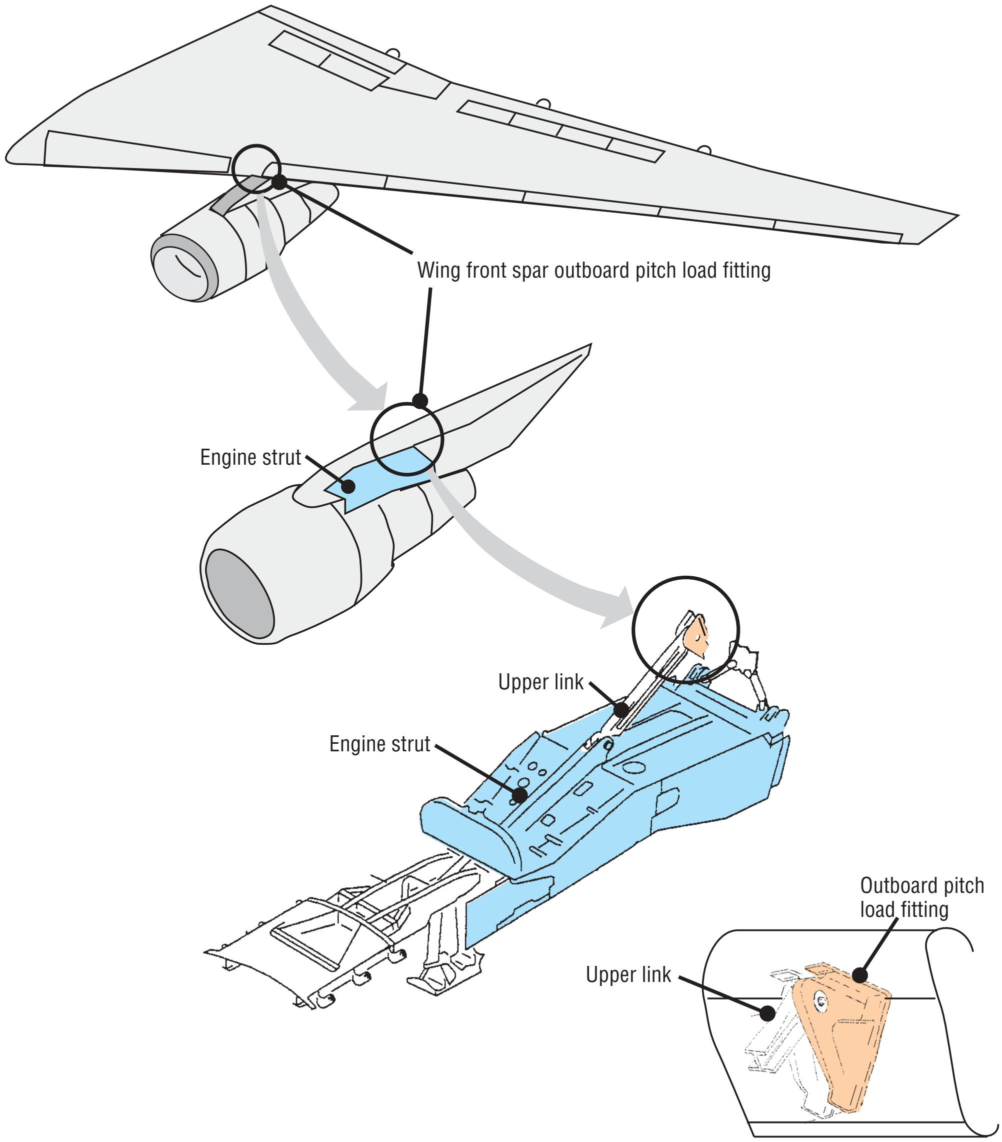
If human error on the part of one or two individuals can go unchecked within an organisation and result in a significant breakdown of the workings of the system, then the failure is a system error and not a human error.

The finding by ANNZES that the primary cause for the failure to conduct the required Airworthiness Limitations Structural Inspections was human error had the potential to focus remedial action on an individual, or individuals, rather than on the underlying systemic problems.

6.10 B767 wing front spar outboard pitch load fitting service bulletin

On 2 March 2000, Boeing issued an Alert Service Bulletin (767-57A0070) to detect and repair cracks in the wing front spar outboard pitch load fitting for the engine mounting strut on B767 aircraft (see Figure 28). The service bulletin was applicable to all aircraft with production line numbers 1–101 inclusive and was based on seven reports that Boeing had received of cracked wing front spar outboard pitch load fittings on B767 aircraft in the world fleet. The youngest aircraft with detected cracks had accumulated 8,826 hours and 3,862 flight cycles, and the oldest aircraft with detected cracks had accumulated 54,502 hours and 26,684 cycles.

FIGURE 28:
Location of B767 wing front spar outboard pitch load fitting

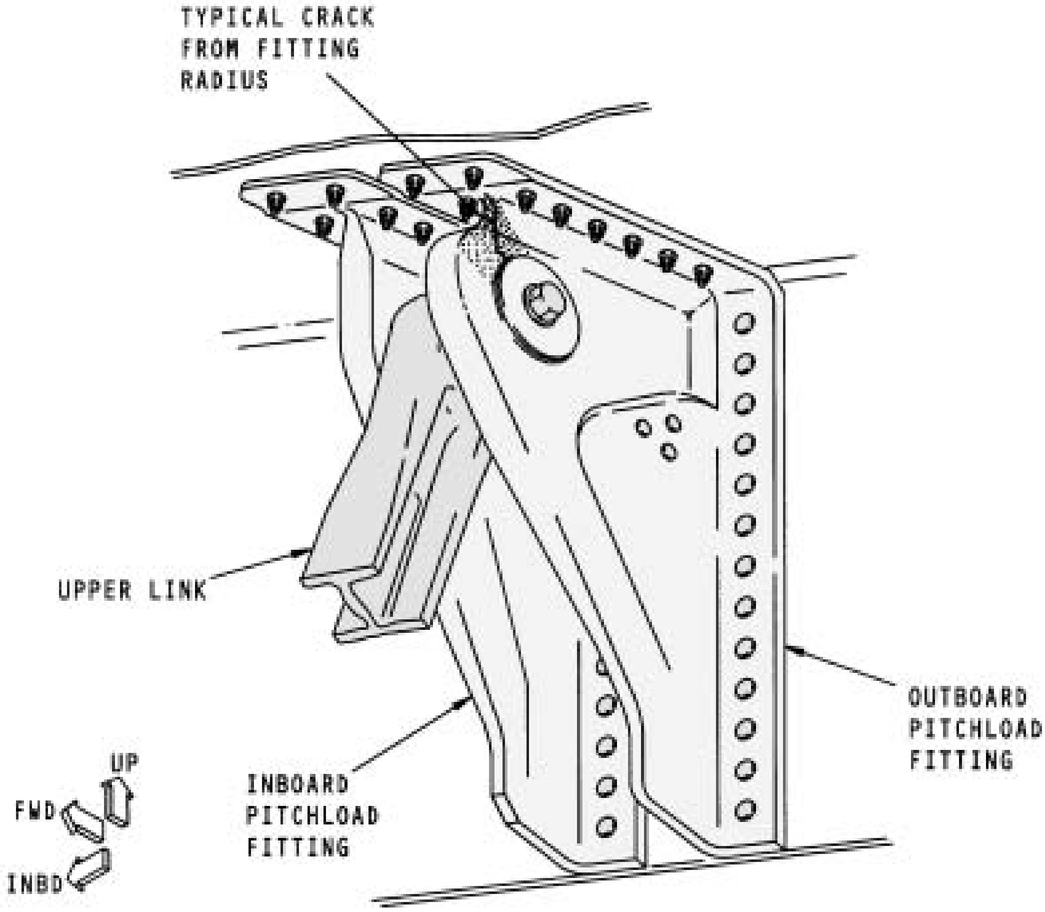


The wing front spar outboard pitch load fitting was part of the upper link load path between the engine and the wing. Cracks in the wing front spar pitch load fitting could have caused possible loss of the upper link load path and separation of the strut and engine from the wing.

The service bulletin provided instructions for the inspection of the outboard pitch load fittings for cracks and instructions for replacement of the fitting. The replacement fittings incorporated an improved radius and lug detail designed to discourage the formation of cracks (see Figure 29).

The service bulletin recommended that the work be carried out within 180 calendar days after receipt of the bulletin. If no cracks were found then it was recommended that the inspection be repeated after every 18 months or 3,000 flight cycles, whichever came first. The terminating action for the service bulletin, whether cracks were found or not, was to carry out the fitting replacement as detailed in the service bulletin.

FIGURE 29:
Construction detail of the B767 wing front spar outboard pitch load fitting



As a Boeing Alert service bulletin that provided data with the potential to affect flight safety, the initial issue of Service Bulletin 767-57A0070 was printed on blue paper with an ALERT banner on the front page (see section 4.3.1). As a manufacturer-issued document, compliance with the service bulletin was not mandatory, in a legal sense, for Ansett B767 aircraft.

A revision to Service Bulletin 767-57A0070 dated 16 November 2000 did not significantly change the intent or method of the service bulletin. As the revision did not add any further information with the potential to affect flight safety, beyond that contained in the initial release of the service bulletin, the revision was not classified as Alert. Therefore it did not carry any of the Alert distinguishing marks included on the initial release, except for retaining the 'A' in the service bulletin number.

6.11 Ansett action on B767 wing front spar outboard pitch load fitting service bulletin

Ansett conducted investigations following the withdrawal from service of Ansett B767 aircraft on 23 December 2000 (see section 6.9.6). In March 2001, Ansett determined that Boeing Service Bulletin 767-57A0070, issued 2 March 2000, for the inspection of the wing front spar outboard pitch load fitting had not been actioned within the recommended 180 days.

The service bulletin had been assigned to the B767 Structures Engineer in the B767 configuration group. The engineer had developed an engineering release[31] for the work and forwarded it to the B767 Configuration Group Team Leader. The engineering release was later returned to the B767 Structures Engineer for further work. However, the engineering release was subsequently overlooked, and no further action was taken on the service bulletin. The structures engineer believed that he overlooked the returned engineering release and service bulletin due to a very high workload.

The B767 Structures Engineer was a senior member of the B767 Configuration Group, and worked largely without direct supervision. The B767 Configuration Group Team Leader routinely checked the work of other less experienced group members. The team leader and the structures engineer were aware that a number of service bulletins had not been actioned. The team leader reported that he was very overworked at the time (see section 6.13.3) and hence Service Bulletin 767-57A0070 had been missed.

The B767 Structures Engineer was not aware that the wing front spar outboard pitch load fitting service bulletin was an Alert service bulletin. The original issue (2 March 2000) of the service bulletin was clearly marked ALERT near the top of the first page in bold letters framed by thick horizontal bars. However, following normal Boeing practice, later revisions did not contain any reference to the Alert status of the original bulletin, beyond the inclusion of the letter 'A' in the service bulletin number. The deletion of the ALERT banner was also not noted in the revision change list, nor highlighted by a change bar.

Although the paperwork for the wing front spar outboard pitch load fitting engineering release had been returned to the B767 Structures Engineer, there was no procedure to record that transfer in the Ansett computerised document control system. Hence the status of the service bulletin was not reflected in the list of documents assigned to the structures engineer.

Observation:

The document control system and workflow procedures within the Ansett Technical Services department were deficient. The system did not provide a means to ensure that the processing of all service documentation was tracked and monitored at all times. Therefore it was difficult for relevant Ansett staff and management to be aware of the action status of all service bulletins applicable to the B767 fleet.

When Ansett realised that the service bulletin had been missed, a decision was made to action it as soon as possible. To ensure that there was no further delay, the B767 Structures Engineer immediately hand delivered the engineering release to the necessary staff for approval.

The Technical Services Manager and the B767 Structures Engineer contacted Boeing for advice as to what course of action Ansett should take. As a result, it was determined that there was not an approved alternative load path for the structure. Ansett and Boeing subsequently agreed that the work should be completed by 30 April 2001.

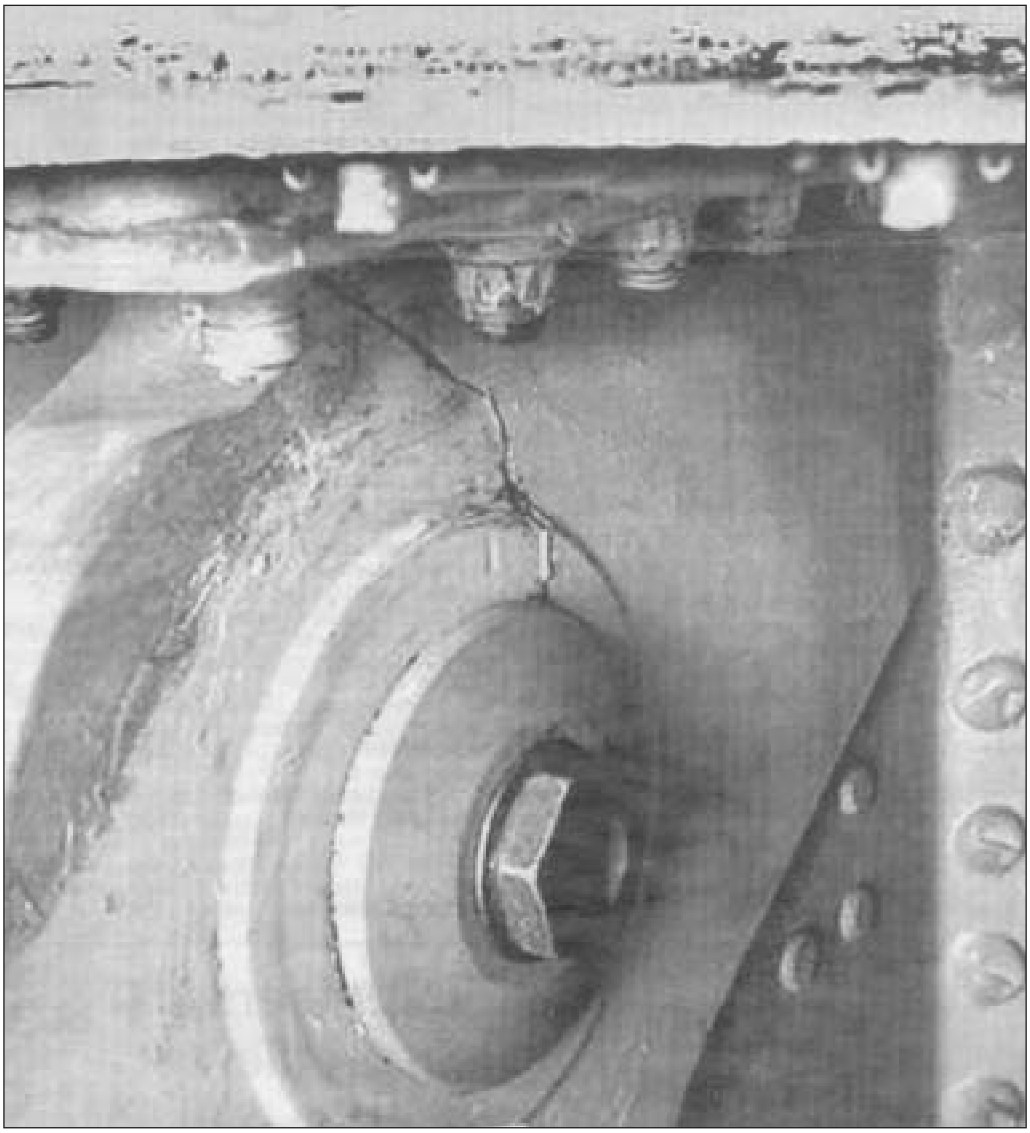
The Structures Engineer reported that there was a major imperative to keep the aircraft in the air as it was just before Easter, a very busy time for the airline.

During the period 7–9 April 2001, inspection of Ansett B767-200 aircraft revealed cracks in the wing front spar outboard pitch load fittings of three aircraft (see Figure

31 An 'engineering release' was an Ansett document used to authorise the planning and implementation of work on an aircraft or component.

30). As a consequence, Ansett withdrew those aircraft from service. On 9 April 2001, CASA grounded the four remaining Ansett B767-200 aircraft with production line numbers 1–101 inclusive (see Table 1), pending inspection. Those inspections were subsequently carried out, and the aircraft were cleared to fly.

FIGURE 30:
Fatigue crack in an Ansett B767 wing front spar outboard pitch load fitting



On 10 April 2001, the ATSB investigation was extended to include an examination of procedures for the control of the continuing airworthiness of Class A aircraft such as the Ansett B767s. Also on that day, CASA issued Airworthiness Directive AD/B767/135, requiring all Australian registered B767 aircraft production line numbers 1–101 inclusive to be inspected in accordance with Boeing Service Bulletin 767-57A0070 before further flight.

On 12 April 2001, the ATSB issued two safety recommendations to CASA concerning aspects of the systems for maintaining the continuing airworthiness of Australian Class A aircraft (see sections 7.2.5 and 7.3.3).

On 18 April 2001, the FAA issued AD 2001-08-23 mandating Boeing SB 767-57A0070 for USA registered B767 aircraft, effective from 14 May 2001.

6.12 Suspension of Certificates of Airworthiness of Ansett Boeing 767 aircraft

On 12 April 2001, the CASA Director of Aviation Safety suspended the Certificates of Airworthiness of the ten B767 aircraft operated by Ansett, with effect from 10 pm that evening. The aircraft affected were B767-200 aircraft VH-RMD/E/F/G/H/K/L/M/O and the B767-300 aircraft VH-BZF.

The CASA Director stated that the suspension of the B767 Certificates of Airworthiness was necessary in the interest of aviation safety, citing a number of issues including a report of an Ansett B767 aircraft operating for eight flights with the door escape-slides not armed. The suspensions were to remain in force for each aircraft until CASA was satisfied that all relevant inspections, tests and maintenance had been conducted, and the aircraft were fit to fly.

The suspensions were carried out under the powers in Civil Aviation Regulations 1998, r. 21.181 (5), which provided that:

> (5) CASA or an authorised person may suspend or cancel a certificate of airworthiness for an aircraft that is being used in regular public transport operations, by written notice given to its holder, if:
>
> (a) any maintenance is not carried out in accordance with Part IVA of CAR 1988; or
>
> (b) the aircraft type ceases to be supported by the type certificate holder, the NAA[32] of the country in which the aircraft's original type certificate was issued or the NAA of a Contracting State, with respect to:
>
> (i) collecting and investigating information on defects; or
>
> (ii) reporting defects to the NAA of the country of original type certification; or
>
> (iii) keeping type records; or
>
> (iv) producing and maintaining manuals; or
>
> (v) issuing instructions for continuing airworthiness; or
>
> (c) CASA or the authorised person otherwise considers that it is necessary to do so in the interests of aviation safety.

On 12 April 2001, CASA issued a press release stating that it intended to issue Ansett with a notice, on 20 April 2001, giving the airline 14 days to 'show cause' why its approval to operate should not be withdrawn. CASA stated that the notice would be based on a pattern of ongoing structural, management and personnel problems.

On 17 April 2001, Ansett submitted the final documents necessary for CASA to inspect the Ansett B767 aircraft as a prerequisite for restoration of the aircraft's Certificates of Airworthiness. CASA began inspection of the aircraft on 18 April 2001 (Figure 31). The aircraft were progressively returned to service between 20 April and 11 May 2001.

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32 National Airworthiness Authority - see section 2.2.

FIGURE 31:
Ansett B767 aircraft undergoing inspection

On 20 April 2001, the CASA Director of Aviation Safety wrote to the Ansett Chief Executive Officer advising that CASA would not be issuing a notice to Ansett to show cause why it should retain its approval to operate. Instead, CASA issued Ansett with a Notice of Concern, that the conduct of maintenance of aircraft operated by Ansett was deficient in several respects, and that there was a risk that those deficiencies were symptomatic of broader systemic failings in Ansett.

CASA cited three other maintenance failures as issues of concern in addition to the Body Station 1809.5 and wing front spar pitch load fitting issues. Those were:

- installation of an incorrect B767 leading-edge slat
- incorrect installation of B767 door sill plates
- incorrect installation of a B767 door escape-slide (girt-bar) mechanism.

The letter foreshadowed that Ansett would be required to enter into a formal agreement to address the issues of concern to CASA, and both parties signed that agreement on 3 May 2001.

6.13 Factors contributing to deficiencies in the Ansett maintenance system

Over a period of four years, the Ansett engineering and maintenance organisation did not incorporate two revisions of the B767 *Maintenance Planning Data Document* (see sections 6.6.1 and 6.6.2), and two revisions of a Boeing service bulletin (see section 6.4.1), into the Ansett system of maintenance.

Observation:

A number of organisational factors contributed to the development of an environment in which lapses by the Ansett engineering and maintenance organisation occurred. Those factors can be categorised into three areas:

- organisational structure and change management
- systems for managing work processes and tasks
- resource allocation and workload.

6.13.1 Organisational structure and change management

6.13.1.1 Corporate ownership of Ansett Australia

Before 1996, Ansett Australia Ltd was jointly owned by News Corporation Ltd and TNT Ltd, each with a 50 per cent shareholding. In 1996, Air New Zealand Ltd acquired TNT Ltd's half share of Ansett Australia. As part of that agreement, Air New Zealand secured an option to buy the News Corporation share of Ansett, if it subsequently become available. Between 1996 and the end of June 2000, News Corporation had, by contractual agreement, management control of Ansett. That management control included the right to appoint the Chief Executive Officer.

In 1997, the Ansett group commenced an internal review process forming the basis of a 'business recovery program'. A taskforce was established to review all company procedures and practices, and to identify where the business could become more efficient and cost effective[33]. Major areas that were identified as offering early gains included procurement, maintenance and engineering, and information management. Another stated goal of the review process was to create an organisational structure that facilitated change.

The business recovery program was developed during 1998 with the goal of company-wide implementation from January 1999, and a wide range of change projects were implemented across all areas of the company. One significant project was the plan to merge the engineering business units of Ansett Australia and Air New Zealand into a single integrated and independent organisation ANNZES (Ansett Australia and Air New Zealand Engineering Services Ltd).

In March 1999, News Corporation and Singapore Airlines announced they had reached an understanding for News Corporation to sell its 50 per cent shareholding in Ansett to Singapore Airlines. However, Air New Zealand exercised its pre-emptive right to buy the remaining half share of Ansett and began negotiating with News Corporation. In February 2000, Air New Zealand announced that it would purchase the remaining 50 per cent of Ansett owned by News Corporation. The Ansett Chief Executive Officer left the company in April 2000.

Air New Zealand completed its purchase of News Corporation's 50 per cent shareholding in Ansett by June 2000. Ansett Australia was then wholly owned by Air New Zealand. A new Chief Executive Officer for the combined Air New Zealand and Ansett group was appointed in January 2001, nine months after the former Ansett Chief Executive Officer had departed.

33 Ansett Holdings Ltd Annual Report 1997.

6.13.1.2 Formation of ANNZES (Ansett Australia and Air New Zealand Engineering Services Ltd)

Engineering and maintenance services for an air transport operator can be provided from within the operator's own organisation, by original equipment manufacturers, or by external maintenance, repair and overhaul organisations. Increasingly, operators have outsourced their engineering and maintenance work to external organisations to achieve greater efficiencies and cost savings.

ANNZES was planned as a major Australasian maintenance, repair and overhaul organisation to serve the needs of both Ansett Australia and Air New Zealand, and to undertake work for other operators. ANNZES comprised a number of operating divisions, including Airframe, Engines, Components, Technical, Manufacturing, Training and Quality Assurance. Planning for the establishment of ANNZES took place in 1998 and 1999, and the company was incorporated in November 1999. ANNZES Ltd was wholly owned, in equal part, by Ansett Australia and Air New Zealand.

The merger of the Ansett and Air New Zealand engineering and maintenance organisations was a strategy developed by senior managers of both companies. Implementation planning of the strategy was extensive and had the full engagement and agreement of both regulators (CASA and the New Zealand Civil Aviation Authority). The planning included both change management and risk management strategies. Senior management of ANNZES was split 50/50 between Auckland and Melbourne and at the Technical Services level direct management was equally split with two Auckland and two Melbourne managers. As an identified risk mitigation strategy, the incumbent Ansett Technical Services Manager agreed to remain in place until the transition plan had been completed to the satisfaction of the regulator.

ANNZES personnel initially comprised only a senior management team. Maintenance and engineering staff remained in the employ of the two separate airlines, and assets such as hangars, spare parts, and specialised tooling equipment also remained with each operator. An immediate full merger of the maintenance organisations was rejected because of concerns among workers about leaving the employment of established operators that many had worked with for a long time. It was envisaged that the transfer of the engineering and maintenance workforce to ANNZES would take place by 2002.

Ansett's maintenance and engineering work was carried out by ANNZES under a Service Level Agreement. Other documentation between the two companies included a Letter of Acceptance and an Aircraft Maintenance Service Agreement. This form of arrangement was not specific to the relationship between Ansett and ANNZES, but could have been used between ANNZES and any air transport operator.

With the formation of ANNZES, the Technical Services departments of Ansett and Air New Zealand were merged into ANNZES Technical, which offered a range of engineering and airline support services including operator, design, and production support. The support services that ANNZES Technical offered air transport operators included services such as aircraft configuration development and tracking, and customised maintenance programs.

The responsibility for Ansett engineering and technical services moved to ANNZES Technical on 20 December 2000. Following concerns raised by CASA, responsibility for part of the Technical Services department and the Maintenance Planning section was returned to Ansett from ANNZES from the beginning of August 2001.

Significant change in the senior management of Ansett engineering and maintenance

Ansett senior management reported that there had been significant change in the senior management of the Ansett engineering and maintenance area, including Technical Services, with the transition to ANNZES during 2000 and early 2001. With the completion of the merger of Ansett and Air New Zealand, most of the senior positions in the combined engineering and maintenance management team were primarily based in Auckland, New Zealand, rather than Melbourne, Australia.

The Manager of the Ansett Engineering Business Unit left Ansett in December 2000. The Manager of Technical Services left Ansett in April 2001.

Observation:

There were significant changes in the senior management of the Ansett engineering and maintenance organisation during 2000 and early 2001. Change in management personnel can lead to a loss of corporate knowledge and to a degree of uncertainty in an organisation. A loss of corporate knowledge can lead to inefficiencies, and in some cases a loss of business continuity while the new management adapts.

Morale within Ansett engineering and maintenance

A number of factors associated with the amalgamation of the Ansett and Air New Zealand engineering business units contributed to staff morale problems within Ansett, including:

- uncertainty about employment
- uncertainty as to the effects of changes in organisational structure
- uncertainty as to corporate ownership
- stress related to issues of resource allocation and workload during the transition.

Ansett staff reported to ATSB investigators that morale was lower than it had been for many years.

6.13.1.3 Structure of Ansett engineering and maintenance

The work carried out by the Ansett engineering and maintenance organisation included line maintenance, heavy maintenance, engine and component maintenance, maintenance development, maintenance planning, and the provision of technical services.

Line maintenance typically involves relatively minor work conducted between scheduled flights, while heavy maintenance normally involves programmed inspection and maintenance during extended time out of service. Maintenance development involves the assessment of what maintenance is required, and when and how it is to be carried out. Maintenance planning then schedules the work at an appropriate time.

There was evidence of deficiencies in the organisational structure and delineation of responsibility within the Ansett engineering and maintenance organisation. For example, responsibility for maintenance development and planning was diffuse and poorly controlled, and modification planners and line planners in different areas reported to different managers. Additionally, the division of staff between Fleet Maintenance and Technical Services meant that there was a diffusion of responsibility for aircraft and component configuration management and tracking.

6.13.1.4 Changes to the structure of the Ansett Technical Services department

A number of the deficiencies within the Ansett engineering and maintenance organisation had been recognised for some time, and a number of responses had been implemented, or planned, to manage the perceived threats. In 1996 the Technical Services Manager developed a SWOT[34] analysis to form the basis of a change program to improve the way in which technical data was managed.

It was recognised that Ansett was being increasingly constrained by its outdated structure and systems. The existing processes were largely paper-based, with serial task processing within and across departments. Ansett was also overly dependent on experienced and long-standing staff to run its systems. As the airline had grown over time, so had the demands placed on the staff and work backlogs had started to increase. In addition, data was input to the mainframe computer system from a number of sources, with no data validation and little effective quality control.

To address these issues, the Technical Services Manager instigated a re-engineering of the functions and processes of the department. This required major organisational and cultural changes. The impact of the changes was significant as many of the staff who were affected had been with the company, in the same role, for up to 30 years. In recognition of the issues to be dealt with, two specialist staff were employed to assist in the change process. A human-relations consultant was appointed to help in dealing with change management and resource issues, and a business analyst position was created to reduce the significant workload of financial analysis on engineering staff.

During late 1997 and early 1998, two major projects were developed and implemented by the Technical Services Manager to address deficiencies that had been identified within the department. Those projects involved:

- Maintenance System and Process Realignment
- Technical Data Cleansing and Alignment.

The objective of the Maintenance System and Process Realignment project was to implement an improved document and data management system (TIMS, see section 6.13.2.2). The objective of the Technical Data Cleansing and Alignment project was to enhance airworthiness control by ensuring documentary compliance in areas of potential high risk.

These projects were supported by the Ansett Director of Maintenance and Engineering and endorsed in 1999 as projects under the umbrella of the Ansett business recovery program. However, other imperatives caused disruption to these response plans and slowed or prevented their introduction. Commitments that disrupted or delayed the implementation of mitigating strategies included work related to:

- Y2K preparedness
- FAA accreditation for the engine workshop and for component overhaul
- the formation of ANNZES as a third-party maintenance, repair and overhaul organisation
- introduction of additional aircraft into the Ansett fleet.

In June 2000, the Technical Services Manager gave a presentation to staff outlining a number of the problems faced by the department, including:

34 Strengths, Weaknesses, Opportunities, Threats.

- the lack of a single point of accountability for aircraft configuration control and tracking
- Technical Services having regulatory responsibility, but shared control of aircraft configuration
- slow, cumbersome and non-integrated business systems
- the potential for poor data integrity.

As part of the program of organisational change to address those issues the structure of the Technical Services department was significantly altered. The previous structure of the department had been along discipline lines, consisting of Structures, Avionics, Materials, and Systems Groups. In the new structure, dedicated teams of people, called aircraft configuration groups, were to be formed for each aircraft type in the Ansett fleet. The aircraft type configuration groups comprised specialists from different disciplines who would be responsible for aircraft configuration management and tracking for a specific aircraft type; for example, B737, B767, and BAe 146.

The principal responsibilities of the configuration groups were aircraft and component configuration management and tracking, airworthiness compliance, data integrity (accuracy and currency), and maintenance of all aircraft and component support manuals for the relevant aircraft type.

It was also envisaged that the aircraft configuration groups would process service documents, amend manuals and carry out tasks related to records, and conduct maintenance development and maintenance planning functions for the relevant aircraft type.

6.13.1.5 Implementation and development of the B767 Configuration Group

The restructuring of the Technical Services department into specific aircraft configuration groups was scheduled to be implemented from August 2000.

The B767 Configuration Group was the first aircraft type configuration group to be established. A staffing proposal was developed in February 2000, and work began on developing procedures. There was difficulty obtaining the necessary staff from their existing sections. A structures engineer joined the Configuration Group but was almost immediately required back in the Structures Group to provide support for aircraft undergoing line and heavy maintenance as they could not cope without him.

During early 2000, the members of the B767 Configuration Group developed many of the work functions and processes for the new aircraft type configuration groups. As outlined by Ansett management, this required the group to develop new roles, job functions, and processes to support operational needs, and to develop new ways of working both within the team and with other departments. However, at the same time, and without extra resources, the group was required to carry out their normal continuing airworthiness activities.

During June and July 2000, a draft organisational structure was developed for the new alignment within Technical Services and staff were briefed on their possible allocation within the new structure. The B767 Configuration Group was still developing work procedures for the configuration groups and a number of issues still had to be addressed. Outstanding issues included accommodation matters, enlisting maintenance development and maintenance planning staff, transferring records section functions, and communicating the role and functions of the configuration groups to other parts of the Ansett engineering and maintenance organisation.

In July 2000, the transition phase to aircraft configuration groups began, with the actual schedule varying for different groups and individuals. It was expected that the process to reallocate existing staff to positions in the new structure would be completed by the end of 2000. The physical move for most people was planned for September 2000. The work processes and procedures that the configuration groups would follow were still being defined during that period. Some functions, such as records, maintenance development, and maintenance planning did not initially transfer to the new groups. It was reported that there was considerable confusion when the configuration groups first began work.

The Structures Group ceased to exist from July 2000. From that time, all structures service bulletins were the prime responsibility of each aircraft type configuration group. In many cases, this resulted in structures service bulletins being processed by personnel who were not experienced in the field.

At a Technical Services senior management team meeting in August 2000, concern was expressed that the situation had reached 'gridlock'[35]. The Technical Services Manager recommended that top priority be given to airworthiness directives, dispatch reliability and work related to aircraft delays. It was suggested that work on standard engineering releases could be halted in the short term. During August 2000, the B767 Configuration Group Team Leader reported to management that there were significant staffing and resource issues within the B767 Configuration Group that needed to be addressed (see section 6.13.3.2).

In September 2000, concern was expressed at a senior management team meeting that staff assigned to the configuration groups were being diverted back to their old roles. At a subsequent meeting in October 2000, the Technical Services Manager indicated that the transitional period for the formation of the aircraft configuration groups would continue until the first quarter of 2001. In February 2001, Technical Services took over responsibility for maintenance development, fleet maintenance, and records.

Observation:

The development of a new organisational structure within the Ansett Technical Services department was planned to deliver efficiencies over time. However, the implementation of the new structure demonstrated a lack of adequate risk management and implementation of change in a number of ways:

- There was inadequate allowance made for the extra demand on resources during the change period, and as a result some work received a low priority or was not actioned.
- At the time of the transition to the new structure, many of the new work functions and processes had not been fully developed.
- During the change, some personnel assigned to the new aircraft type configuration groups were diverted back to their previous tasks – this added to disorder during the transition and exacerbated resource constraints within the new groups.
- The B767 Configuration Group was responsible for developing new work functions and processes but was not sufficiently resourced to carry out this function without seriously compromising the ongoing work of the group.

35 Gridlock, in this context, refers to a breakdown in the progress of work through the system.

6.13.1.6 Maintenance Resource Management

Maintenance resource management is a framework to ensure that all the resources available to a maintenance organisation are used to the fullest extent possible. This is essential in a field such as aviation maintenance where complexity, time pressures, and critical outcomes combine to create an environment that is unforgiving of human error.

Ansett had no formal maintenance resource management program in place for engineering and maintenance staff.

Maintenance resource management deals with issues such as:

- communication and coordination between individuals and departments
- the development of work practices that are resilient to human error
- the effect on human performance of factors such as fatigue, stress and environment
- the development of an effective safety culture.

One of the principles of maintenance resource management is an understanding that communication and coordination issues are as important as technological issues in promoting the best maintenance outcomes possible. Poor communication and coordination between individuals and departments can lead to inefficient and error-prone maintenance practices. Good communication and coordination can improve maintenance outcomes and reduce costs.

The importance of communication in maintenance work has not always been appropriately recognised. With an engineering background, maintenance managers and technicians often have highly developed technical skills, but they may not have similarly developed communication skills. Good communication and coordination between maintenance personnel may need to be fostered by appropriate encouragement and training. Examples of current maintenance resource management programs include the Boeing 'Model Maintenance Safety Program' and the Transport Canada 'Human Performance in Maintenance Program'.

The ATSB report *ATSB survey of licenced aircraft maintenance engineers in Australia*, published in February 2001, recommended that maintenance personnel should receive training in maintenance resource management. The report was based on information from 1,359 aircraft maintenance engineers in Australia.

6.13.1.7 Communication and coordination within Ansett engineering and maintenance

The implementation of the B767 Airworthiness Limitations Structural Inspection program by Ansett was characterised by poor communication and coordination between individuals and functional areas within the Ansett engineering and maintenance organisation. Reliance on informal work procedures resulted in a system that was vulnerable to a breakdown in communication and coordination between the Maintenance Development section and the Technical Services department (see section 6.13.2).

An ANNZES in-house investigation, dated 25 January 2001, reported that the Ansett engineering and maintenance organisation had for some time been characterised by a ‘silo mentality’[36] in which there was poor communication and interaction between different sections.

Observations:

- There were indications of poor communication and coordination between individuals and functional areas within the Ansett engineering and maintenance organisation.
- The effect of poor communication and coordination is likely to have a greater impact in an organisation that relies on informal procedures and lines of communication rather than formal systems to regulate and track the flow of information within the organisation.
- Ansett did not have a maintenance resource management program in place for engineering and maintenance staff. A number of identified shortcomings in the engineering and maintenance organisation may have been ameliorated if maintenance resource management training had been provided for relevant staff.

6.13.2 Systems for managing work processes and tasks

The engineering and maintenance function of a large air transport operator is a complex operation. Two essential elements of the systems necessary to support the organisation are a comprehensive and effective set of work procedures and good support infrastructure such as information management systems.

There were a number of deficiencies in process management and work systems in the Ansett engineering and maintenance organisation including:

- a lack of robust procedures for process management in some safety-critical areas
- an over reliance on individual performance to ensure error-free outcomes
- a ‘legacy’[37] information management system with limited functionality.

The potential effect of these deficiencies on the Ansett system for continuing airworthiness assurance was demonstrated by the breakdown of the processing by Ansett of the June 1997 revision to the B767 *Maintenance Planning Data Document* (see section 6.6.1), and of the service bulletin for B767 wing front spar outboard pitch load fitting (see section 6.11).

6.13.2.1 Process management

Lack of robust procedures

The Ansett procedures for receiving, assessing and actioning manufacturers’ service bulletins and *Maintenance Planning Data Document* revisions were largely informal and lacked many of the safeguards necessary to ensure that tasks were completed in a timely manner. Much of the workflow was controlled using a manual paper-based

36 A ‘silo mentality’ refers to a tendency for different parts of the same organisation to operate independently of one another, to the detriment of the organisation as a whole. For example, a department or section may give insufficient consideration to how its decisions and actions could affect other parts of the organisation. Poor communication, coordination, and cooperation are typical of a silo mentality.

37 ‘Legacy’ systems are information management systems that have been in operation for many years. They typically perform business-critical functions and are usually mainframe or minicomputer systems accessed from remote terminals. Legacy is a generic term, not a brand name.

process that relied on individuals to monitor and track the status of work within the system. In some cases there were no formal procedures to specify how critical functions should be performed. Some procedures lacked a formal closure mechanism, creating the possibility that failure to complete an action could go unrecognised. There was no formal system for establishing and monitoring work priorities to ensure that time-critical work was acquitted within relevant date, flight time or flight cycle limits.

A number of other factors reduced the effectiveness of Ansett's procedures for ensuring the continuing airworthiness of its fleet. Senior management reported that the Ansett engineering and maintenance manuals were large and unwieldy. Many of the manuals were not stand-alone documents. Hence users needed to access information from disparate sources, with an increased chance of information being missed or misinterpreted. Staff reported that it was often difficult to determine what documents were important in a particular situation. In addition, although many procedures required communication and coordination between different areas of the Ansett engineering and maintenance organisation, the 'silo mentality' of the organisation resulted in poor communication between functional areas.

Over-reliance on individual performance

A fundamental shortcoming of the Ansett engineering and maintenance system was over-reliance on the error-free performance of individuals within the system. The lack of formal processes with internal checks increased the risk that human error could go undetected and compromise the continuing airworthiness of the Ansett fleet. There was little redundancy built into the system. Some procedures relied on a single person and were therefore very dependent on the competency, application, memory, and workload of the individual concerned.

The diversity of aircraft types in the Ansett fleet contributed to a situation where some engineering and maintenance programs for different aircraft types were largely the domain of one or two people. In combination with a lack of effective work systems, the over-reliance on individuals allowed a situation to develop where it was possible for an error or omission by a particular specialist to go undetected for a significant period of time.

6.13.2.2 Ansett engineering and maintenance information management systems

An essential element of the support infrastructure necessary for an engineering and maintenance organisation to be able to provide an effective continuing airworthiness function is an efficient information management system.

The existing Ansett engineering and maintenance information management system was largely based on two separate legacy mainframe systems, FOCUS and EMIS. Those systems had substantial data management and retrieval limitations. FOCUS was an engineering document tracking system. However, the use of FOCUS was not mandatory and the data it contained was not validated. EMIS was an aircraft engineering and component tracking and scheduling system, and was used to plan work schedules in relation to date, flight cycles, or flight hours. It was reported that the FOCUS/EMIS mainframe system was difficult to use and lacked functionality. For example, it could take Ansett staff some weeks to extract and process the necessary data to demonstrate regulatory compliance with airworthiness directives for an aircraft type.

Senior Ansett staff had been aware for some time that the information management systems that supported the work of engineering and maintenance were in need of upgrading. Between 1989 and 1994, three business cases were developed for new information management systems but in each case the proposal was rejected on a cost/benefit basis.

A risk evaluation, in 1996, of the Ansett Technical Services area identified a number of deficiencies in the legacy information technology support systems, including a heavy reliance on manual intervention for data integrity and consistency, and an inability to support the demands for timely data access and reporting.

In 1997, the Ansett board authorised the development of a new Technical Information Management System (TIMS) to replace the existing mainframe systems. TIMS was to be an integrated system for the management of aircraft configurational, maintenance and compliance requirements. TIMS and the associated projects came under the umbrella of the Ansett business recovery program in October 1999.

TIMS was intended to capture, review, and cross-reference all maintenance system data. It would combine the information currently held in FOCUS and EMIS and add additional information to create an integrated picture of the maintenance status of the Ansett fleet. The maintenance requirement database module would be able to import maintenance planning data and other information from manufacturers in electronic form, thereby reducing the likelihood of error in the data. The system would include information by aircraft registration and build status, which could then be related to certification requirements. The TIMS workflow, data requirements and analysis functions were designed to encapsulate existing corporate knowledge that was currently held only by longstanding engineering staff who knew the history of the Ansett fleet.

A major part of the development work for TIMS involved 'data cleansing' – the preparation and validation of the necessary data for entry into the new database. The work required to complete the data cleansing task was considerable and it was estimated that for the complete TIMS implementation the total amount of work required was 75,000 hours. Approximately 20,000 data items had been identified as having anomalies.

CASA was briefed on the TIMS project, and it was intended that CASA would have direct access to the system for audit purposes.

In July 2000, ANNZES management halted the full implementation of TIMS, pending a review of the project. Work continued on a partial system with reduced functionality.

In early December 2000, the Ansett structures engineer from the B767 configuration group in Technical Services visited IBM in the USA for work related to the testing of the TIMS system. As a result of working with the B767 *Maintenance Planning Data Document* he was confirmed in his view that the inspections which resulted in the December 2000 groundings had been missed as they had a 25,000 flight-cycle compliance threshold rather than a 50,000 cycle threshold (see section 6.6.2).

Observations:

- The existing Ansett engineering and maintenance information management system did not have the functionality to adequately safeguard against a breakdown in processing of manufacturer service documentation.
- A new Technical Information Management System (TIMS) was being introduced to the Ansett engineering and maintenance area. TIMS had the potential to safeguard against a breakdown in processing of manufacturer service documentation, but the full implementation of the TIMS system was delayed.

6.13.2.3 Processing of *Maintenance Planning Data Document* revisions

The Ansett system for processing B767 *Maintenance Planning Data Document* revisions was characterised by a lack of formally documented processes and an over-reliance on the work of particular individuals. The relevant Ansett manuals did not fully document the procedures to be used by the Maintenance Development section, including communication and coordination with other sections of Ansett engineering and planning.

Maintenance Planning Data Document revisions were received by the Ansett Technical Library and forwarded to the Maintenance Development Manager. The Manager would then allocate the work to the fleet type coordinator. It was usual practice for the Maintenance Development Manager to stamp the document with the names of the people to whom it was to be circulated. However, on occasions this was not done.

The Ansett Maintenance Development section received a large number of documents from manufacturers and other sources. However, most of the control of workflow was a manual process. Issues such as applicability and modification status were checked manually and any necessary changes to the maintenance system were also entered manually.

Depending on the nature of the task, the processing of maintenance planning data could involve input from a number of staff in various sections. There was no formal system in Ansett for coordinating and monitoring the workflow associated with that activity. Some tasks were quite complex, for example when an alternative means of compliance was developed, or in a situation where no procedure existed. It was reported that the complete process could involve up to ten people, depending on the type of work involved. However, it was not a controlled process and there was no formal procedure for monitoring and tracking files that were transferred to other areas of the Ansett engineering and maintenance organisation. Consequently, there was no record of when a file was expected back, or when it was actually returned to the Maintenance Development section.

Copies of some maintenance planning documentation were only held in the Maintenance Development Manager's office. That had the potential to impede easy access to the material by personnel from other areas of the Ansett engineering and maintenance organisation.

Observation:

Ansett process management and work systems for the receipt, review and actioning of *Maintenance Planning Data Document* revisions were not effective in providing continuing airworthiness assurance.

6.13.2.4 Processing of service bulletins

The Ansett system for processing service bulletins was reliant on error-free action by individuals to ensure that work was actioned in an appropriate and timely manner. There was no formal procedure to monitor the processing of service bulletins against constraints such as date, flight time or flight cycle limitations.

The Senior Structures Engineer stated that he would hand deliver engineering releases arising from Alert service bulletins to the appropriate groups so that the task would not be lost in an in-tray. The number of outstanding structures service bulletins increased over time, and required constant monitoring to ensure that no important service bulletins were missed.

Service bulletins were received by the Ansett Technical Library and then sent to the appropriate section for assessment. Prior to February 2000, the Fleet Maintenance department received and assessed all service bulletins, except structures service bulletins. Structures service bulletins, and all other structural issues except those relating to *Maintenance Planning Data Document* inspections, were handled by the Structures Group. This was done to avoid communication problems by having all structural issues within the airline handled by the one group.

The process for the review and actioning of service bulletins could involve a number of people and areas. For example, an engineering release would be prepared by one person, checked by another person, and possibly returned for further work. Once approved, a technical authorisation would be raised and sent to management for financial approval, following which it would be sent to the Maintenance Planning section. Although some details of the processing were recorded in the engineering document tracking system, the system could not monitor or report on overdue items.

The Ansett system for processing service bulletins did not provide a means to automatically track and review documentation. There was therefore no reminder to individual staff or management that work on a service bulletin was pending or overdue. It was reported that engineering releases could sometimes be misplaced and subsequently found in management or maintenance planning in-trays. The system relied on human monitoring and intervention to prevent this breakdown in process from occurring.

In some cases, no action was necessary in relation to service bulletins. For example, some modifications might not be applicable to the Ansett fleet, or might be deemed not appropriate based on operational experience. If no action was required, that would be recorded on the assessment document, but the system had no method to indicate that a service bulletin had not been actioned.

From about February 2001, service bulletins were sent from the Ansett Technical Library to the aircraft configuration groups, instead of the Structures Group or the Fleet Maintenance department, for actioning. However, formal work procedures for the configuration groups were still being developed and there was confusion as to who was responsible for the review and processing of service documentation. It was reported that, in general, staff continued to action service bulletins in accordance with past practice.

Observations:

Ansett process management and work systems for the receipt, review and actioning of service bulletins were not sufficiently robust to provide continuing airworthiness assurance.

> The fact that staff had in the past produced a high quality output may have masked inherent deficiencies in a system that was overly reliant on human performance.

The deficient actioning of the B767 wing front spar outboard pitch load fitting service bulletin (see section 6.11) illustrated the potential for a breakdown in the Ansett system. The B767 Structures Engineer received the service bulletin and, after preparing an engineering release, forwarded the document to the B767 Configuration Group Team Leader for approval. The document was then returned to the structures engineer for further work. However, while the engineer physically received the engineering release, the document tracking system did not have the ability to reflect this. In addition, because the system had no automatic check for lost or delayed service bulletins, neither the structures engineer nor his supervisor were alerted to the fact that the service bulletin had not been actioned.

6.13.3 Resource allocation and workload

The investigation received strong and consistent reports from a number of Ansett staff that resource allocation and workload issues had been significant within the Ansett engineering and maintenance organisation for a number of years. Those issues had specifically been raised in both the Technical Services department and the Maintenance Development section.

In addition to the degree of organisational change that Ansett had undergone in recent times, a number of other factors contributed to or exacerbated workload issues in the Ansett engineering and maintenance organisation. These included:

- a diverse and changing aircraft fleet
- an ageing aircraft fleet
- a number of inefficient maintenance practices
- the diversion of resources during the introduction of a new information management system
- a 'broad brush' approach to the introduction of efficiency measures to all areas.

A diverse and changing aircraft fleet

The Ansett fleet was relatively diverse compared to other operators with which it competed, and included Boeing, Airbus and British Aerospace aircraft.

The Ansett fleet also included several variants of the same aircraft model. For example, from 1997 the fleet included two B767 variants, and different configurations within those variants for maintenance planning and development purposes. Aircraft that Ansett leased added further configurations to the fleet. The diverse Ansett fleet required extra resources in areas such as technical support. The introduction of the first aircraft of a new type into the fleet required significantly more work than that required for the introduction of subsequent aircraft of the same type.

Extra demands were also placed on the Maintenance Development section when aircraft were introduced into, or transferred out of, the Ansett fleet. It was reported to take approximately 3,000 hours of technical work to introduce a second-hand or leased aircraft into the Ansett fleet. That diverted a number of staff away from their normal duties.

In early 1999, the Technical Services Manager gave a presentation to the Ansett and Air New Zealand Executive Committee that outlined both the increasing complexity of the Ansett fleet and the decreasing number of engineering and maintenance staff.

An ageing aircraft fleet

Maintaining older aircraft can be more resource intensive than is the case for younger aircraft. Even if an aircraft is well maintained, the frequency and range of inspections generally increases with aircraft age. Ageing aircraft tend to develop more faults, and take longer to inspect and maintain.

Uncertainty about corporate ownership, and corporate ownership changes, contributed to delayed decisions in relation to the re-equipment of the Ansett fleet. By the year 2000, seven aircraft in the Ansett B767 fleet were between 16 and 17 years old.

Inefficient maintenance practices

Cannibalisation is the process where an unserviceable part is replaced by a used part taken from another aircraft. It is a technique for maintaining aircraft serviceability when there are shortages in the availability of replacement parts. However, over-reliance on cannibalisation can have an adverse effect on maintenance efficiency. High cannibalisation rates can reflect a chronic shortage of spare parts, or may reflect problems in diagnosing faults, or a lack of testing equipment.

Cannibalisation can increase maintenance workloads and costs. It requires at least twice the maintenance time of normal repairs because it involves the removal and installation of parts from two aircraft instead of one, and at the end of the job an unserviceable part has been replaced with a used part, rather than a new or overhauled part. In addition, there is a potentially increased risk of collateral damage to the aircraft and components involved.

In August 1997, at the request of Ansett, Boeing carried out a review of Ansett engineering and maintenance. The report of that review stated, in part:

> Parts robberies [cannibalisations] have been addressed and re-addressed throughout this report and remain a significant problem for ANS [Ansett]. Component shops have the desire and capability to reduce the need to rob parts if given the proper support from supply to turn components/parts with an actual defect. However nearly half (47%) of all parts removed and replaced with robbed parts are returned 'No Defect Found' because of lack of time to thoroughly troubleshoot due to meeting on-time departure schedules.

In September 2000, a CASA audit of Ansett maintenance activities and related processes also identified excessive cannibalisation as a deficiency. The report stated that a lack of an adequate inventory of spare parts resulted in a high demand for parts removed from other aircraft within the Ansett fleet.

Repeated short-term maintenance fixes to Ansett aircraft, particularly during busy periods, were also reported. While there were operational benefits to keeping aircraft in service until repairs could be made at a convenient time and place, the extra work in continuing to operate aircraft with persistent, though permissible, defects resulted in decreased maintenance efficiency.

> **Observation:**
>
> - Ansett was over-reliant on the cannibalisation of parts to return aircraft to service. Ansett had been aware of this shortcoming for a number of years, however, the problem persisted and adversely affected maintenance efficiency.
> - Repeated short-term fixes to maintain aircraft in service at times of high demand can adversely affect maintenance efficiency.

Diversion of resources during the introduction of a new information management system

The introduction of a new technical information management system (TIMS) to replace the existing legacy information technology system was an ongoing major project within the Technical Services department over a number of years. During 1999 and 2000, a significant amount of resources were diverted to data cleansing work associated with the introduction of the new system (see section 6.13.2.2).

In October 1999, senior staff of the Technical Services department expressed their concerns to management about the amount of work that was required from staff remaining in Technical Services as personnel were diverted to data cleansing. Staff continued to raise concerns about resource issues with management throughout the year 2000.

A 'broad brush' approach to the introduction of efficiency measures to all areas

The Ansett business recovery program introduced in 1999 sought efficiency gains throughout the company, including engineering and maintenance. Initiatives aimed at introducing business efficiencies are by no means contrary to flight safety. Indeed, the systems necessary for good safety management and good business management share much in common.

However, there was evidence that in some cases efficiency measures were introduced into the Ansett engineering and maintenance organisation without being adequately tailored to specific work areas. In particular, resource allocation issues in both the Technical Services department and Maintenance Development section placed an additional burden on senior staff. For example, the requirement to develop a business case for the replacement of any staff member added to the workload of supervisors who already had substantial and crucial responsibilities directly related to continuing airworthiness and flight safety.

6.13.3.1 Resource allocation and workload issues in Maintenance Development

The Maintenance Development Manager reported that for an extended period of time resource allocation and workload issues had been a major problem in the Maintenance Development section. These issues included:

- difficulty in gaining approval for extra staff
- the time needed to train new staff
- staff diverted to database work
- work associated with the introduction of new aircraft types or models
- work associated with Ansett regional airlines and special projects.

The manager reported that the Maintenance Development section could only cope with special projects by involving several, or all, staff members on the project. An example was the extra effort required when aircraft were introduced to, or left, the Ansett fleet. However, the concentration of resources on one particular task would cause other projects and routine work to slip further behind.

The Maintenance Development Manager stated that the lead time available to prepare for the introduction of new aircraft types had been minimal. The section had had just four months to prepare for the introduction to service of the B747-300 in 1997, and five months for the B747-400 in 1999. When a large proportion of the resources of the Maintenance Development section were devoted to the initial introduction of an aircraft, other work of the section was put behind by up to six months.

In March 1995, the Maintenance Development Manager wrote to the Engineering and Planning Manager stating that by current estimation the backlog of work was approximately 60 weeks per Maintenance Development Engineer. He also stated that it was not anticipated that the backlog could be significantly reduced within the next two years. The Manager recommended an increase in Maintenance Development staffing levels as a matter of urgency in the interest of maintaining a system of maintenance for each aircraft type that was both cost effective and met all legal requirements.

A memo from the Maintenance Development Manager to the Acting Engineering and Planning Manager in November 1999, listed 27 major maintenance development projects or tasks that were either in progress or pending.

The Maintenance Development Manager stated that excessive workload in the section had resulted in a lack of adequate oversight of the B767 Airworthiness Limitations Structural Inspection program.

Observation:

Resource allocation and workload issues had been evident within the Ansett Maintenance Development section for a considerable period of time. That contributed to the lack of recognition by Ansett of the significance of service documentation related to the B767 Airworthiness Limitations Structural Inspection program. Consequently the program was not implemented in a timely manner.

6.13.3.2 Resource allocation and workload issues in Technical Services

There was evidence that resource allocation and workload in the Ansett Technical Services department had been an issue for some time.

Senior staff of the Technical Services department repeatedly raised concerns about resource issues with management throughout the year 2000. Concerns raised included overtime budgets, the work involved in developing a business case to fill staff vacancies, and the backlog of work that had built up as a result of the introduction of the new TIMS information management system. Those difficulties were increased by the need for senior staff members to train and mentor a number of inexperienced staff in the configuration groups.

From the latter half of 2000 through April 2001, the Technical Services Manager raised the issue of resource allocation and workload with the ANNZES Head of Technical and the Ansett Chief Operating Officer on a continuing basis. Two of the options proposed to address the identified shortcomings were the accelerated transfer of staff from other Ansett departments, such as Fleet Maintenance, and the transfer of responsibility for configuration management of the Ansett B747 aircraft to the Air New Zealand part of

ANNZES. The latter course would have released experienced Ansett staff to support the B767 and Heavy Maintenance. However, while both of these options were supported by the ANNZES Head of Technical and the Ansett Chief Operating Officer they were not implemented.

The B767 Configuration Group was the first to be established and carried an extra workload in developing procedures to be used by all the aircraft configuration groups. In September 2000, the Team Leader of the B767 Configuration Group indicated that the current workload was beyond the ability of the group and that there was an ever-increasing backlog of work. The Team Leader indicated that additional clerical support was imperative for a range of tasks, including the recording and tracking of technical authorisation requests, service document evaluation forms, and service documents. The Technical Services Manager recommended that priorities be examined, and suggested that standard engineering releases could be halted in the short term. The top priorities were to be airworthiness directives, and scheduled services dispatch reliability and delays.

An email from a team leader to the Technical Services Manager in November 2000 noted the difficulties in resolving the potentially conflicting goals of higher productivity and lower maintenance costs. The email concluded in part:

> We are reaching a point of crisis where our work input far exceeds our work output capacity given the current staffing numbers, skill set and experience. To resolve this issue requires either:
>
> 1. An increase in Config. Group staff with the correct skills and experience to acquit their responsibilities, or
>
> 2. A decrease in Config. Group responsibilities until the correct staffing level is attained.

While low priority tasks, such as non-urgent service bulletins, could be rescheduled, they could not be postponed indefinitely. It was reported that at times a large backlog of service bulletin work accumulated in this way. A senior staff member reported that in the past Alert service bulletins had been actioned without delay. However, in more recent times, high workload and a lack of experienced staff had meant that this was not always the case.

In February 2001, the Technical Services senior management team meeting noted that the configuration groups had a very high workload and that help was needed. On 9 March 2001, the Team Leader of the B767 Configuration Group sent an email to the Technical Services Manager saying that he did not wish to continue in his current role. He stated that the workload and responsibilities required of the configuration group team leaders were totally unreasonable and unmanageable. Team leaders had to be familiar with all documents assigned to the group and to check all service bulletins, whether they were structures, avionics, mechanical, or component related, and to review, track and ensure compliance with all airworthiness directives applicable to the aircraft type and its components. The Team Leader made the comment that it was only a matter of time before an airworthiness directive was overlooked because of the number of emails and constant demands on team leaders' time. Another configuration group team leader reported that the situation was both physically and mentally exhausting.

On 19 March 2001, the Team Leader of the B767 Configuration Group sent an email to the Technical Services Manager reiterating that the current workload was beyond the limited resources and expertise of the group. On 21 March 2001, the Team Leader sent a further email stating that he no longer wished to continue in his role when he returned from leave on 28 March 2001. On 7 April 2001, it was discovered that the B767 wing front spar outboard pitch load fitting Alert Service Bulletin (SB 767-57A0070), first released on 2 March 2000 and revised on 16 November 2000, had not been actioned by the B767 Configuration Group.

The structures engineer in the B767 Configuration Group, who was tasked with actioning the B767 wing front spar pitch load fitting service bulletin, stated that his work responsibilities, in order of priority, were airworthiness directives, line maintenance work, heavy maintenance work, and finally service documents (including service bulletins). The engineer was also on an out of hours call-out roster, and was frequently needed for line maintenance work overnight.

The B767 Structures Engineer stated that because of the priority of 'aircraft on ground' work, for example line and heavy maintenance, he had limited time to devote to work related to service bulletins. He was also responsible for other project work, which included compiling data for an Ansett insurance claim for aircraft damage caused by a hailstorm in Sydney during April 1999. The engineer said that when staff were on leave, other staff members only picked up urgent work such as 'aircraft on ground' tasks.

The structures engineer stated that he believed that the B767 wing front spar pitch load fitting service bulletin had been overlooked because of overwork.

Observation:

Resource allocation and workload issues had been evident within the Ansett Technical Services department for a considerable period of time and contributed to the lack of action by Ansett to implement Boeing Alert Service Bulletin 767-57A0070, relating to the B767 wing front spar outboard pitch load fitting.

6.14 Previously identified deficiencies in the Ansett flight operations organisation

On 19 October 1994, Ansett B747 VH-INH was on a flight from Sydney to Osaka when one of the engines lost oil and was shut down. The aircraft returned to Sydney. On approach to land the flaps and landing gear were slow to extend because pressure in the hydraulic system was lower than normal after the engine had been shut down. The aircraft landed with the nose-gear retracted, and sustained substantial damage to the forward fuselage.

The then Bureau of Air Safety Investigation identified a number of deficiencies within the Ansett flight operations organisation related to the introduction of the B747 into the Ansett fleet and the commencement of international operations[38]. A number of those deficiencies were similar to deficiencies within the Ansett engineering and maintenance organisation highlighted in this report.

The deficiencies identified by the Bureau of Air Safety Investigation included the findings that:

38 BASI Investigation Report 1999403038 *Boeing 747-312 VH-INH, Sydney (Kingsford-Smith) Airport, NSW, 19 October 1994.*

- management processes did not highlight critical deficiencies during project planning or implementation
- critical instructions and procedures had not been developed before B747 training commenced
- procedures evolved rapidly and constantly as training progressed, causing confusion among trainees
- senior Ansett staff responsible for planning and project management continued to have operational responsibilities crucial to flight safety.

Following the B747 VH-INH occurrence in October 1994, Ansett initiated an ongoing safety review and improvement process throughout the company. An external audit of all flight operations and the engineering and maintenance organisation was completed in May 1996. A new Operational Safety Department was developed to maintain safety standards across all areas of the company.

Observation:

A number of deficiencies within the Ansett engineering and maintenance organisation identified in this report were very similar to deficiencies that had previously been identified within the Ansett flight operations organisation.

7 CIVIL AVIATION SAFETY AUTHORITY

7.1 Legislated powers and responsibilities

The Civil Aviation Safety Authority (CASA) was established as an independent statutory authority on 6 July 1995, through amendment of the *Civil Aviation Act 1988* (the Act). CASA's primary focus is delivering aviation safety to the Australian public.

The Act defines CASA's functions in sections 3A and 9, as follows:

> 3A **Main object of this Act**
>
> The main object of the Act is to establish a regulatory framework for maintaining, enhancing and promoting the safety of civil aviation, with particular emphasis on preventing aviation accidents and incidents.
>
> 9 **CASA's functions**
>
> (1) CASA has the function of conducting the safety regulation of the following, in accordance with this Act and regulations:
>
> (a) civil air operations in Australian territory;
>
> (b) the operation of Australian aircraft outside Australian territory;
>
> by means that include the following:
>
> (c) developing and promulgating appropriate, clear and concise aviation safety standards;
>
> (d) developing effective enforcement strategies to secure compliance with aviation safety standards;
>
> (e) issuing certificates, licenses, registrations and permits;
>
> (f) conducting comprehensive aviation industry surveillance, including assessment of safety-related decisions taken by industry management at all levels for their impact on aviation safety;
>
> (g) conducting regular reviews of the system of civil aviation safety in order to monitor the safety performance of the aviation industry, to identify safety-related trends and risk factors and to promote the development and improvement of the system;
>
> (h) conducting regular and timely assessment of international safety developments.

CASA also has the safety-related function of encouraging the aviation industry to accept its obligation to maintain high standards regarding aviation safety (s. 9(2)(a)), as well as promoting full and effective consultation and communication with all interested parties related to aviation safety (s. 9(2)(b)). In addition, CASA has the role of developing Australia's civil aviation capabilities, skills and services for the benefit of the Australian community and for export (s. 9(3)(e)).

Section 9A expressly states that CASA must give primacy to the safety of air navigation in carrying out its functions.

CASA's powers are broad and far-reaching. Section 13 of the Act states that:

> In addition to any other powers conferred on it by this Act, CASA has, subject to this Act, power to do all things necessary or convenient to be done for or in connection with the performance of its functions.

7.1.1 CASA delegations and authorisations

Under the Civil Aviation Regulations 1988 CASA has the power to issue delegations and authorisations in relation to the various powers that it holds.

A delegation is a legal mechanism whereby an individual or body possessing legal powers transfers the right to exercise any or all of those powers to another person or body. Civil Aviation Regulations 1988, r. 7, permits the Director to delegate all or any of CASA's powers and functions to any person under the regulations. The Director is not restricted to delegating his or her powers to officers or employees of the Authority. In effect, a CASA delegate becomes an agent of CASA with respect to the powers delegated to them.

Subparagraph 34AB of the *Acts Interpretation Act 1901* provides, inter alia, that where an Act confers power on a person or body to delegate a function or power, that:

> (c) a function or power so delegated, when performed or exercised by the delegate, shall, for the purposes of the Act, be deemed to have been performed or exercised by the authority.

Therefore, while CASA can delegate its functions and powers associated with the regulation of air navigation, it remains ultimately responsible and accountable, particularly in the context of aviation safety.

Authorisation confers on a person a right to do something which, without that authorisation, the person would not have the right to do. CASA can appoint a person to be an authorised person under Civil Aviation Regulations 1988 (CAR 1988), r. 6. Authorisations can also be given to persons who are not connected with CASA.

The use of delegations and authorisations can have a number of advantages, including the decentralisation of decision making and the devolution of tasks to operational staff who have a high level of technical experience and expertise.

Some Ansett staff were CASA delegates, however, none of those delegations were relevant to this report. CASA authorisations to Ansett staff relevant to this report included CAR 1988 r. 35 *Approval of the design of a modification or repair,* CAR 1988 r. 42M(1) *Approval of an aircraft's system of maintenance*, and CAR 1988 r. 42R(1) *Approval of a change to an aircraft's approved system of maintenance.*

7.2 CASA action in relation to continuing airworthiness requirements

7.2.1 Regulatory basis for continuing airworthiness requirements for Australian registered aircraft

One of the responsibilities of a State of Registry relates to the mandating of the Airworthiness Limitations Structural Inspection requirements for damage tolerant aircraft types on its register (see section 4.2.3). The Airworthiness Limitations Structural Inspections are developed, by the manufacturer, as part of the system to ensure that structural integrity is maintained throughout the operational life of the aircraft.

The State of Registry is in the best position to determine which of the Airworthiness Limitations Structural Inspections should be mandatory for aircraft of that type on the State's register. Guidance material in the ICAO *Airworthiness Manual* states:

> The continuing structural integrity program should be initiated by the organization responsible for the type design and developed jointly with representatives of operators and airworthiness authorities. The authority in each State of Registry having aeroplanes affected should determine how, and to what extent, the substance of the programme is made mandatory, consistent with the State of Registry's own experience with the aeroplane and its procedures for enforcement of continuing airworthiness requirements.[39]

It is not clear how Australia has intended to act in this area. The legal effect of some potentially relevant provisions in Australian civil aviation legislation is uncertain, partly because in some aspects the provisions are drafted in general terms, and in some respects ambiguously.

Australian civil aviation law does not include any precise or explicit requirement that aircraft operators comply with airworthiness limitations requirements, such as the Airworthiness Limitations Structural Inspections, issued by an aircraft manufacturer. For example, there is no provision in Australian civil aviation legislation similar to US Federal Aviation Regulations, s. 91.403 which provides in part:

> (c) No person may operate an aircraft for which a manufacturer's maintenance manual or instructions for continued airworthiness has been issued that contains an airworthiness limitations section unless the mandatory replacement times, inspection intervals and related procedures specified in that section … have been complied with.

It is arguable that compliance with such material is required, or could be required, under one or more general provisions of Australian aviation legislation, or a combination of those provisions, including:

- Civil Aviation Order 100.5(9.1) *Replacement of time-lifed components*
- approved maintenance data under CAR[40] 1988, rr. 2A, 39, 40, 42M, 42R, 42V
- approved system of maintenance under CAR 1988, rr. 39, 40, 42M, 42R
- Type Acceptance Certificate issued under CAR 1998, r. 21.29A
- Certificate of Airworthiness issued under CAR 1998, r. 21.176(5)
- conditions on an Air Operator Certificate under the *Civil Aviation Act 1988*, s. 28BA
- the *Civil Aviation Act 1988*, s. 98(3A)
- the *Acts Interpretation Act 1901*, s. 49A.

However, whether these provisions effectively mandate compliance with airworthiness limitations is uncertain. The language of the relevant provisions is in some respects imprecise and the exact operation of the provisions in relation to airworthiness limitations is open to different interpretations. In short, the question of whether, and

39 ICAO *Airworthiness Manual* (Doc 9760-AN/967) 2001, Volume II, Part B, Chapter 6, *Structural Integrity Programme*, p. 6.2.2.

40 Civil Aviation Regulations. Note: Some references are to the Civil Aviation Regulations 1988 and some to the Civil Aviation Regulations 1998. Both sets of regulations currently co-exist.

to what extent, these provisions require compliance with the Airworthiness Limitations Structural Inspections for a damage tolerance aircraft type is open to legal interpretation.

Some particular aspects would also act to limit the effectiveness of these indirect means of mandating airworthiness limitations. Any obligation under CAO 100.5 (9.1) would probably not extend to additional requirements included in revised service documentation. However, airworthiness limitations are routinely revised in light of further testing and service experience. While provisions related to the approved system of maintenance cover a situation in which the Certificate of Registration holder becomes aware of a defect or inappropriateness in the system, there is no express provision for the Certificate of Registration holder to keep the system under review to ensure that any such limitations are brought to light.

The investigation found no evidence to indicate that CASA had specifically considered to what extent, and by what mechanism, it would mandate compliance with the Airworthiness Limitations Structural Inspections for Australian registered damage tolerant Class A aircraft.

The mandatory nature of certain airworthiness requirements acts as a clear and direct signal to operators that those items have significant safety of flight implications and should be actioned in a timely manner. Any ambiguity or lack of clarity as to what continuing airworthiness requirements have been accorded mandatory status has the potential to weaken a defence with regard to flight safety.

Observation:

For safety assurance, it is important that both the nature and extent of any legal maintenance requirements are clear and unambiguous.

There was uncertainty as to whether Australian civil aviation legislation required Australian operators to comply with the Airworthiness Limitations Structural Inspections as intended by the State of Design and the manufacturer.

It is desirable that, where appropriate, the continuing airworthiness requirements for Australian Class A aircraft reflect the documented intent of the State of Design and/or State of Manufacture, and that it is clear:

- which requirements are mandatory for operators of Australian Class A aircraft
- how compliance with those requirements is mandated under Australian civil aviation legislation.

Safety Recommendation R20020245

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority develop and issue clear guidance material for, and review its surveillance of, Australian operators of Class A aircraft in relation to:

- continuing airworthiness assurance activities, including the major defect reporting system
- knowledge of mandatory continuing airworthiness requirements under Australian civil aviation legislation
- the transmission of information to the organisation responsible for the type design
- the receipt, assessing and actioning of safety-related service documentation.

CASA has indicated (16 August 2002) that it agrees in principle with this recommendation, stating that the current advisory material, along with that proposed in the new maintenance regulations, provide for this.

7.2.2 Differences between the Australian and US regulatory systems for continuing airworthiness

The regulatory basis for continuing airworthiness of aircraft on the US civil register is significantly different from that in Australia, largely because of differences in the broader regulatory framework of the two countries. US law, in particular the *Administrative Procedures Act*, does not allow the FAA to apply requirements 'retrospectively' to US air operators under normal circumstances.

Hence, it was necessary for the FAA to issue an airworthiness directive to specifically mandate compliance for each additional continuing airworthiness requirement they wished to mandate for US operators of existing B767 aircraft (see section 8.2). CASA was not similarly constrained in its ability to require compliance by Australian operators of B767 aircraft with revised or additional continuing airworthiness requirements.

As a result of the differences between the Australian and US regulatory systems for continuing airworthiness, Australian operators were potentially in a different position from US air operators when Boeing released FAA-approved changes to the B767 Airworthiness Limitations Structural Inspections.

Observation:

The differing legislative frameworks between Australia and the USA contributed to an unclear situation in relation to the mandating of section 9 of the B767 *Maintenance Planning Data Document* in Australia.

In practice, and irrespective of the legal requirements, compliance with section 9 of the *Maintenance Planning Data Document* would provide operators with greater continuing airworthiness assurance.

7.2.3 CASA awareness of aspects of the B767 continuing airworthiness program

The B767 was the first Class A aircraft type designed to damage tolerance specifications to be introduced into regular public transport service in Australia. The damage tolerance approach introduced significant changes to the system for ensuring continuing airworthiness throughout an aircraft's service life, and the Airworthiness Limitations Structural Inspections were a critical element of that new system.

Historically, Australia had been involved in pioneering work in the evaluation and control of fatigue in aircraft structures. Engineers and scientists from the Aeronautical Research Laboratories were involved in early fatigue research in late 1940s and staff of the airworthiness authority were involved in the development of ICAO airworthiness-related recommended practices and guidelines.

In 1974, a specialist Fatigue Evaluation section was established in the Airworthiness Engineering Branch of the then Commonwealth Department of Shipping and Transport. It was the practice of the Fatigue Evaluation section to promulgate airworthiness directives to implement the schedule of inspection and retirement of structural components, such as Airworthiness Limitations and Certification Maintenance Requirements.

In some cases Australia introduced more stringent fatigue-related requirements for aircraft on the Australian register than were promulgated by the State of Design. For example, certain small aircraft types were initially certified in the US without any consideration being given to wing or empennage fatigue. However, the airworthiness authorities of Australia and the UK required fatigue evaluation on those types before allowing the aircraft to operate in their respective countries. Recent proposed US rule changes would require US registered aircraft to meet similar requirements to those that have been in place for Australian registered aircraft of those types for many years[41].

Over a number of years, however, the number of engineering staff of the Australian airworthiness authority that dealt with fatigue and structural issues was progressively reduced. In May 1995 the Fatigue Evaluation section was abolished, and a subsequent reorganisation in March 1999 led to a further reduction in airworthiness engineering staff.

When the B767 entered service in 1982 the Airworthiness Limitations Structural Inspection program for the aircraft type had not been finalised. This was in accordance with the principle and practice of the MSG–3 philosophy in which information from operational experience was an important factor in setting specific flight cycle thresholds for inspections. At the time it was envisaged that the B767 Airworthiness Limitations Structural Inspection program would be promulgated by airworthiness directive for Australian operators. However by the time the program was published in April 1997 the Fatigue Evaluation section had been abolished and its staff dispersed.

The investigation found no evidence to indicate that, from the time the B767 Airworthiness Limitations Structural Inspection program was introduced in April 1997 until the Ansett B767 aircraft were withdrawn from service in December 2000, that CASA had given any formal consideration to the introduction of the program by Australian operators.

Observation:

A loss of airworthiness engineering expertise and corporate knowledge from CASA, and the bodies that pre-dated it, had occurred over many years. As a result, when the B767 Airworthiness Limitations Structural Inspection program was released in June 1997, CASA did not actively consider how the program would he handled in Australia, including what, if any, related action CASA should take.

7.2.4 CASA action to mandate B767 *Maintenance Planning Data Document* section 9 revisions

On 29 December 2000, CASA issued a Direction to Ansett under the Civil Aviation Regulations 1988, r. 38, *Maintenance Directions*, requiring Ansett to ensure that all current maintenance requirements of the Airworthiness Limitations and Certification Maintenance Requirements were met. That Direction to Ansett had the effect of mandating immediate compliance with all the applicable items in section 9 of both the August 1997 and August 2000 revisions of the B767 *Maintenance Planning Data Document*.

On 19 April 2001, the FAA issued Airworthiness Directive 2001-08-28, mandating compliance by US operators of B767 aircraft with production line number 669 and below with the August 1997 revision of the *Maintenance Planning Data Document*,

41 FAA Notice of Proposed Rule Making (NPRM 99-02), *Aging airplane safety*, August 1999.

section 9. Compliance was required before 1 June 2004. At the time of publication of this report, the FAA had still not mandated similar compliance for the items in section 9 of the August 2000 revision of the B767 *Maintenance Planning Data Document*.

On 5 December 2001, CASA issued Airworthiness Directive AD/B767/145, mandating compliance with section 9 items in the August 2000 revision of the B767 *Maintenance Planning Data Document*. Compliance was required before 1 June 2004.

7.2.5 The ATSB recommendation concerning the CASA review of continuing airworthiness requirements

CASA was not previously aware that the FAA process for mandating compliance with the B767 Airworthiness Limitations Structural Inspections by means of a series of airworthiness directives had become significantly delayed. As a result, in December 2000, CASA specifically mandated that Ansett immediately comply with both the June 1997 and June 2000 section 9 revisions of the B767 *Maintenance Planning Data Document*.

On 12 April 2001, the ATSB issued Recommendation R20010092 to CASA, recommending that CASA take steps to ensure that the continuing airworthiness requirements for Australian Class A aircraft were not compromised through any lack of action by the national airworthiness authorities of other countries.

CASA reported (14 May 2001) that, as part of the work necessary to develop a Bilateral Aviation Safety Agreement between Australia and the United States, it would be conducting an audit of FAA procedures and outcomes. In addition, CASA stated that it would continue to issue airworthiness directives that were found to be necessary for the continuing airworthiness of aircraft, even if the State of Design had not issued a mandatory requirement.

7.2.6 Complexity of Australian civil aviation legislation

Prior to December 2000, CASA and Ansett believed that it was mandatory for Australian B767 operators to comply with the Airworthiness Limitations Structural Inspections contained in section 9 of the B767 *Maintenance Planning Data Document*. However, subsequent legal opinion suggested that the regulatory basis for mandating compliance with those provisions was far from clear and unambiguous. Close scrutiny of possibly relevant provisions in Australian civil aviation legislation highlighted the complexity of that legislation, and the difficulty that even specialist legal personnel can have in determining the actual effect of certain provisions.

Potential difficulties in interpreting Australian civil aviation legislation have been raised before. In a survey of CEOs and/or Chief Pilots of 346 organisations holding Air Operator Certificates for commercial passenger-carrying operations[42], almost half of the respondents commented on the aviation safety legislation. The majority view was that the legislation presented problems of ambiguity, complexity, imprecision, and relevance. Other respondents made reference to the volume of legislation and its 'legalistic' framing, making its comprehension difficult for the aviation industry.

42 B Dannatt, February 2000. *Report to CASA on a survey of commercial air transport operators.*

Observation:

It is apparent that even specialist legal personnel can have difficulty in interpreting the effect of some provisions in Australian civil aviation legislation, including those relating to continuing airworthiness.

Complex and ambiguous legal provisions can result in a poor understanding of what are essential maintenance requirements and therefore have the potential to compromise air safety.

CASA has instigated a *Safety through Clarity* reform program to address the problem of complexity of the Australian civil aviation legislation. The CASA Director of Aviation Safety stated (1 November 2001) that the regulations must be clear, concise, consistent, and unambiguous. The focus is to be on safety and simplicity. The Director also noted that this concept had been embraced by the Attorney-General's Department as a basis for legal drafting of the regulations.

7.3 CASA action in relation to manufacturers' service bulletins

7.3.1 Review by CASA of manufacturers' service bulletins

Until 1990, specialist staff of the then Australian Civil Aviation Authority reviewed service bulletins relevant to Australian Class A aircraft that were issued by aircraft, component, and engine manufacturers. Because of those reviews, the Authority would from time to time issue airworthiness directives to mandate compliance by Australian operators with particular service bulletins. In some cases, action was taken by the Civil Aviation Authority before, or in the absence of, action by the national airworthiness authority of the State of Design or Manufacture of the aircraft.

In 1990, as part of a major review of its role and functions, the Civil Aviation Authority decided that it would no longer carry out an in-depth review of service bulletins as a matter of course. In December 1990, the Authority issued an Airworthiness Advisory Circular (AAC No. 6-16), titled *Service Bulletin Review*, which stated:

> Nobody in the Australian aircraft maintenance business can be unaware of the forthcoming changes to the maintenance CAO's [Civil Aviation Orders]. In essence more responsibility is being transferred to maintenance organisations to assess the safety significance of maintenance information. This particularly applies to manufacturers service bulletins.
>
> The exact details and schedule for the new arrangements are under review and for the time being the review of overseas Airworthiness Directives and alert documents from manufacturers will continue. However, as a step towards transferring responsibility to industry, the assessment of routine service bulletins by airworthiness specialists has already ceased.
>
> Owners, operators and maintenance organisations are urged to carefully assess the safety, reliability and cost implications of manufacturers service recommendations. The onus is now on you.

As a result of this change in policy, the Civil Aviation Authority, and later CASA, tended not to take action to mandate a service bulletin unless, and until, the national airworthiness authority of the State of Design and/or Manufacture of the aircraft had taken corresponding action.

In July 1991, the Civil Aviation Authority issued an Airworthiness Advisory Circular (AAC No. 6-23), titled *Airworthiness Directive Policy*, which included additional comment on the change in policy related to service bulletins:

> The days of waiting for the CAA [Civil Aviation Authority] specialists to assess a Bulletin as serious and issue an AD [airworthiness directive] are gone – the specialists may not even see the Bulletin in future.
>
> The absence of any check or evaluation by the CAA does involve some risk as recognised by major Authorities such as the UK CAA and the US FAA who evaluate every SB [service bulletin], both local and foreign. However, this work is labour intensive and therefore costly and the CAA believes the Australian industry to be sufficiently mature and responsible to be relied upon to make their own assessments and take appropriate action accordingly.

Airworthiness Advisory Circular No. 6-16 was cancelled in February 1999 and, since that time, CASA has not issued any further guidance material to the aviation industry in relation to service bulletins. At the time of publication of this report, Airworthiness Advisory Circular No. 6-23 was still current.

Observation:

Devolution by CASA of safety regulation tasks may be appropriate, but CASA retains ultimate responsibility for safety regulation and needs to be able to satisfy itself that air safety will not be significantly compromised and that an appropriate balance (see Appendix 7) has been achieved.

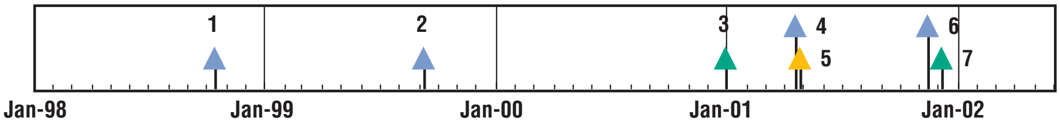
7.3.2 CASA action to mandate B767 service bulletins in December 2000 and April 2001

Service bulletins issued by aircraft manufacturers are by nature advisory documents. For any particular operator, compliance with a service bulletin only becomes mandatory if the State of Registry issues an airworthiness directive to that effect, or directs compliance by some other legal means. Typically, the State of Design or Manufacture will first take action, as they normally have the closest relationship with the design organisation or manufacturer.

In December 2000, and again in April 2001, CASA immediately mandated compliance with a B767 service bulletin before such action had been taken by the State of Design. In both cases the CASA action followed concerns about safety of flight issues. Figure 32 and Figure 33 outline the time sequence of events related to those two service bulletins, and in particular actions taken by Boeing (▲), CASA (▲), and the FAA (▲).

Figure 32 outlines actions associated with Boeing Service Bulletin 767-53-0078 concerning fatigue cracking in the area of the B767 Body Station 1809.5 bulkhead outer chord. It was not until November 2001 that the service bulletin was upgraded by Boeing to Alert status, with the warning that undetected cracking had the potential to result in the loss of the horizontal stabiliser.

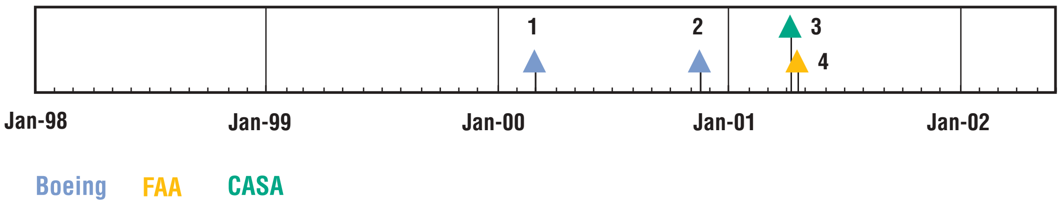
FIGURE 32:
B767 Body Station 1809.5 bulkhead outer chord service bulletin sequence of events



	Entity	Date	Action
1	Boeing	15 October 1998	Service Bulletin 767-53-0078 issued
2	Boeing	9 September 1999	revision 1 to service bulletin issued
3	CASA	29 December 2000	CAR 38 (1988) Direction to Ansett mandating compliance with service bulletin
4	Boeing	19 April 2001	revision 2 to service bulletin issued
5	FAA	27 April 2001	Airworthiness Directive (2001-09-13) issued to US operators
6	Boeing	15 November 2001	revision 3 to service bulletin issued - upgraded to Alert status
7	CASA	5 December 2001	Airworthiness Directive (AD/B767/146) issued to Australian operators

Figure 33 outlines actions associated with Boeing Service Bulletin 767-57A0070 concerning fatigue cracking in the B767 wing front spar pitch load fitting. The service bulletin warned operators that undetected cracking in that area had the potential to result in the separation of the strut and engine from the wing.

FIGURE 33:
B767 wing front spar pitch load fitting service bulletin sequence of events



	Entity	Date	Action
1	Boeing	2 March 2000	Alert Service Bulletin 767-57A0070 issued
2	Boeing	16 November 2000	revision 1 to service bulletin issued
3	CASA	10 April 2001	Airworthiness Directive (AD/B767/135) issued to Australian operators
4	FAA	18 April 2001	Airworthiness Directive (2001-08-23) issued to US operators

CASA did not mandate Boeing Service Bulletins 767-53-0078 and 767-57A0070 in a timely manner because it was relying on the FAA to monitor, and mandate where appropriate, compliance with service bulletins issued by Boeing. Therefore, when the FAA process for reviewing service bulletins broke down in those particular cases (see section 8.1), CASA was not aware that the matters addressed in the bulletins required it to ensure that operators took action without delay.

7.3.3 The ATSB recommendation concerning CASA review of manufacturers' service bulletins

In December 2000 and April 2001, CASA specifically mandated compliance with two B767 service bulletins, subsequent to the identification of safety of flight issues. In both cases, CASA took action to mandate compliance with those service bulletins before they had been mandated by the FAA, the national airworthiness authority of the State of Design and Manufacture.

On 12 April 2001, the ATSB issued Recommendation R20010093 to CASA, recommending that CASA take responsibility to ensure that all service bulletins relevant to Australian Class A aircraft were received, assessed for safety of flight implications, and implemented or mandated as appropriate. In accordance with its normal practice, the ATSB did not specify any particular means by which the recommendation should be addressed.

CASA subsequently initiated a comprehensive review of the handling of service bulletins related to Class A aircraft, by manufacturers, operators, CASA, and authorities responsible for type certification. The Board of CASA considered that the importance of the issue was sufficient for the review to be a three-tier process. The findings of the CASA team would be reviewed by an external expert panel, and finally signed off by a world expert on the subject.

The final report to CASA, dated on 13 September 2001, listed 24 recommendations[43] aimed at increasing the safety effectiveness and resilience of the Australian continuing airworthiness system. A related implementation plan stated:

> Adoption of the recommendations will require changes to Australian legislation, practices and guidance material, as well as initiatives to influence needed change in ICAO Standards and manufacturing industry procedures.

The implementation plan listed target date information for 19 of the recommendations. The majority of the corresponding action items were scheduled for completion during 2002.

7.4 Policy changes by CASA in relation to safety-related roles and functions

The Civil Aviation Authority policy decision in 1990 to reduce the involvement of its specialist staff in reviewing manufacturers' service bulletins relevant to Australian Class A aircraft was one aspect of a broader reappraisal of the Authority's role and functions.

One significant change introduced by the Civil Aviation Authority was to encourage industry self-administration with reference to prescribed safety regulatory standards[44]. To that end, the Authority indicated that it would:

- avoid undertaking activities which over-regulated the industry
- devolve to the aviation industry those safety regulatory activities which could be more efficiently performed by industry than by the Authority
- introduce quality assurance and control programs as regulatory activities were devolved to the industry.

As a result of that policy, the Civil Aviation Authority reduced its previous level of involvement in a number of areas related to aviation safety.

For example, in 1991, the Civil Aviation Authority discontinued any form of regulatory oversight of aviation fuel manufacture and distribution. Following that change in policy, there were no longer any formal lines of communication between the Authority and manufacturers or distributors of aviation fuel. Hence, the Authority was only likely to become aware of any problem in fuel quality through informal channels, and possibly only by receiving reports of fuel related incidents or accidents.

In March 2001, the ATSB released Investigation Report BS20000002 *Systemic investigation into fuel contamination* following the grounding of large numbers of piston-engine aircraft across eastern Australia in early January 2000 because of contaminated aviation fuel. The existence of widespread fuel contamination of that nature had the potential to severely affect the safety of flight of many aircraft.

The ATSB report into the fuel contamination found that there was no indication to suggest that the Civil Aviation Authority considered the effect on safety when it decided to discontinue any oversight of aviation fuel quality. The report stated:

43 The report included 14 recommendations from the CASA review team and a further 10 recommendations from an external expert panel and a world expert in the subject that reviewed the original report.

44 Civil Aviation Authority Annual Report 1990-91.

> The conscious abrogation [on the part of the Civil Aviation Authority] of any responsibility for regulatory oversight of a requirement for flight that was safety critical removed an essential organisational element in the system of safe aviation.

As a result of the investigation, on 30 March 2001, the ATSB issued Safety Recommendation R20000133 to CASA:

> The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority ensure that prior to any significant devolution or change in regulatory process, appropriate measures are taken to ensure that aviation safety is not diminished.

At the date of publication of this report, CASA had not provided a response to Safety Recommendation R20000133 to the ATSB.

Observation:

Similarities are evident in the unintended consequences of a reduction in the involvement of Authority specialist staff in reviewing manufacturers' service bulletins relevant to Australian Class A aircraft and the Authority's decision to discontinue the regulatory oversight of aviation fuel manufacture and distribution.

It would be prudent for CASA to review its policy for managing changes to civil aviation requirements to seek to ensure that no unintended, but identifiable and manageable, risks are introduced by the changes.

7.5 Changes to CASA methods of aviation industry oversight

In essence, CASA regulates Australia's aviation industry through:

- initiating civil aviation legislation
- the issuing of licenses, certificates, delegations, and authorisations
- surveillance
- enforcement processes
- safety education.

CASA's approach to surveillance was outlined in its Aviation Safety Surveillance Program (ASSP) manual. The manual was initially introduced in May 1994, with new versions issued in May 1996, September 1997, and August 1999 (version 4.0).

Section 1.1.1 of the ASSP manual (August 1999) stated that the purpose of the manual was to identify the responsibilities of surveillance personnel, and to provide guidelines and procedures for surveillance planning, conducting surveillance, recording and reporting surveillance activities, and analysing surveillance data. Section 2.1.1 stated that the ASSP was a "surveillance strategy undertaken in a systematic manner to provide an assessment of the aviation industry's safety level and to implement appropriate responses".

The ASSP manual referred to product audits and systems audits as being the two main types of surveillance activity. Product audits focussed on inspecting the end-product of a system. They were the traditional type of surveillance activity conducted by CASA and other similar regulatory authorities. The ASSP manual defined a systems audit as:

> an audit of the organisational structure, management responsibilities, procedures, processes and resources of the auditee.

CASA's product-based surveillance system was structured around individual inspections by the Authority's operational staff. CASA's compliance branch staff reported that the ability of the traditional product-based approach to identify safety deficiencies was limited. In effect, the product-based approach meant CASA was performing an external quality control function by trying to identify problems with the end-product of the aviation system.

CASA began to introduce a systems audit approach to surveillance in the mid–1990s, in line with global developments[45]. CASA staff were provided with training in quality systems audit techniques, and attempts were made to integrate those techniques into the surveillance system. However, there was a lack of understanding among staff as to where the techniques fitted into the role of a regulatory inspector. As a result this initial attempt to introduce systems audits stalled.

In May and June 1997, CASA Compliance Branch personnel met with representatives of the major airlines to discuss surveillance issues. The meeting agreed that the airlines should introduce a quality assurance approach to their operations to enhance aviation safety management. It was also agreed that CASA surveillance should focus on an operator's management systems rather than the end-product of the operation. It was noted that other regulatory agencies had been introducing similar approaches.

CASA was aware that, given its resource constraints, it was unlikely that it would be able to conduct product surveillance at the levels specified in the ASSP. The approach, therefore, was for operators to use their internal expertise to detect end-product failures, and for the Authority to focus its activities on ensuring that operators had appropriate management systems and procedures in place to prevent end-product failures.

In 1997, CASA increased its efforts in developing a systems-based approach to surveillance because of the limitations of the product-based audit approach. General details concerning the new approach and how it was to be implemented were introduced into the ASSP manual in June 1997. However, these were primarily administrative procedures, and provided little guidance to CASA personnel on how to actually audit an operator's systems. Some trial audits using these procedures were conducted.

It was intended that further systems-based audits would be trialed on two major operators in the 1998–99 financial year, and to accommodate those trial audits, the planned frequency of traditional product-based audit activities was significantly reduced. However, the trial did not commence as planned. CASA personnel reported that there were some difficulties developing an appropriate systems model and guidance material. There was also some resistance to the new approach from CASA inspectors, who believed that it was important for CASA to be conducting a significant amount of end-product inspection activities.

In April 1999, a specialist auditor was appointed to the position of CASA Manager Compliance Practices and Procedures. In June 1999, a planned project to introduce the new surveillance approach was commenced. The new approach consisted of systems-based audits with product surveillance included. The goal of the surveillance review was established as:

45 Challenge 2000: *Recommendations for future aviation safety regulation*. Booz-Allen & Hamilton, McLean, VA, 1996.

> To encourage and achieve industry development of management responsibility and effective safety management processes whilst efficiently monitoring and evaluating industry compliance.

A major component of the systems-based safety audits was the use of multi-disciplinary teams of CASA personnel, including flying operations inspectors, airworthiness inspectors, and cabin safety and engineering experts. Industry was briefed on the proposed approach, and audit guidelines and a safety system specification were developed. Systems-based safety audits of flying operations started in July 1999 in Brisbane, Melbourne and Sydney, and included product-based audits during the changeover.

In August 1999, an ICAO audit of the Australian civil aviation oversight system was carried out as part of the ICAO Universal Safety Oversight Audit Programme (see section 2.2.3). The objective was to determine whether Australia complied with the safety oversight related standards and recommended practices of Annex 1, *Personnel Licensing*, Annex 6, *Operation of Aircraft*, Annex 8, *Airworthiness of Aircraft* and related provisions in other Annexes. This was a part of an ICAO program of auditing all States that were signatories to the *Chicago Convention*. The ICAO audit of the Australian safety oversight system noted, among other issues, that:

- A large number of differences existed between the Australian regulations and relevant ICAO Annex provisions. However, the Australian provisions were not necessarily of a lower standard than the minimum requirements of the Annex provisions.
- CASA was facing an important challenge due to simultaneous internal reorganisation, changes in the oversight policy from product inspections to systems audits, and a complete restructuring of the regulations.
- Australia had an elaborate system of designees and relied on approximately 2,500 designees acting under Instruments of Authorisation and Delegations to complement its work. Although this system was generally found to be adequate, no formal procedures had been established for the surveillance of designees.
- The areas of aircraft certification, manufacturing and continuing airworthiness were satisfactory. However, revision of the airworthiness regulations, and the need for aircraft maintenance reliability information to be maintained and sent to CASA as part of CASA's risk management system, were areas which required improvement.

The shortcomings of CASA's product-based audits and the adoption by it of a systems-based audit approach have also been reported on previously by the ATSB[46].

In November 1999, the Australian National Audit Office (ANAO) undertook an audit of CASA's surveillance and enforcement activities. The report pointed out a number of shortcomings in the surveillance system, including a serious shortfall in meeting inspection targets. A follow-up audit in June 2002 indicated that the position was significantly improved and concluded:

> Overall, CASA has improved its management of aviation safety compliance since the 1999 audit, particularly in areas such as the identification of risks at the operator level;

46 See Investigation Reports 199802830 *Cessna 185E Floatplane VH-HTS, Calabash Bay, NSW, 26 July 1998*; 199904538 *Boeing 747-438 VH-OJH, Bangkok, Thailand, 23 September 1999*; and 200002157 *Piper PA31-350 Chieftain VH-MZK, Spencer Gulf, SA, 31 May 2000*.

the frequency and coverage of surveillance; and enforcement of the Act. CASA has adequately addressed the majority of the recommendations from the 1999 audit and has partially implemented the remaining relevant recommendations.

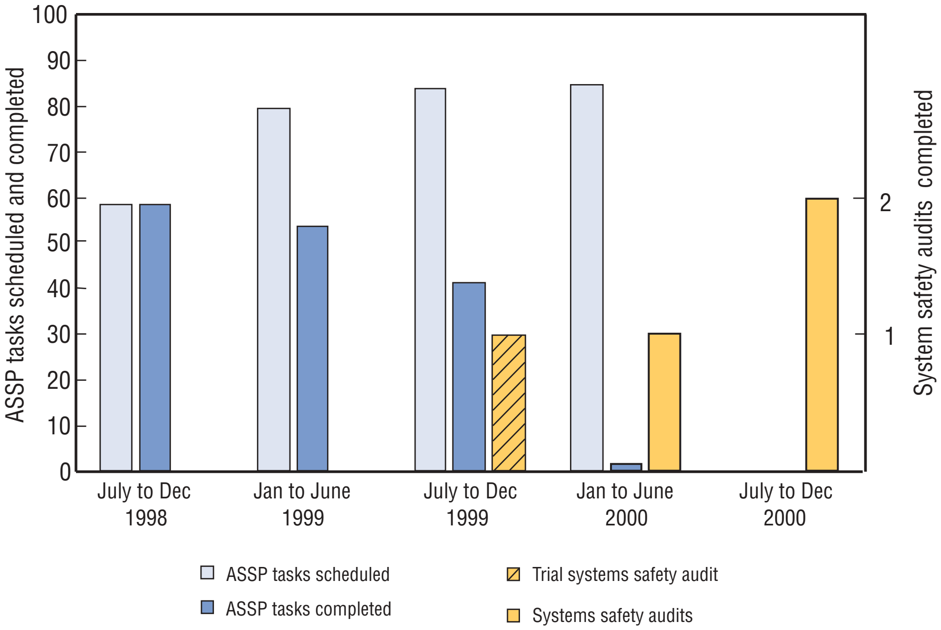
7.6 CASA surveillance of Ansett engineering and maintenance

CASA surveillance of Ansett engineering and maintenance was conducted both formally and informally.

Day to day dealing with Ansett engineering issues was primarily the responsibility of a senior engineer from the CASA Melbourne office. Informal surveillance of the Ansett engineering and maintenance organisation was based on unscheduled visits by the engineer, or other CASA personnel, in the course of their normal duties. That informal surveillance was not documented on CASA files.

Figure 34 provides a picture of the formal airworthiness surveillance conducted on Ansett up to December 2000. The different approach to surveillance adopted through systems-based audits is such that it is not possible to make a comparison between the old product-based surveillance and the new systems-based approach. Rather, the figure indicates when systems audits were conducted and how the overall level of surveillance reduced significantly during the transition period.

FIGURE 34:
CASA airworthiness surveillance of Ansett from July 1998 to December 2000



Note: Data for product-based and systems-based surveillance are shown on the one figure for convenience. However, because of the different approaches the scales used for product-based and systems-based audits cannot be directly compared.

The systems-based safety audits of Ansett conducted in August 1999 (a trial audit), June 2000, September 2000 and November/December 2000 were not focussed on Ansett's handling of continuing airworthiness information. Product-based surveillance of Ansett ceased in March 2000. This was three months before the developed CASA systems-based audit program for Ansett was begun and was a period during which Ansett was undergoing significant change.

The June 2000 systems-based safety audit of Ansett did not examine areas relevant to the handling of service bulletins or the Maintenance Development section. The audit noted, among other things, a number of minor issues in relation to the control of documents and records, primarily relating to dangerous goods, but generally found that Ansett had procedures and practices in place to meet its regulatory obligations.

The handling of service bulletins and airworthiness issues was also not assessed during the September 2000 systems-based safety audit. However, the audit identified a number of issues that suggested that the Certificate of Approval holder was in a risk situation. Some of those issues related to:

- a recent high turnover of qualified staff and license holders
- staff training, including LAME (Licensed Aircraft Maintenance Engineer) training programs
- the low morale of staff working on aircraft
- the number of defects carried by company aircraft and a shortage of spare parts, reflected by the high number of ‘cannibalised’ parts from aircraft in heavy maintenance
- change within the company, including change of ownership, a change of structure and many management changes.

CASA introduced a system of Safety Trend Indicators questionnaires during the implementation of the systems-based safety audits. The questionnaires, which were completed by auditors about the organisations they were auditing, were intended to provide an indication of an organisation’s ability to consistently produce a product that supported safe aviation.

A Safety Trend Indicator questionnaire related to Ansett was completed on 6 October 2000, and comments appended to the questionnaire noted that:

> Ansett currently being taken over by Air New Zealand with a joint Engineering Org [organisation] to eventuate, this is causing low morale and unknown factors to arise. CASA involved in changes taking place.

A systems-based safety audit of Ansett conducted in November/December 2000 did not examine the Maintenance Development section or the handling of service bulletins, but did examine some aspects of maintenance control. The audit found that suitable systems were in place for the areas examined, but with regard to maintenance control, there was insufficient guidance material in certain processes that could contribute to errors of judgement being made.

Another Safety Trend Indicator questionnaire was completed on 22 December 2000, and included the comment:

> Company will face significant organisational change during the next 12 months, due to amalgamation with AIR NZ [Air New Zealand].

No information was found to indicate that CASA had increased safety-systems surveillance of the Ansett engineering and maintenance organisation prior to April 2001, in response to the significant and ongoing change that was occurring at all levels of the organisation (see section 6.13.1).

Observations:

- The traditional CASA product-based surveillance system had not revealed the systemic deficiencies in the Ansett engineering and maintenance organisation.

- The introduction of the new systems-based surveillance system by CASA from June 2000 provided a potentially better tool for identifying organisational deficiencies. However, the system was not sufficiently mature to have been likely to have identified Ansett's systemic deficiencies.
- Although there had been a number of indicators that Ansett was in a situation of increasing risk, there was no consequent increase in CASA's airworthiness surveillance of Ansett.

Safety Recommendation R20020246

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority, as a part of its oversight role, review the policies and procedures for carrying out, and responding to the findings of, risk assessments of organisations that operate Class A aircraft. The review should address the adequacy of methods for:

- gathering and assessing information relevant to possible risks to safe operations
- determining, carrying out, and reviewing the CASA response to the assessed level of risk.

CASA has indicated (16 August 2002) that it supports this recommendation in principle. CASA reported that it is currently developing an enhanced version of the Safety Trend Indicator which will capture more data and enhance CASA's comparative risk analysis capability. The intention is to monitor each component of an airline's operations so that audits can be focussed on the components that pose the greatest safety risk.

7.7 Major defect reporting

A 'major defect' in an aircraft is defined in the Civil Aviation Regulations 1988, r. 2, as:

> … a defect of such a kind that it may affect the safety of an aircraft or cause the aircraft to become a danger to person or property.

Australian Civil Aviation Regulations 1988, r. 51, requires the holder of an aircraft's Certificate of Registration to submit a report to CASA of any major defects, to investigate those defects, and to report to CASA on that investigation. CASA retains the right to investigate any defect on its own behalf.

Civil Aviation Regulations 1988, r. 51A, defines a subset of major defects more prescriptively to include defects that have caused, or could cause:

- a primary structural failure
- a control system failure
- an engine structural failure; or
- fire in an aircraft.

Civil Aviation Regulations 1988, r. 51A, requires any person connected with the operation of, or the carrying out of maintenance on, an aircraft, to advise CASA immediately of any defect detected within the definition of section 51A. In addition, Civil Aviation Regulations 1988, r. 52A(3), requires that a report of any other major defect must be sent to CASA within two working days of the discovery of the defect.

The major defect reporting system[47] is an important component in the continuing airworthiness system. Its purpose is to ensure that defect information is received, analysed, and acted on in a timely manner. For the system to succeed, operators must provide complete and accurate defect information to CASA. However, according to CASA, there has been a declining reporting level from operators due to:

- a reluctance to report in case of enforcement actions
- a misunderstanding of responsibilities and procedures
- perceived poor feedback mechanisms.

Information from the major defect reporting database is publicly available on the CASA web site. However, the information is provided without explanation or qualification. In some cases information received through the major defect reporting system is disseminated by way of other CASA documentation such as Airworthiness Bulletins[48] or by publication in *Flight Safety Australia*, CASA's safety magazine.

The events surrounding Ansett's handing of cracks found in the area of the Body Station 1809.5 bulkhead outer chord of its B767 aircraft demonstrated some of the shortcomings in the operation of the Australian major defect reporting system.

Ansett first identified cracks in this area of one of its B767 aircraft during an inspection on 19 January 1996 (see section 6.3). Ansett's original major defect report on the Body Station 1809.5 bulkhead cracks was received by CASA on 22 February 1996. The CASA Melbourne office closed that defect as a 'known defect', as CASA were aware of an 'in-service activities report' issued by Boeing about that defect in 1993. There were three other identified instances of cracking in Ansett B767 Body Station 1809.5 bulkheads before December 2000. However, only one of those was the subject of a major defect report (VH-RMD, 20 January 1997).

It was reported that there was a misunderstanding by Ansett as to whether there was a requirement to repeatedly report the same defect type after submission of the original report. As a result, CASA was not always notified of recurring defects and, therefore, the frequency and significance of some defects could not be adequately recognised by CASA. In addition, until early 2001, Ansett's Procedures Manual specified that major defect reports were to be submitted to CASA only after the completion of an Ansett investigation. That procedure had the potential to delay CASA's awareness of those defects.

Ansett's Procedures Manual did not specify whether major defect reports should be sent to the CASA Melbourne office or to the CASA Canberra central office. In June 1998, a decision was made in CASA to centralise all major defect reporting to the Canberra office. However, the CASA Melbourne office realised this would remove a valuable source of information, and requested that Ansett also provide them with copies of major defect reports sent to the CASA Canberra office. Ansett found that arrangement 'administratively burdensome' and it was agreed with CASA for Ansett to continue to send major defect reports to the CASA Melbourne office, and not to the CASA Canberra office.

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47 The CASA major defect reporting (MDR) system has recently been renamed the service difficulty reporting (SDR) system – see CASA Airworthiness Bulletin AWB 00-4, *Service Difficulty Reporting System*, (May 2001).

48 CASA issues Airworthiness Bulletins to disseminate essential airworthiness information not considered mandatory. Prior to April 2001, Airworthiness Bulletins were called Airworthiness Advisory Circulars.

Observation:

The CASA Canberra central office database for major defect reports was incomplete, partly due to deficiencies in reporting, and the information received was not fully analysed. In addition, feedback to the initiators of major defect reports, and to other operators, was limited. As a result, the potential safety benefit of the major defect reporting system was not fully achieved.

Safety Recommendation R20020247

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority review the structure and procedures of the major defect reporting system to ensure that:

- all relevant defect information is received from operators in a timely manner
- defect information received is monitored, processed, and analysed
- defect information and information derived from subsequent investigations is disseminated to all relevant parties and made publicly available.

CASA has indicated (16 August 2002) that it supports this recommendation in principle, stating that as a result of a review of the service difficulty reporting system it has implemented a number of measures to improve the system, including:

- introducing procedures to ensure that principal maintenance specialists review all reports
- developing a service difficulty report workflow management system
- providing monthly reports to the CASA Executive on all reports that are still open.

7.8 Certification Maintenance Review

ICAO Annex 8, Part II, p. 5.1 requires that for an aircraft's Certificate of Airworthiness to remain valid, the continuing airworthiness of the aircraft shall be determined by a periodical inspection. As outlined in the ICAO *Airworthiness Manual*,[49] that requirement is intended to ensure that compliance is maintained with the aircraft's type design, and that the aircraft's system of maintenance meets continuing airworthiness requirements.

To assist in meeting this requirement, Certification Maintenance Reviews are required by some national airworthiness authorities; for example, the New Zealand Civil Aviation Authority (Civil Aviation Regulations, s. 121.417, *Maintenance review*) (see Appendix 19). At the time of publication of this report a Certification Maintenance Review was not required under Australian regulations.

The object of a Certification Maintenance Review is to ensure that all work required to maintain the continuing airworthiness of an aircraft has been carried out. In particular, the review verifies whether:

- all the maintenance specified in the maintenance program for the aircraft has been completed within the time periods specified
- all applicable airworthiness directives have been complied with

49 ICAO *Airworthiness Manual* (Doc 9760-AN/967, 2001), Volume II, Part B, Chapter 4, *Maintenance of the validity of the Certificate of Airworthiness*, p. 4.1.1.

- all defects entered in the maintenance records have been rectified or properly deferred.

A Certification Maintenance Review should ensure that both operator and regulator can be satisfied that for each Class A aircraft all the mandatory requirements for continuing airworthiness have been met. This is particularly important for Class A aircraft designed under the MSG–3 damage tolerance philosophy, where the mandatory inspection program of structurally significant items is an inherent part of the requirements for continuing airworthiness.

Safety Recommendation R20020248

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority consider the introduction of a periodic Certification Maintenance Review requirement for Australian Class A aircraft.

CASA has indicated (16 August 2002) that it agrees in principle with this recommendation, stating that this requirement will be included in the new suite of maintenance regulations to be introduced in early 2003.

8 US FEDERAL AVIATION ADMINISTRATION

8.1 Delays by the FAA in mandating B767 service bulletins

In December 2000 and April 2001, CASA specifically mandated compliance with two B767 service bulletins before action was taken by the US Federal Aviation Administration (FAA) as the State of Design and Manufacture. That was contrary to existing practice where action taken by CASA in relation to US-designed aircraft would normally follow, rather than precede, similar action taken by the FAA. In both cases, CASA acted quickly when it was established that the FAA had not acted on matters potentially concerning the safety of flight of B767 aircraft.

The sequence of events in relation to the issuing of these service bulletins by Boeing, and subsequent actions by CASA and the FAA, are outlined in Figure 32 and Figure 33 in section 7.3.2.

FAA Airworthiness Directive 2001-09-13, issued on 27 April 2001, concerned fatigue cracking in the area of the B767 Body Station 1809.5 bulkhead outer chord. Undetected cracking in that area had the potential to result in the loss of the horizontal stabiliser. FAA Airworthiness Directive 2001-08-23, issued on 18 April 2001, concerned fatigue cracking in the B767 wing front spar pitch load fitting. Undetected cracking in that area had the potential to result in the separation of the strut and engine from the aircraft.

On 24 August 2001, the US Secretary of Transportation, whose Department included the FAA, reported:

> ...some lapse in the FAA process for issuing airworthiness directives that may have contributed to the situation in Australia with the Ansett 767 aircraft. In reviewing our records we found that in the case of the Ansett 767 airplanes, two Boeing service bulletins were inadvertently not made mandatory by the FAA through an airworthiness directive (AD). In October 1999, the FAA changed its internal process for overseeing continued airworthiness of Boeing products and has instituted improvements to our review system. Unfortunately, these two bulletins were not adequately assessed. If we had reviewed them in greater depth, the applicable ADs would have been issued last year.

The Secretary of Transportation also reported that changes had been made to FAA procedures to ensure that, in future, all service bulletins issued by US manufacturers would be properly assessed, and appropriate action taken.

The lack of timely action by the FAA in relation to Boeing Service Bulletins 767-53-0078 and 767-57A0070 led in turn to an initial lack of awareness by CASA of the nature of the defects the bulletins related to. However, when CASA became aware that the two service bulletins had not been adequately addressed it took action in December 2000 and April 2001 respectively (see section 7.3.2).

Observation:

The FAA did not take timely action to issue airworthiness directives in relation to two B767 service bulletins, and consequently CASA was not alerted to significant flight safety issues for that aircraft type. These events indicated a reliance on the part of CASA on timely action being taken by the State of Design or Manufacture to ensure the continuing airworthiness of Australian Class A aircraft.

It is desirable that CASA satisfy itself that such problems have been addressed by the FAA, and that similar problems are not an issue in other bodies acting on the behalf of a State of Design or Manufacture.

8.2 Delays by the FAA in mandating B767 airworthiness limitations

In the US, aircraft that have been certified to damage tolerance standards must have Instructions for Continued Airworthiness that include an Airworthiness Limitations section (see 4.2.3). Typically, the specific airworthiness limitations material that must be complied with is referenced in the Type Certificate Data Sheet for the particular aircraft type. For example, the Type Certificate Data Sheet for the B767 references the B767 *Maintenance Planning Data Document*, section 9.

Aircraft manufacturers may need to incorporate new or more restrictive life limits and inspections into the Airworthiness Limitations section from time to time, based on in-service experience and post-certification testing.

In practice, revised requirements are developed by the manufacturer with input from operators and airworthiness authorities, and in the first instance promulgated by the State of Design. The requirements are then forwarded to States of Registry to act on as they deem appropriate as they are in the best position to determine what aspects of the requirements should be mandatory for aircraft on their register.

In the US, revisions to airworthiness limitation requirements cannot be imposed ‘retrospectively’ on aircraft already in service, except by specific legal action, because new or more restrictive requirements are considered ‘rules’ under the US *Administrative Procedures Act 1946* (United States Code, Title 5, Sub-chapter II). A ‘rule’ is broadly defined to include statements of agency policy prescribing legal requirements. Hence, for existing US aircraft, the FAA can only require compliance with the new or more restrictive inspection requirements by engaging in specific rulemaking. In practice that is achieved by issuing an airworthiness directive.

Normal practice is for the FAA to first issue a Notice of Proposed Rule Making, which contains the details and justification of the proposed rule. A period is then allowed for public comment. Usually this is between 60 to 120 days, except that for airworthiness matters related to transport category aircraft a shorter comment period of between 30 and 45 days is allowed. This normal procedure can be bypassed by the rapid issue of an emergency airworthiness directive if immediate action is required to address an urgent safety issue.

In contrast to the approach taken by the FAA, other States of Design may not issue airworthiness directives when airworthiness limitations are revised. However, by whatever means, the State of Design should transmit continuing airworthiness information to States of Registry for the safe operation of their aircraft, in accordance with ICAO Annex 8, Part II, p. 4.2.2.

8.2.1 FAA regulatory action in relation to the B767 *Maintenance Planning Data Document* June 1997 section 9 revision

The FAA process for mandating and managing the release of the Airworthiness Limitations Structural Inspections for an aircraft type designed to damage tolerance criteria was developed for the first time for the Boeing 767 and 757 aircraft, which were the first US aircraft designed to damage tolerance criteria.

Revision 15 of the B767 Type Certificate Data Sheet, dated 1 August 1997, incorporated a note advising that the FAA intended to issue an airworthiness directive to mandate compliance with the B767 Airworthiness Limitations Structural Inspections contained in the June 1997 revision of section 9 of the *Maintenance Planning Data Document*.

It was foreshadowed that the proposed airworthiness directive would be applicable to all existing B767 aircraft, namely those with production line numbers 1–668. The airworthiness directive did not apply to B767 aircraft with production line numbers 669 and greater, because the Type Certificate Data Sheet that covered their certification (revision 15 or later) directly mandated compliance for those aircraft.

The FAA Notice of Proposed Rule Making for the airworthiness directive to mandate the B767 *Maintenance Planning Data Document* June 1997 section 9 revision was issued on 28 January 1999, approximately 18 months after the issue of revision 15 of the B767 Type Certificate Data Sheet. The Notice of Proposed Rule Making (97-NM-276-AD, Federal Register 64(18), 4372-4374) required that comments from interested parties be received by 15 March 1999.

The summary to FAA Notice of Proposed Rule Making 97-NM-276-AD said in part:

> The revision [to B767 *Maintenance Planning Data Document* section 9] would incorporate into the ALI [Airworthiness Limitations Instructions] certain inspections and compliance times to detect fatigue cracking of principal structural elements (PSE). This proposal is prompted by analysis of data that identified specific initial inspection thresholds and repetitive inspection intervals for certain PSE's (identified as structural significant items - SSIs - in the ALI) to be added to the ALI. The actions specified by the proposed AD [airworthiness directive] are intended to ensure that fatigue cracking of various PSE's is detected and corrected; such fatigue cracking could adversely affect the structural integrity of these airplanes.

During March 1999, the FAA received responses to the Notice of Proposed Rule Making from Boeing, four air transport operators, the Air Transport Association (ATA), and the Air Line Pilots Association. The correspondence from the ATA summarised the input of two of the individual airlines. No substantive changes were made to the proposed airworthiness directive as a result of responses received.

On 19 April 2001, the FAA issued Airworthiness Directive 2001-08-28 that mandated the June 1997 *Maintenance Planning Data Document* section 9 revision for aircraft with line numbers 1-669 inclusive[50]. The airworthiness directive read in part:

> Revise Section 9 of the Boeing 767 Maintenance Planning Data (MPD)
>
> (a) Within 3 years after the effective date of this AD, revise Section 9 of the Boeing 767 Maintenance Planning Data (MPD) Document entitled 'Airworthiness Limitations and Certification Maintenance Requirements (CMR's)' to incorporate Subsection B of Boeing Document D622T001-9 [section 9 of the *Maintenance Planning Data Document*], Revision 'June 1997'.

The effective date for FAA Airworthiness Directive 2001-08-28 was 1 June 2001, hence compliance was required before 1 June 2004.

50 As Revision 15 of the B767 Type Certificate Data Sheet directly mandated compliance for aircraft with line numbers 669 and above, aircraft 669 is covered in both instances. However, that fact does not appear to carry any significance.

Observation:

Three and a half years elapsed between the FAA amendment of the B767 Type Certificate Data Sheet (August 1997) that foreshadowed an airworthiness directive to mandate compliance with the June 1997 *Maintenance Planning Data Document* section 9 revision, and the issuing of that airworthiness directive by the FAA in April 2001. That delay had the potential to result in poor safety outcomes.

If that process had been concluded in a more timely manner, the airworthiness directive would possibly have alerted Ansett (and other operators) to the process intended to mandate the B767 Airworthiness Limitations Structural Inspection requirements, and to the time frame involved for compliance with the program.

8.2.2 FAA regulatory action in relation to the B767 *Maintenance Planning Data Document* June 2000 section 9 revision

The original B767 Airworthiness Limitations Structural Inspection program released in the June 1997 revision of the *Maintenance Planning Data Document*, section 9, was mandated by the FAA for aircraft with production line numbers 1–669 on 19 April 2001 by FAA AD 2001-08-28. The next B767 *Maintenance Planning Data Document* section 9 revision was dated June 2000 and included three Body Station 1809.5 Airworthiness Limitations Structural Inspection items, each with a flight cycle threshold of 25,000 cycles. Those inspection items were the focus of the withdrawal from service of Ansett B767 aircraft VH-RMD/E/F/G/H/K/L on 23 December 2000 (see section 6.7).

At the time of publication of this report, the FAA had not issued an airworthiness directive mandating compliance with the B767 *Maintenance Planning Data Document* section 9 June 2000 revision. On 10 October 2001 the FAA advised the ATSB that the FAA Seattle Aircraft Certification Office had sent the necessary information to the FAA Transport Aircraft Directorate for the preparation and release of the Notice of Proposed Rule Making and that work on the draft had commenced. It was stated that the timing of the Notice of Proposed Rule Making release could be affected by higher priority airworthiness directive work.

8.2.3 FAA regulatory process for later damage tolerance aircraft types

Information received from the FAA indicates that it intends to apply the same regulatory process used for mandating and managing the release of the B767 Airworthiness Limitations Structural Inspection program to other US damage tolerance aircraft types designed to Federal Aviation Regulations, s. 25.571, *Damage-tolerance and fatigue evaluation of structure.*

One benefit of mandating compliance with revised Airworthiness Limitations Structural Inspection requirements by airworthiness directive is that the revised requirements are more likely to come to the attention of other States of Registry. That is because States of Registry are likely to have well developed systems for monitoring airworthiness directives issued by States of Design. In contrast, States of Registrys' systems for monitoring changes to the operating rules of other States are likely to be less well developed and it is possible that if that method was used to promulgate airworthiness limitation information then some States of Registry might not be alerted to the new requirements.

However, the method adopted by the FAA for mandating revised Airworthiness Limitations Structural Inspection requirements has the potential to result in delay, as evidenced in the case of the B767. For every revision to the Airworthiness Limitations Structural Inspections, for every US-designed damage tolerance aircraft type, the FAA will be required to:

- amend the Type Certificate Data Sheet for the aircraft type
- issue a Notice of Proposed Rule Making and assess the responses received; and
- issue an airworthiness directive mandating compliance for existing aircraft.

This cycle of regulatory actions will need to be repeated numerous times as successive revisions to the Airworthiness Limitations Structural Inspection program are released in light of in-service experience and other information. In the case of the B767 the time taken to complete the first regulatory process cycle exceeded three years. At the time of publication of this report, the second cycle had yet to be completed.

Observation:

The system used by the FAA to mandate compliance with new or more restrictive Airworthiness Limitations Structural Inspections for existing aircraft by issuing an airworthiness directive has the advantage of being highly visible to States of Registry that require the information. However, the process is complex and has the potential to result in significantly delayed outcomes.

8.2.4 The priority accorded to FAA Airworthiness Limitations Structural Inspections airworthiness directives

The damage tolerance based Airworthiness Limitations Structural Inspection requirements are developed to ensure that the structural integrity of an aircraft is maintained throughout its service life. Loss of structural integrity can potentially led to a catastrophic failure and loss of the aircraft. Therefore, compliance with the inspections is essential for safe operation and is normally mandated by the State of Registry. The mechanism by which this is achieved for existing US-registered aircraft is by the issuing of a series of airworthiness directives that cover successive revisions to the Airworthiness Limitations Structural Inspections.

In general, airworthiness directives are issued when an unsafe condition is known to exist in an aircraft or aeronautical product and the condition exists, or is likely to exist or develop, in other aircraft or aeronautical products of that type (see Appendix 11).

The FAA *Airworthiness Directives Manual,* section 158, outlines why it is appropriate that the airworthiness directives process is used to mandate the damage tolerance Airworthiness Limitations Structural Inspections (see Appendix 20):

> Because loss of structural integrity would constitute an unsafe condition, it is appropriate to impose these requirements through the AD [airworthiness directive] process.

The purpose of the FAA Airworthiness Directive 2001-08-28 was to address the identified unsafe condition of fatigue cracking in certain structurally significant items of some B767 aircraft. The corresponding Notice of Proposed Rule Making 97-NM-276-AD specifically stated that an unsafe condition had been identified that was likely to exist or develop in other B767 aircraft. The proposed actions were intended to ensure that fatigue cracking would not adversely affect the structural integrity of those aircraft.

Although the FAA Airworthiness Directive 2001-08-28 addressed a known unsafe condition, a period of approximately three and a half years elapsed between the time that the airworthiness directive was first foreshadowed in August 1997 and when the directive was finally issued in April 2001.

The FAA Aircraft Certification Service (21 December 2001) explained the delay in issuing Airworthiness Directive 2001-08-28 in the following terms:

> In evaluating this delay, it is well to keep in mind that the primary purpose of ADs [airworthiness directives] is to address an existing unsafe condition in a product that is likely to exist or develop in other products of the same type design. The structural inspections of section 9 of the MPD [B767 *Maintenance Planning Data Document*] are not performed to mitigate a known unsafe condition which is the primary purpose of an AD; they are performed to discover any possible unsafe condition that may exist or develop in the fleet as it ages. Once an unsafe condition is identified by one of these inspections, or by any other means of discovery, a new AD would be issued addressing that particular unsafe condition.
>
> The Federal Aviation Administration Transport Airplane Directorate handles about 650 AD actions per year. In considering the priorities for attention, existing and known unsafe conditions are given priority. Since AD 2001-08-28 was mandating the revision of a document, it did not address a known unsafe condition requiring immediate attention.

The argument by the FAA Aircraft Certification Service that Airworthiness Limitations Structural Inspections do not address an existing unsafe condition is not in accord with MSG–3 damage tolerance design philosophy (see section 4.2). Under that approach, the mandatory Airworthiness Limitations Structural Inspections are designed to detect fatigue cracks in areas of the aircraft structure that have been shown to be more susceptible to fatigue and corrosion damage than expected, based on testing and in-service experience.

Observations:

- There was evidence of a significant difference in understanding as to the reason and importance of the Airworthiness Limitations Structural Inspections for damage tolerance aircraft types within different sections of the FAA.
- The FAA Aircraft Certification Service did not accept that the requirements of the Airworthiness Limitations Structural Inspections addressed a known unsafe condition requiring immediate attention. That resulted in a delay in issuing the US airworthiness directive for the June 1997 revision of B767 Airworthiness Limitations Structural Inspection program.
- If FAA Airworthiness Directive 2001-08-28 had been issued in a more timely manner, it would have provided an additional source of information to alert Ansett and CASA to the revised requirements of the B767 Airworthiness Limitations Structural Inspection program.

On 21 December 2001, the FAA Aircraft Certification Service reported that, in relation to the delay in issuing FAA AD 2001-08-28:

> After review, including consideration of airline feedback, we have not identified any substantive problems resulting from the delay in issuing AD 2001-08-28.

Safety Recommendation R20020240

The Australian Transport Safety Bureau recommends that the US Federal Aviation Administration ensure that there is a defined and consistent understanding throughout the FAA as to the importance of airworthiness directives that mandate revisions of the Airworthiness Limitations Structural Inspections for damage tolerance aircraft types, and that such airworthiness directives are processed and released without undue delay.

8.3 Delays in FAA rulemaking processes

The delay by the FAA in issuing airworthiness directives for the June 1997 and June 2000 revisions of the B767 Airworthiness Limitations Structural Inspection program reflected problems that had been evident in the FAA rulemaking system for many years[51].

A 1998 report by the US National Research Council's Committee on Aircraft Certification Safety Management considered delays in the FAA rulemaking process related to continuing airworthiness[52]. The report concluded that the rulemaking process was excessively complex and that not enough staff hours were dedicated to rulemaking in the relevant FAA offices. As a result, worthwhile safety-related rulemaking projects could languish for years. It was stated that significant delays occurred during reviews of Notices of Proposed Rulemaking and final rules by the Office of the Secretary of Transportation. Delays were also caused by differing and strongly held points of view within the FAA, other federal agencies, and/or industry. In such cases, deferring action or referring a matter back to another office for reconsideration was often the easiest, but least productive, course of action.

Recent attempts to address the problem began in 1996, when the US Congress passed legislation setting specific deadlines for FAA rulemaking action. For example, Congress established a 16 month timeframe for the finalisation of significant rules after the close of the public comment period. In 1998 the FAA undertook a major reform effort to address the identified problems and to respond to the timeframes for rulemaking that the Congress had established.

FAA Airworthiness Directive 2001-08-28 that mandated the June 1997 *Maintenance Planning Data Document* section 9 revision was issued approximately two years after the close of the public comment period.

Observation:

There has been evidence of significant and endemic delays in the FAA rulemaking process over many years. The events of December 2000 demonstrated the potential consequences of such delays. It would be prudent for States of Registry to consider the potential impact that delays in the FAA rulemaking process could have on the continuing airworthiness assurance of US-designed and/or manufactured aircraft types on their register.

Safety Recommendation R20020241

The Australian Transport Safety Bureau recommends that the US Federal Aviation Administration ensure that adequate systems are in place to alert States of Registry of US-designed and/or manufactured aircraft types when delays in FAA rulemaking have the potential to compromise the continuing airworthiness assurance of those aircraft types.

8.4 Determination of grace periods

The introduction of mandatory continuing airworthiness requirements, such as the B767 Airworthiness Limitations Structural Inspections, involves the determination of compliance thresholds and grace periods. Inspection programs of that kind are

51 *How to improve the Federal Aviation Administration's ability to deal with safety hazards.* Report by the Comptroller General of the United States. Report No. CED-80-66, February 1980.

52 *Improving the Continued Airworthiness of Civil Aircraft: A Strategy for the FAA's Aircraft Certification Service.* National Academy Press, Washington, DC, 1998.

developed by aircraft manufacturers and approved by the relevant State of Design. Individual States of Registry then determine what aspects of the program should be mandatory for aircraft of that type on their register.

The logic behind the development of fatigue related inspection thresholds is based on engineering principles that consider predictable rates of damage propagation, and known damage detection systems. The determination of grace periods includes the additional consideration of a range of operational and commercial concerns (see section 4.3.2.1). Compliance times may be specified in terms of flight cycles, calendar time or flight hours, depending on which are more critical for the specific problem being addressed. Typically fatigue cracking is flight cycle driven. However, related grace periods are sometimes given in calendar time.

The Notice of Proposed Rule Making for FAA Airworthiness Directive 2001-08-28, related to the June 1997 revision to the B767 Airworthiness Limitations Structural Inspections, contained a section titled *Determination of Grace Period*. The FAA argued that a three year grace period was adequate, as many of the major B767 operators worldwide, and almost all USA B767 operators, had been aware of the proposal for several years. However, the Notice of Proposed Rule Making gave no information about the analysis used to determine that the three year period was sufficiently conservative from a safety of flight aspect.

Aircraft of the same type are often flown by many different operators in many different environments and the number of flight cycles accumulated per year for individual aircraft and operators' fleets can vary greatly. Therefore, when compliance thresholds and grace periods are based on unrelated measures, for example flight cycles and calendar time, the determination of a suitable grace period may rely as much on a subjective assessment of the risk involved as on objective criteria.

Observation:

Determining an appropriate grace period involves consideration of both safety aspects, and operational and commercial factors. The process should be systematic, transparent, and fully documented. However, evidence suggests that the process may be largely a subjective one.

Safety Recommendation R20020242

The Australian Transport Safety Bureau recommends that the US Federal Aviation Administration ensure that the process for determining grace periods for aircraft to comply with airworthiness directives is both systematic and transparent. Information about the methodology and results used to determine grace periods, including those associated with the Airworthiness Limitations Structural Inspections for damage tolerance aircraft types, should be included in the relevant Notice of Proposed Rule Making.

8.5 FAA processing of airworthiness information from operators

In early 2000, the FAA established a new system for the receipt and assessment of airworthiness information provided by Boeing. The new system, the Continued Operational Safety Program (COSP), was developed to ensure that the FAA and Boeing adequately considered all service difficulties reported by operators of Boeing aircraft.

The COSP program fulfilled requirements in accordance with Federal Aviation Regulations, s. 21.3, for the reporting of failures, malfunctions, and defects from Boeing to the FAA. Communications that Boeing received from operators and Boeing field service representatives concerning continuing airworthiness issues were forwarded to the COSP committee. The committee acted separately, and parallel to, any Boeing processes for addressing the issues raised in the communication.

COSP formalised the process for investigating defects and making decisions about mandating defect control measures. Under COSP, both the FAA and Boeing assessed the defect separately, and their assessments were presented to a panel of experts from both organisations. The primary function of COSP was to assess the need for an airworthiness directive and, where appropriate, to trigger the development of an airworthiness directive by the FAA.

The formalisation of the process through the COSP system led to a significant increase in the number of service bulletins being generated.

Observation:

The increase in service bulletin numbers suggests that the COSP system has enhanced the effectiveness of the measures for identifying potential safety improvements.

9 ANALYSIS

9.1 Introduction

The operation of a Class A aircraft is a complex and safety-critical activity. The necessary degree of safety can only be achieved by successfully managing both expected and unexpected events that can potentially affect flight safety. The system for ensuring the continuing airworthiness of a Class A aircraft is crucial to achieving operational safety assurance.

This analysis discusses why the systems to ensure the continuing airworthiness of some Class A aircraft operated by a major Australian airline were not adequate to provide the desired level of assurance. In particular, the analysis addresses why:

- significant deficiencies developed within the continuing airworthiness system of the operator's engineering and maintenance organisation; and
- the presence of those deficiencies was not revealed by the Civil Aviation Safety Authority's oversight of continuing airworthiness of Class A aircraft.

The analysis also addresses the potential for enhancement of the international systems within which individual ICAO States oversee and regulate the continuing airworthiness of transport aircraft.

9.2 Ansett Australia

Over a number of years, the safety management systems employed by the Ansett engineering and maintenance organisation deteriorated to the extent that continuing airworthiness for the Ansett B767 fleet could no longer be assured.

The Ansett B767 aircraft were withdrawn from service because fatigue inspections of the aircraft structure had not been carried out. Fatigue cracking in the Body Station 1809.5 bulkhead outer chord and in the wing front spar outboard pitch load fittings had the potential to compromise the structural integrity of the aircraft.

To maintain continuing airworthiness assurance Ansett's systems had to provide a means by which Ansett could verify that it had received all necessary continuing airworthiness information, incorporated that information into its system of maintenance, and completed all necessary work required under its system of maintenance within the specified period.

None of these requirements were fulfilled for the Ansett B767 fleet. Consequently, the Ansett engineering and maintenance organisation was unable to fulfil its prime function, safety assurance, for those aircraft.

From a safety perspective, the prime concern of the Ansett events of December 2000 and April 2001 was that the events were indicative of serious underlying systemic deficiencies within the Ansett system for continuing airworthiness assurance. Those deficiencies had significant safety of flight implications, and were the result of organisational factors within the Ansett engineering and maintenance organisation.

The importance of organisational factors in ensuring air safety is well recognised[53]. Final responsibility for safety rests with the senior management of an operator, as recognised in the *Civil Aviation Act 1988*, s. 28BE (see Appendix 15).

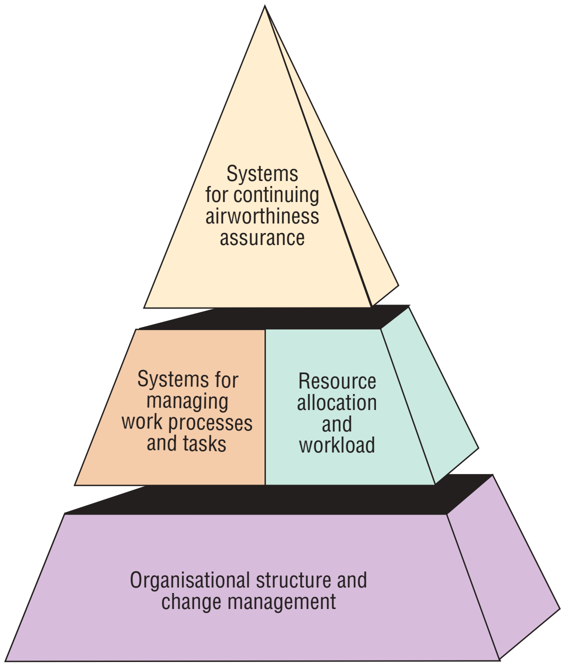
The specific deficiencies identified within the Ansett engineering and maintenance organisation can be divided into three areas:

- organisational structure and change management
- systems for managing work processes and tasks
- resource allocation and workload.

Detailed information specific to each of those areas can be found in section 6.13. The factors did not act independently of each other, but combined to greater effect, resulting in a loss of continuing airworthiness assurance.

Figure 35 indicates how, ideally, a sound organisation structure combines with robust systems and adequate resource allocation to provide continuing airworthiness assurance.

FIGURE 35:
Factors affecting the Ansett system for continuing airworthiness assurance



Loss of continuing airworthiness assurance for Ansett B767 aircraft

The Ansett continuing airworthiness system deteriorated over time to the point that Ansett could no longer be confident of the airworthiness status of B767 aircraft in its fleet.

Ansett was experienced in the philosophy and application of maintenance practices for damage tolerant aircraft. However, it mishandled a fundamental continuing airworthiness requirement for its B767 aircraft, the implementation of the

53 ICAO *Human factors digest No.10: Human factors, management and organization*. ICAO Circular 247-AN/148, 1993.

Airworthiness Limitations Structural Inspection program released in 1997. It was almost two and a half years before Ansett staff recognised that some of the inspections had been introduced with lower 25,000 flight-cycle thresholds than they expected, and that therefore some Ansett aircraft were already over the threshold. Resource constraints and a lack of adequate procedures contributed to that failure. Further inspections with a 25,000 cycle threshold, related to the Body Station 1809.5 bulkhead outer chord, were introduced in June 2000 but not actioned by Ansett.

Similar deficiencies were evident in Ansett's handling of the March 2000 Boeing Alert service bulletin concerned with cracks to the B767 wing front spar pitch load fitting. Boeing recommended that the work should be carried out within 180 days, but the service bulletin was overlooked in the Ansett system and was only rediscovered a year after it was initially issued.

Those events demonstrated that Ansett did not have adequate control of the assessment and implementation of manufacturers' service documentation for its B767 fleet, a process crucial to ensuring the continuing airworthiness of those aircraft. In addition, Ansett's internal quality assurance procedures did not detect that fundamental deficiency.

Systemic problems within the Ansett engineering and maintenance organisation

The investigation revealed that underlying systemic deficiencies within the Ansett engineering and maintenance organisation led to a loss of continuing airworthiness assurance for Ansett B767 aircraft.

Organisational structure and change management

Ansett had been subject to considerable corporate uncertainty and organisational change for an extended period of time. Those factors appear to have hindered the organisation's capacity to plan and manage strategically, and particularly affected Ansett's engineering and maintenance organisation.

The formation of ANNZES, in November 1999, from the combined engineering business units of Ansett Australia and Air New Zealand, led to significant change in the structure and management of the Ansett engineering and maintenance organisation. As a consequence, there was a considerable loss of corporate knowledge, including knowledge about the nature and limitations of the Ansett systems that supported continuing airworthiness.

Coming on top of existing pressures, the amount of change introduced into the Ansett engineering and maintenance organisation, and the time frame for its implementation, required an effort on the part of the organisation that it was not able to meet while still providing continuing airworthiness assurance for all of the Ansett fleet.

The reorganisation of the Ansett Technical Services area was intended to deliver a more efficient structure in the long term. However, in the short term the reorganisation placed considerable extra demands on resources. In some critical areas, management did not adequately allow for that extra demand on resources during the change period, resulting in some essential work receiving a low priority or not being actioned.

For example, the B767 Configuration Group was responsible for developing many of the new work functions and processes for the aircraft configuration groups, but was not sufficiently resourced to carry out that function without compromising the ongoing work of the group. During the change, some personnel assigned to the new aircraft type configuration groups were diverted back to their previous tasks. That resulted in disorder during the transition, and placed further strains on the existing resource constraints within the new groups. Hence, deficiencies in change management meant that there was a breakdown in the progress of work through the system for controlling maintenance of the B767 fleet, and not all new work could be effectively completed.

Systems for managing work processes and tasks

Ansett's procedures and work systems for continuing airworthiness assurance lacked the ability to ensure the effective completion of essential work.

That fundamental deficiency was not identified by the Ansett quality assurance function, in part because it primarily operated in a quality control manner using product-based audits, rather than assessing the appropriateness and effectiveness of the systems that the engineering and maintenance organisation relied on.

Many of the Ansett procedures critical for the continuing airworthiness assurance of its aircraft were informal and lacked the safeguards necessary to ensure that tasks were completed in a timely manner. Some key tasks were overly dependent on individuals to monitor and track the status of work within the system. That deficiency was significant in the withdrawal from service of B767 aircraft in December 2000 and April 2001.

In some cases there were no formal procedures to specify how critical functions should be performed. In other cases procedures lacked closure, creating the possibility that a failure to complete an action could go unrecognised. The system did not have the capability to ensure that time-critical work was carried out within relevant date, flight time or flight cycle limits. Hence, when a structures engineer in the Technical Services area did not action the wing front spar pitch load fitting service bulletin, there was no further defence within the Ansett system to raise an alert that the time-critical work had not been carried out.

Ansett staff had developed informal safeguards to help prevent errors. For example, in some cases staff would hand-deliver Alert documentation to the appropriate groups so that the work would not be lost in an in-tray.

The Ansett system lacked adequate formal work procedures, and was overly reliant on human performance, and therefore the system was very dependent on the competency, motivation, and workload of individual staff members in key positions. High workload in the Maintenance Development section resulted in insufficient attention being paid to the B767 Airworthiness Limitations Structural Inspection program and led to a loss of airworthiness assurance. There was little redundancy built into the system, and it was possible for human error to go undetected for a considerable period of time. Inadequate maintenance resource management, such as poor communication and coordination between individuals and functional areas, added to that problem. For example, better communication and coordination between the Ansett Maintenance Development section and the Technical Services department could have detected the missed B767 Airworthiness Limitations Structural Inspections at an earlier time.

Another weakness in the Ansett system was in the area of information management. The systems supporting the Ansett engineering and maintenance organisation had substantial data management and retrieval limitations. They were difficult to use and lacked essential functionality to safeguard against any breakdown in the processing of manufacturer service documentation. That contributed to the events of December 2000 and April 2001.

Resource allocation and workload

The loss of continuing airworthiness assurance for the Ansett B767 aircraft was due, in part, to the excessive workload of some personnel in key positions.

Resource allocation and workload issues had been evident within the Ansett engineering and maintenance organisation for a number of years. The situation was further exacerbated by the diverse, changing, and aging Ansett fleet. Inefficient maintenance practices, such as excessive cannibalisation of parts and repeated short-term maintenance fixes, placed further demands on maintenance resources.

There was evidence that efficiency measures were introduced into the Ansett engineering and maintenance organisation without sufficient tailoring to the needs of specific work areas. Repeated concerns about that situation were expressed to senior Ansett engineering and maintenance management. In August 2000, management recommended that top priority be given to airworthiness directives, scheduled services dispatch reliability and work related to aircraft delays. It was suggested that work on some lower priority items could be halted in the short term.

Putting non-urgent work on hold is at best a stop-gap measure. Evidence from Ansett indicated that a backlog of work had existed in some areas of the engineering and maintenance organisation for a number of years. The danger is that even non-urgent work must be done eventually, and in time will itself become urgent. The development of an organisational culture in which long-term delays to maintenance action are regarded as normal has the potential to reduce the capacity for effective control of all necessary maintenance action.

In any organisation, thorough risk assessment is essential for effective introduction of efficiency measures. In Ansett, there was evidence that measures aimed at achieving greater productivity throughout the engineering and maintenance organisation had been introduced without sufficient regard to the different circumstances and criticality of the different work areas within the organisation. In addition, insufficient consideration had been given to the possible consequences of resource constraints on the core activities of some safety critical areas of the organisation.

Cumulative effect of Ansett deficiencies

The greatest effect of the systemic deficiencies within the Ansett engineering and maintenance organisation was felt when they acted in combination.

The loss of continuing airworthiness assurance for the B767 fleet was brought about by a combination of inadequate systems, over-reliance on individual performance, and resource constraints. Acting individually, each of these factors may not have been serious enough to bring about the events of December 2000 and April 2001. However, acting together, they were.

Some of Ansett’s key work procedures were largely informal, poorly documented, and lacked sufficient safeguards to identify problems. Therefore, in some crucial areas the system was reliant on the commitment, experience and work performance of just one or two people. The reliance on error-free human performance was, in turn, exacerbated by workload issues.

In addition to the internal factors affecting the Ansett system for continuing airworthiness assurance, external factors also played a part. Chief among the external factors was the potential for ambiguity and confusion to be introduced because of differences in the mechanisms used by the USA and Australia to mandate compliance with certain continuing airworthiness requirements. That is an undesirable situation in a system where any misunderstanding can compromise safety.

9.3 Civil Aviation Safety Authority

CASA performs an essential role in the continuing airworthiness system. It is a difficult and complex role that can act as an important defence in limiting accidents and incidents. CASA is ultimately responsible for aviation safety regulation in Australia, as enshrined in legislation. In practice, CASA discharges that responsibility both directly, through its own actions, and indirectly, by promulgating standards and monitoring compliance by other parties.

Because the role of CASA within the Australian aviation safety system is so encompassing, particular care must be exercised when assessing the significance of CASA's role in the circumstances of any particular occurrence[54].

Lack of clarity of regulatory requirements

The regulatory basis for mandating the Airworthiness Limitations Structural Inspections was not clear in Australian civil aviation regulations.

ICAO places specific responsibilities on States of Registry to determine the continuing airworthiness of an aircraft, but it is up to individual States to determine how, and to what extent, structural inspection requirements are mandated within their jurisdiction.

Ansett and CASA believed that compliance with the B767 Airworthiness Limitations Structural Inspections was mandatory, and six of Ansett's B767 aircraft were withdrawn from service in December 2000 after it was established that some inspections had been missed. However, subsequent legal opinion cast doubt on the legal status of those inspections. As a result of that uncertainty, CASA specifically directed Ansett to comply.

One of the functions that Australian legislation confers on CASA is the promulgation of clear safety standards. In this case the documented requirements for maintaining an effective continuing airworthiness system for Australian Class A aircraft were not clear and unambiguous, and that increased the potential for a reasonable misinterpretation, and therefore an inconsistent application, of the requirements.

When subjected to scrutiny by legal experts there was no clear determination of a regulatory basis for mandating the Airworthiness Limitations Structural Inspections in Australia. However, as Ansett believed that those requirements were mandatory, the lack of legal clarity was not a factor in this instance.

Delegations and authorisations

CASA makes use of an extensive system of delegations and authorisations in the performance of its statutory functions. However, CASA remains responsible and accountable for those delegations and authorisations. That is not to say that such a system is inappropriate. On the contrary, as detailed in the ICAO *Safety Oversight Manual*, there is a need for the State (via CASA) and the aviation community to share responsibility for the safe, regular and efficient conduct of civil aviation activities. That does not diminish CASA's overall responsibilities for aviation safety. What is essential

54 See Chapter 8, *The regulator's unhappy lot,* in JT Reason (1997), *Managing the risks of organizational accidents,* Ashgate: Hants, England.

in that shared and balanced approach, is the need for CASA to have an effective oversight system for all safety-critical aspects of an operator's organisation and for those to whom it has devolved its activities.

When, in 1990, the then Civil Aviation Authority transferred the responsibility for the assessment of service bulletins to operators, that did not reduce the Authority's underlying role. CASA must still satisfy itself that appropriate action is being taken by operators of Class A aircraft in relation to service bulletins to ensure the continuing airworthiness of those aircraft. If responsibility for a safety-critical aspect of aviation is transferred to another party, and the competence and actions of that party are not adequately monitored by CASA, then CASA cannot fulfil its obligations. In combination with Ansett's ownership and commercial issues, and delays by the FAA, that devolution of responsibility led to an unanticipated increase in risk related to the continuing airworthiness systems for Ansett B767 aircraft.

CASA surveillance

To a degree, the unanticipated nature of the problems that arose in Ansett during 2000 and 2001 were a legacy of CASA's old product-based surveillance system. It is unlikely that the problems, which were brought to the attention of CASA by the airline itself, would have been identified by CASA under this old system even if surveillance target levels had been achieved. CASA's move to systems-based auditing was designed, among other things, to address known limitations in traditional product-based surveillance.

CASA surveillance levels of Ansett under the product-based system had stopped altogether by March 2000. Given that it was unlikely that CASA would have identified the deficiencies in the Ansett engineering and maintenance area under that system anyway, that reduction in surveillance may have had little bearing on events. However, it was a period during which significant organisational change was occurring within Ansett, and without strong formal surveillance, CASA was not gathering important intelligence about the safety health of Ansett.

Airworthiness related systems-based audits of Ansett started in June 2000, although a trial systems audit had been conducted in August 1999. However, none of the systems-based audits conducted between June 2000 and December 2000 examined the Technical Services area or the handling of continuing airworthiness information. The audit findings did identify issues that were indicative of significant systemic problems within Ansett, such as the high number of staff leaving the company, low staff morale, shortages of spare parts and high rates of cannibalisation, and the major organisational changes occurring in Ansett. The Safety Trend Indicator forms completed in October and December 2000 also noted issues relating to staff morale and organisational change.

Under the systems approach to auditing, there is a greater emphasis on ensuring that organisations have robust safety and quality systems in place, that is, systems that are resilient to human error. CASA's surveillance under the new approach should have been capable of ensuring that such systems were in place. It is questionable whether CASA's new approach to surveillance would have identified the specific problems associated with Ansett's missed inspections. However, it would be reasonable to expect that a mature systems-based approach would have identified the deficiencies in Ansett's system for actioning continuing airworthiness material.

CASA response to indications that Ansett was at increased risk

Ansett had displayed symptoms of systemic problems. The company was also going through a period of significant organisational change — a period when there is an increasing risk to safety. However, the investigation found no evidence to indicate that CASA took specific action in response to this situation.

CASA did not ensure that systems were in place to provide confidence in the continuing airworthiness of the Ansett B767s. CASA has always had the ability to conduct risk based audits in response to intelligence gathered about an organisation, a perceived risk situation, or some safety deficiency in its operations. Intelligence about an organisation can be gathered by CASA through monitoring of the organisational and financial status of an operator, audit reports, Air Safety Occurrence Reports (ASORs), confidential reports, reliability data, and major defect reports. In hindsight it was clear that CASA's response to Ansett's increasing risk profile was not adequate, including after problems became apparent in December 2000.

Major defect reporting

If major defect reports had been submitted by Ansett for each Body Station 1809.5 bulkhead problem, they may have acted as a prompt to alert CASA. As it happened, CASA seemed unaware of the ongoing nature of those problems, and probably would not have taken any action if Ansett itself had not drawn the issue to CASA's attention. Major defect reports could have provided an important defence within the system that otherwise failed on this occasion. There is a potential for the major defect report system to provide a useful input into the continuing airworthiness systems for Australian Class A aircraft.

International harmonisation

ICAO Annex 8, Part II, p. 4.2.5 requires a State of Registry to ensure that information relating to potential adverse effects on the continuing airworthiness of an aircraft type is forwarded to the design organisation. ICAO Annex 6, Part I, p. 8.5.2 requires a State of Registry ensure that operators, action continuing airworthiness material. Australian civil aviation regulations did not specifically require operators to satisfy either of those requirements. While that does not necessarily imply that Australian operators were not fulfilling those functions, it would be preferable for the requirements to be clearly stated in Australian civil aviation regulations. That would provide a focus for both operators to carry out those activities, and for CASA to formalise surveillance methods for the activities.

9.4 ICAO international system for continuing airworthiness

The reliability of the international continuing airworthiness system could be enhanced by ensuring that the design and operation of the entire system is coherent and well coordinated. If that were achieved, it would result in a more robust system.

The ICAO guidelines to support the overall design of the international system are incorporated in the ICAO standards, recommended practices, and guidance material. However, while these sources describe the necessary information flows, they do not always provide guidance on how the tasks may be performed.

Enhancing the reliability of the international continuing airworthiness system

The international continuing airworthiness system is complex and must be highly reliable. In designing such a system, the following features would enhance its reliability:

- a consistent understanding of the system's goals and methods
- clearly defined responsibilities for ensuring the effective functioning of the system
- inherent resilience to identify and manage process deviations.

A consistent understanding by all parties of the system's goals and methods

The international continuing airworthiness system involves the activities of many different organisations. In many respects, the aircraft operator is the last link in an extended safety information chain in which each of the different organisations has its own unique perspective, objectives, and possibly conflicting priorities. That has the potential to affect the quality of the safety information that the operator ultimately receives.

The ICAO *Airworthiness Manual* (Doc 9760-AN/967, 2001) states the objectives of the global continuing airworthiness system (see Appendix 2), and the Standards in ICAO Annexes state what the individual parties shall do in relation to continuing airworthiness. However, there is still a potential for the actions of the individual parties to be influenced by other objectives.

The mandatory continuing airworthiness information necessary for Ansett was developed by being processed through a number of different organisations with different systems and objectives. Conflicts among those systems and objectives had the potential to, and sometimes did, compromise the quality of the information upon which Ansett relied.

Clearly defined responsibilities for ensuring the effective functioning of the system

The responsibilities of the individual parties in the international continuing airworthiness system are not adequately defined to ensure that the entire system is not compromised by the action, or inaction, of one party. Clearly defined lines of responsibility enhance the reliability and effectiveness of safety-critical systems. For example, in aviation a chief pilot is supported by a training and check organisation. Such a formalised structure reduces the potential for a diffusion of responsibility that could adversely affect safety.

Inherent resilience to identify and manage process deviations

The continuing airworthiness system should have inherent resilience to allow operators to be confident that the continuing airworthiness information they receive, and rely on, is correct, timely, and complete. Inherent resilience will allow the system to tolerate unexpected deviations that could result in pre-defined tolerances or limitations being exceeded.

The processes that Ansett's systems relied on for gathering information, incorporating it into its system of maintenance, and managing the system of maintenance were not resilient. They did not enhance Ansett's capacity to identify and manage events, creating the potential to compromise the continuing airworthiness of the Ansett fleet.

Relevance of ICAO standards

The community of States contracted to the Chicago Convention has developed minimum standards in the ICAO Annexes. Agreement has to be reached by almost all the international aviation community before ICAO can adopt a standard. Therefore, an ICAO standard can only give a broad statement of intent and description of overall procedural requirements, rather than give a detailed prescriptive requirement for an international continuing airworthiness system. The international system as described in ICAO documentation cannot, therefore, provide a complete and prescriptive model for ensuring an adequate international system for continuing airworthiness: it can only provide a framework from which such a system may be developed. This report makes a number of recommendations designed to improve the system.

9.5 US Federal Aviation Administration

The FAA acts on behalf of the USA, the State of Design for Boeing aircraft. As outlined in sections 8.1 and 8.2, certain actions, and inactions, by the FAA had considerable bearing on the course of events outlined in this report.

Timeliness of action by the State of Design

The FAA airworthiness directive that mandated the June 1997, B767 Airworthiness Limitations Structural Inspection program was not issued until approximately two years after the close of the public comment period for the related Notice of Proposed Rulemaking. That delay had the potential to result in poor safety outcomes.

Timely action by the FAA in issuing the airworthiness directive would have had the potential to alert Ansett, CASA, and other operators, to the process in train to mandate the June 1997 program, and of the time frame specified for compliance with the program. The delay until April 2001 by the FAA occurred, in part, because different sections of the FAA had conflicting views about whether the airworthiness directive addressed a known unsafe condition that could potentially arise in other aircraft of the same type.

The inconsistent understanding within the FAA as to the priority that should be afforded to the B767 Airworthiness Limitations Structural Inspection program has the potential to lead to confusion, including for international operators, and could possibly compromise the effectiveness of the program. As such, it is a significant safety issue.

A breakdown in process within the FAA also resulted in a delay by the FAA in issuing an airworthiness directive in relation to the Boeing Alert service bulletin concerning the B767 wing front spar outboard pitch load fittings. The initial service bulletin was issued by Boeing in March 2000, but the FAA did not issue an airworthiness directive in relation to the bulletin until April 2001. An FAA airworthiness directive in relation to the Body Station 1809.5 bulkhead outer chord was also not issued until April 2001.

Grace periods

There is a potential conflict between the different approaches used to develop structural inspection thresholds and any related grace periods.

Inspection regimes such as the B767 Airworthiness Limitations Structural Inspection program are developed by aircraft manufacturers, and approved by the relevant State of Design, on the basis of extensive analysis of information obtained during design and testing, and from operational experience. However, the methods used to determine a suitable grace period for aircraft that have already passed the compliance threshold is much less well-defined. In fact, evidence suggests that the determination process is largely subjective, rather than objective.

Determining an appropriate grace period must be a careful balance between safety considerations on the one hand, and operational and commercial concerns on the other. The process should be systematic and transparent, and to this end it should be documented appropriately.

10 FINAL COMMENT

The events depicted in this report clearly demonstrate that a combination of inappropriate systems and inadequate resource allocation can lead to undesirable outcomes. This is because people and robust systems are two of the prime defences against error in complex safety-critical systems, such as aviation. Both people and systems can detect and mitigate the effects of errors, from whatever source.

Consequently, all aspects of the air transport system must have effective mechanisms in place to detect and mitigate the effects of human error if it is to remain safe. If a failure by one or two individuals can result in a failure of the system as a whole, then the underlying problem is a deficient system, not human fallibility.

The situation that developed within the Ansett engineering and maintenance organisation was the result of particular events and circumstances over an extended period of time. However, other environments could give rise to a similar situation, and therefore potentially lead to similar results. All operators should be aware of the potential for a combination of less than fully developed systems and stretched human resources to compromise continuing airworthiness assurance.

Even a relatively small air operator should not under-estimate the complexity of ensuring the continuing airworthiness of its fleet. The international system is, by necessity, very complex. It is made up of a number of large organisations that have to work together to make another, larger, system work effectively.

In any complex system, subtle changes over time can lead to the development of situations that may result in unforeseen consequences. Without effective monitoring, the system may slowly deteriorate until it is no longer capable of performing the task for which it was originally intended. A gradual transformation may mask the effects of change until a combination of events leads to a rapid and severe readjustment. It is possible to see the situation that developed within Ansett in this light.

Ansett had undergone considerable change over a number of years. Many of the Ansett systems were developed at a time when the company faced a very different aviation environment. A number of significant changes had taken place since 1990. These changes included the ending of the two-airline policy in the domestic airline industry and the introduction of a 'user pays' principle that required industry and users of the system to cover a significant part of the cost of the provision of air safety services.

Over time, efficiency measures were introduced to improve productivity within the Ansett organisation. However, as Ansett emerged from the earlier protected environment, the equally necessary introduction of modern robust systems did not keep pace with the relative reduction in human resources. Therefore a situation gradually developed in which the nature of the Ansett system fundamentally changed. That eventually had unforeseen, and undesired, consequences.

Until Ansett withdrew their aircraft from service, there was apparently little or no awareness within Ansett or CASA of the underlying systemic problems that had developed within the Ansett engineering and maintenance organisation. The presence of organisational deficiencies remained undetected.

The question that naturally arises is "How could this have happened?" The answer may in part lie simply in the need to be mindful.

The concept of 'organisational mindfulness'[55] has been developed to help understand the successful operation of 'high reliability organisations'. High reliability organisations operate in an environment where it is not prudent to adopt a strategy of learning from mistakes. The essence of organisational mindfulness is the idea that no system can guarantee safety for once and for all. Rather, it is necessary for an organisation to cultivate a state of continuous mindfulness, or unease, and always be alert to the possibility of system failure[56].

The preoccupation of high reliability organisations with possible failure means that they are willing to accept redundancy. They will deploy more people than is necessary in the normal course of events so that there are extra resources to deal with abnormal situations when they arise. This means that staff are not routinely placed in situations of overload that may adversely affect their performance. Appendix 21 outlines the processes that characterise organisational mindfulness in more detail.

While high reliability organisations are preoccupied with failure, more conventional organisations focus on their successes. They use success to justify the elimination of what is seen as unnecessary effort and redundancy, and they interpret the absence of failure as evidence of the competence and skilfulness of their managers. This focus on success breeds confidence that all is well, and leads to a tendency for management and staff to drift into complacency.

Australia has a long-standing reputation as a world leader in safe aviation operations. However, this investigation indicated that there were a number of deficiencies within the system for ensuring the continuing airworthiness of Class A aircraft in Australia. These deficiencies occurred within the operator concerned, Ansett, the regulatory body of the State of Design, the FAA, and the Australian regulatory body, CASA.

That those safety deficiencies went undetected, both within the operator and within the regulators, for an extended period of time, raises the question as to whether Australia's historically good aviation safety record led to a degree of complacency within the aviation safety system.

The world aviation system has undergone considerable change in the last decade, and Australia has been no exception. Economic deregulation and changes in the commercial environment have been accompanied by equally major changes in the regulatory sphere, resulting in many improvements in safety and efficiency. Nevertheless, periodic review is needed to ensure that existing systems for maintaining air safety keep pace with the changing environment.

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55 Weick KE and Sutcliffe KM (2001). *Managing the unexpected: Assuring high performance in an age of complexity.* Jossey-Bass: San Francisco, USA

56 Similar safety concepts have been described as 'chronic unease' (Reason, 1997) and 'requisite imagination' (Westrum, 1993).

11 SAFETY ACTION

Where considered necessary or desirable, the ATSB makes recommendations with the intention of improving the safety of the aviation system by overcoming deficiencies identified in the course of an investigation. Recommendations should not be seen as a mechanism to apportion blame or liability. They are directed to those agencies that should be best able to give effect to the safety enhancement intent of the recommendations, and are not, therefore, necessarily reflective of deficiencies within those agencies.

As a result of its investigation detailed in this report the ATSB has issued safety recommendations to the International Civil Aviation Organization, the US Federal Aviation Administration, and the Civil Aviation Safety Authority. There are no recommendations to Ansett Australia because the airline has ceased operation. Detailed information supporting the recommendations can be found in the body of the report.

11.1 Recommendations to ICAO

Safety Recommendation R20020238 – *see section 3.3.3.*

The Australian Transport Safety Bureau recommends that the International Civil Aviation Organization develop standards for States of Registry to ensure that there are appropriate performance measures for continuing airworthiness standards, that take into consideration:

- the process defined in the standard
- a defined outcome that the standard is intended to achieve.

Safety Recommendation R20020239 – *see section 4.3.1.*

The Australian Transport Safety Bureau recommends that the International Civil Aviation Organization develop standards for the classification and format of service information issued by aircraft, engine, and component manufacturers.

11.2 Recommendations to FAA

Safety Recommendation R20020240 – *see section 8.2.4.*

The Australian Transport Safety Bureau recommends that the US Federal Aviation Administration ensure that there is a defined and consistent understanding throughout the FAA as to the importance of airworthiness directives that mandate revisions of the Airworthiness Limitations Structural Inspections for damage tolerance aircraft types, and that such airworthiness directives are processed and released without undue delay.

Safety Recommendation R20020241 – *see section 8.3.*

The Australian Transport Safety Bureau recommends that the US Federal Aviation Administration ensure that adequate systems are in place to alert States of Registry of US-designed and/or manufactured aircraft types when delays in FAA rulemaking have the potential to compromise the continuing airworthiness assurance of those aircraft types.

Safety Recommendation R20020242 – *see section 8.4.*

The Australian Transport Safety Bureau recommends that the US Federal Aviation Administration ensure that the process for determining grace periods for aircraft to comply with airworthiness directives is both systematic and transparent. Information about the methodology and results used to determine grace periods, including those associated with the Airworthiness Limitations Structural Inspections for damage tolerance aircraft types, should be included in the relevant Notice of Proposed Rule Making.

11.3 Recommendations to CASA

Safety Recommendation R20020243 – *see section 3.1.*

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority review the effectiveness of the system for the transmission of information on faults, malfunctions and defects to the organisation responsible for the aircraft's type design, in accordance with ICAO Annex 8, Part II, paragraph 4.2.5.

Safety Recommendation R20020244 – *see section 3.2.*

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority review relevant Australian civil aviation legislation and regulations to ensure that operators of Class A aircraft are required to have an acceptable system for receiving, assessing and actioning safety-related service documentation, in accordance with ICAO Annex 6, Part I, paragraph 8.5.2.

Safety Recommendation R20020245 – *see section 7.2.1.*

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority develop and issue clear guidance material for, and review its surveillance of, Australian operators of Class A aircraft in relation to:

- continuing airworthiness assurance activities, including the major defect reporting system
- knowledge of mandatory continuing airworthiness requirements under Australian civil aviation legislation
- the transmission of information to the organisation responsible for the type design
- the receipt, assessing and actioning of safety-related service documentation.

Safety Recommendation R20020246 – *see section 7.6.*

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority, as a part of its oversight role, review the policies and procedures for carrying out, and responding to the findings of, risk assessments of organisations that operate Class A aircraft. The review should address the adequacy of methods for:

- gathering and assessing information relevant to possible risks to safe operations
- determining, carrying out, and reviewing the CASA response to the assessed level of risk.

Safety Recommendation R20020247 – *see section 7.7.*

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority review the structure and procedures of the major defect reporting system to ensure that:

- all relevant defect information is received from operators in a timely manner

- defect information received is monitored, processed, and analysed
- defect information and information derived from subsequent investigations is disseminated to all relevant parties and made publicly available.

Safety Recommendation R20020248 – *see section 7.8*

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority consider the introduction of a periodic Certification Maintenance Review requirement for Australian Class A aircraft.

11.4 Recommendations issued to CASA on 12 April 2001

Safety Recommendation R20010092 – *see section 7.2.5.*

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority take steps to ensure that the continuing airworthiness requirements for Australian registered Class A aircraft are not compromised through any lack of action by the national airworthiness authorities of other countries.

Safety Recommendation R20010093 – *see section 7.3.3.*

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority take responsibility to ensure that all service bulletins relevant to Australian registered Class A aircraft are received and assessed for safety of flight implications. The assessment process should ensure that those aspects affecting the safety of flight of Class A aircraft are implemented or mandated as necessary and that appropriate systems are in place to ensure compliance.

11.5 Other safety action

The Australian Transport Safety Bureau will distribute copies of this report to all ICAO contracting States, and all operators and maintainers of Class A aircraft on the Australian civil register, to alert them to the potential for certain organisational behaviours to compromise their systems for continuing airworthiness.

The ATSB will recommend to operators and maintainers of Class A aircraft that they examine their systems to ensure that the continuing airworthiness of their aircraft is not compromised by issues identified in the report, such as:

- organisational structure and change management
- systems for managing work processes and tasks
- resource allocation and workload issues.

The ATSB will also recommend that operators review the adequacy of their systems for the receipt and assessment of service documentation and continuing airworthiness information.

ABBREVIATIONS

AD	Airworthiness Directive
ALI	Airworthiness Limitations Instructions
ALSI	Airworthiness Limitations Structural Inspections
ANNZES	Ansett Australia and Air New Zealand Engineering Services
ATA	Air Transport Association
BS	Body Station
CAA	Civil Aviation Authority
CASA	Civil Aviation Safety Authority
CMR	Certification Maintenance Requirements
COSP	Continued Operational Safety Program
DTR	Damage Tolerance Rating
FAA	US Federal Aviation Administration
FAR	US Federal Aviation Regulation
ICAO	International Civil Aviation Organization
MPD	Maintenance Planning Data
MRB	Maintenance Review Board
MSG	Maintenance Steering Group
MSI	Maintenance Significant Item
MTOW	Maximum certificated Take-Off Weight
NAA	National Airworthiness Authority
PSE	Principal Structural Element
SB	Service Bulletin
SSI	Structural Significant Item
SSIP	Supplemental Structural Inspection Program
TC	Type Certificate
TCDS	Type Certificate Data Sheet
TIMS	Technical Information Management System

GLOSSARY

Air Operator Certificate
An Air Operator Certificate (AOC) is issued by CASA to an operator permitting them to carry out a particular type of commercial operation including scheduled transport services, charter operations and aerial work (Civil Aviation Regulations 1988, r. 206 (1)). For the purposes of this report operator and AOC holder are taken to have the same meaning.

Airworthiness Directive
A document that requires mandatory action to address an unsafe condition that exists, or is likely to exist, or could develop, in an aircraft, engine, propeller or component.

Airworthiness Limitations
A section of the Instructions for Continued Airworthiness that contains all mandatory replacement times, structural inspection intervals, and related structural inspection procedures for damage tolerance and fatigue evaluation of the aircraft structure.

ATA Numbering System
A standard numbering system for aircraft systems, sub-systems and units.

Certificate of Airworthiness
A Certificate of Airworthiness is issued for an aircraft when it can be shown that the aircraft conforms to the type design and is in a condition for safe operation.

Certificate of Approval
A Certificate of Approval is issued by CASA to an organisation for approval to conduct specified tasks associated with the maintenance of aircraft.

Certification Maintenance Requirements
Maintenance tasks that are developed during certification of the aircraft where safety analysis of the systems has identified a safety-critical item.

Civil Aviation Authority
Under ICAO, a body established by a State to provide all the regulatory services necessary for the control of civil aviation operations in the State's airspace, and for the control of civil aircraft on the State's register.

Class A aircraft
Class A aircraft are Australian registered aircraft that are maintained to a specified standard that is required for aircraft certificated in the transport category, or that are used in regular public transport operations (Civil Aviation Regulations 1988, rr. 2(1), 2(2C), & 206(1)(c)). The maintenance required for Class A aircraft is more rigorous in its application and control than the maintenance required for other Australian civil aircraft.

Damage
Change to a structure that occurs during both normal and abnormal operation. Damage that occurs during normal operation (such as corrosion, fatigue cracking and wear) may be predicted, and maintenance planning is based on prediction of the rate

of damage development during normal operation. Damage during abnormal operation requires special and individual assessment for its management.

Damage tolerant structure
A structure that is able to sustain a given level of fatigue, corrosion, manufacturing defects, or accidental damage, and still withstand design loads without structural failure or excessive structural deformation for a predetermined period that allows for a set number of opportunities to detect the damage.

Design Service Goal
The period of time, flight cycles or flight hours, established at design and/or certification for which the principal structure will be "reasonably free from significant cracking" (FAA Advisory Circular 25.571-1C). Also sometimes called the Design Service Objective.

Fail–safe structure
A structure designed to retain its required residual strength for a period of unrepaired use after the failure or partial failure of a principal structural element.

Fatigue damage
The initiation and growth of a crack or cracks due to cyclic loading.

Flight cycle
A completed take-off and landing sequence.

Instructions for Continued Airworthiness
Airworthiness Instructions developed during the certification of an aircraft relating to procedures necessary to ensure continuing airworthiness, including the aircraft maintenance manual and a separate and specific Airworthiness Limitations section.

Maintenance Controller
A person appointed by the operator of a Class A aircraft, and approved by CASA, to control the maintenance for that aircraft.

Maintenance Significant Item
An aircraft system or component the failure of which could affect safety on the ground or in flight, is undetectable during operation, and could have significant operational or economic impact.

Multiple element damage
The simultaneous presence of fatigue cracks in adjacent structural elements.

Multiple load path structure
A structure with redundant elements, where the failure of an individual element would result in the applied loads being safely distributed to other load carrying members.

National Airworthiness Authority
Under ICAO, the body established by a State to provide all the airworthiness regulatory services necessary for civil aviation operations in the State's airspace, and by civil aircraft on the State's register. This function is commonly undertaken by a State's civil aviation authority.

Organization Responsible for the Type Design
Under ICAO, the organisation that provides a continuing airworthiness function for the type fleet throughout its service life. The Organization Responsible for the Type Design may be the manufacturer, a separate design organisation, a national regulator, or any other organisation approved by the regulator. Primarily referred to as the design organisation in this report.

Principal Structural Element
A structural element that contributes significantly to the carrying of flight, ground, or pressurisation loads, and whose integrity is essential in maintaining the overall structural integrity of the aircraft. The term Structural Significant Item can be considered to be the same as a Principal Structural Element.

Residual strength
The maximum load carrying capacity of a damaged structure.

Safe–life structure
A structure designed to withstand a certain number of events (flight cycles, landings, or flight hours) with a low probability that the strength of the structure will degrade below its designed ultimate strength before the end of its approved life.

Service Bulletin
A document used by a manufacturer to notify operators of recommendations that may address safety or airworthiness related problems or operational or economic matters. Service bulletins may require action for inspection, repair, rework, modification, part replacement and functional checks of an aircraft.

Single load path structure
A structure in which the loads are ultimately distributed through a single member, the failure of which would result in the loss of the capacity to carry the applied load.

State of Design
The State having jurisdiction over the Organization Responsible for the Type Design.

State of Manufacture
The State having jurisdiction over the Organization Responsible for the Final Assembly of the aircraft.

State of Registry
The State on whose register the aircraft is entered.

State of the Operator
The State in which the operator's principal place of business is located or, if there is no such place of business, the operator's permanent residence.

Structural Significant Item
A definition can be found under Principal Structural Element.

Type Certificate
A Type Certificate is issued by the civil aviation authority of the State of Design stating the airworthiness standard for the aircraft type or model, aircraft engine or aircraft propeller. Some states use a different term for Type Certificate such as Type Approval Certificate, Certificate of Type Approval, Fiche de Navigabilité.

Type Certificate Data Sheet
A section of the Type Certificate which documents the conditions and limitations prescribed by the applicable airworthiness regulations and any other limitations and information found necessary for type certification.

Widespread fatigue damage
Fatigue damage in a structure to the extent that the structure no longer meets its damage tolerance requirements. The presence of cracks of a sufficient size and density in a structure, to the extent that it can no longer maintain its required residual strength.

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Air Transport Association
ATA Spec 113: Maintenance Human Factors Program Guidelines
http://www.air-transport.org/public/publications/display1.asp?nid=938

Boeing Human Factors products and services
http://www.boeing.com/commercial/ams/mss/brochures/humanfactors.html

FAA
Human Factors in Aviation Maintenance and Inspection (HFAMI)
http://hfskyway.faa.gov/

APPENDIXES

Appendix 1: Relevant Boeing 767 service bulletins and related airworthiness directives

Body Station 1809.5 bulkhead outer chord		
Boeing	**FAA**	**CASA**
SB 767-53-0078 Original release: 15 October 1998 Revision 1: 9 September 1999 Revision 2: 19 April 2001 Revision 3: Alert SB 767-53A0078, 15 November 2001		**CAR 38 (1988) Direction** to Ansett 29 December 2000, mandating SB 767-53-0078 latest revision (Revision 1 current at the time)
	AD 2001-09-13 Amdt 39-12220	**CASA AD/B767/146**
	Applicability: SB 767-53-0078 Revision 2 dated 19 April 2001	Applicability: listed in SB 767-53A0078 Revision 3 dated 15 November 2001
	Issued: 27 April 2001	Gazetted: 5 December 2001
	Effective: 24 May 2001	Effective: 27 December 2001

Wing front spar outboard pitch load fittings *		
Boeing	**FAA**	**CASA**
Alert SB 767-57A0070 Applicability line no. 1-101 Original release: 2 March 2000 Revision 1: 16 November 2000 Revision 2: 2 August 2001	**AD 2001-08-23 Amdt 39-12200**	**AD/B767/135**
	Applicability: listed in SB 767-57A0070 Revision 1 dated 16 November 2000	Applicability: listed in SB 767-57A0070 Revision 1 dated 16 November 2000
	Issued: 18 April 2001	Gazetted: 10 April 2001
	Effective: 14 May 2001	Effective: 10 April 2001
		AD/B767/135 Amdt 1
		Gazetted: 8 August 2001
		Effective: 9 August 2001

* Cracks that start on the edge of the lug, in the radius between the lug and the horizontal flange, and grow in towards the bore.

<table>
<tr><th colspan="3">B767 Maintenance Planning Data Document (MPD) section 9, June 1997 revision</th></tr>
<tr><th>Boeing</th><th>FAA</th><th>CASA</th></tr>
<tr><td rowspan="5">MPD revision August 1997

Section 9 revision dated June 1997

TCDS A1NM Revision 15 dated 1 August 1997, Note 3 foreshadows the release of an airworthiness directive</td><td></td><td>CAR 38 (1988) Direction to Ansett 29 December 2000, to ensure “all current maintenance requirements of the Airworthiness Limitations and Certification Maintenance Requirements have been met.”</td></tr>
<tr><td>AD 2001-08-28 Amdt 39-12205</td><td rowspan="4"></td></tr>
<tr><td>Applicability: B767-200 & 300 series aircraft line numbers 1 through 669 inclusive</td></tr>
<tr><td>Issued: 19 April 2001</td></tr>
<tr><td>Effective: 1 June 2001</td></tr>
</table>

<table>
<tr><th colspan="3">B767 Maintenance Planning Data Document (MPD) section 9, June 2000 revision</th></tr>
<tr><th>Boeing</th><th>FAA</th><th>CASA</th></tr>
<tr><td rowspan="5">MPD revision August 2000

Section 9 revision dated June 2000</td><td rowspan="5">At the time of publication of this report the Notice of Proposed Rule Making was being drafted.</td><td>CAR 38 (1988) Direction to Ansett 29 December 2000, to ensure “all current maintenance requirements of the Airworthiness Limitations and Certification Maintenance Requirements have been met.”</td></tr>
<tr><td>CASA AD/B767/145</td></tr>
<tr><td>Applicability: B767-200 and 300 series aircraft line numbers 1 through 669.</td></tr>
<tr><td>Gazetted: 5 December 2001</td></tr>
<tr><td>Effective: 27 December 2001</td></tr>
</table>

Appendix 2: The concept of continuing airworthiness

Excerpt from the ICAO *Airworthiness Manual* (Doc 9760-AN/967, 2001).

Volume II – Design Certification and Continuing Airworthiness
Part B – Continuing Airworthiness

Introduction to the Concept of Continuing Airworthiness

Note: General information on the continuing airworthiness procedures followed in individual ICAO Contracting States is published in ICAO Circular 95 – The Continuing Airworthiness of Aircraft in Service.

2.1 Continuing airworthiness covers all of the processes ensuring that, at any time in their operating life, all aircraft comply with the airworthiness requirements in force and are in a condition for safe operation.

2.2 It includes, under the control of the respective Civil Aviation Authorities of the State of Design and the State of Registry:

a) design criteria which provide the necessary accessibility for inspection and permit the use of established processes and practices for the accomplishment of maintenance;

b) preparation by the organization responsible for the type design of the specifications, methods, procedures and tasks necessary to maintain the aircraft and publication of this information in a format that can be readily adapted for use by an operator;

c) adoption by the operator of specifications, methods, procedures and tasks, using the information provided by the organization responsible for the type design and preparing that material in the form of a maintenance program suitable for its operation;

d) the reporting of defects and other significant maintenance and operational information by the operator to the organization responsible for the type design in accordance with the requirements of the State of Registry;

e) the analysis of defect, accident and other maintenance and operational information by the organization responsible for the type design, the State of Design and the State of Registry and the initiation and transmission of information and recommended or mandatory action to be taken in response to that analysis;

f) consideration of, and, as deemed appropriate by the operator or the State of Registry, action on the information provided by the organization responsible for the type design or the State of Design, with particular emphasis on action designated as "mandatory";

g) accomplishment by the operator of all mandatory requirements concerning the aircraft with particular reference to fatigue life limits and any special tests or inspections required by the certification process or subsequently found necessary to ensure structural integrity; and

h) preparation of and compliance with supplemental structural inspection programs and subsequent requirements related to aging aircraft.

Appendix 3: Excerpts from the Convention on International Civil Aviation

Convention on International Civil Aviation (*Chicago Convention*)
Eighth Edition 2000 (ICAO Doc 7300/8).

Preamble

WHEREAS the future development of international civil aviation can greatly help to create and preserve friendship and understanding among the nations and peoples of the world, yet its abuse can become a threat to the general security; and

WHEREAS it is desirable to avoid friction and to promote that cooperation between nations and peoples upon which the peace of the world depends;

THEREFORE, the undersigned governments having agreed on certain principles and arrangements in order that international civil aviation may be developed in a safe and orderly manner and that international air transport services may be established on the basis of equality of opportunity and operated soundly and economically;

Have accordingly concluded this Convention to that end.

Part I – Air Navigation

Chapter VI – International Standards and Recommended Practices

Article 37

Adoption of international standards and procedures

Each contracting State undertakes to collaborate in securing the highest practicable degree of uniformity in regulations, standards, procedures, and organization in relation to aircraft, personnel, airways, and auxiliary services in all matters in which such uniformity will facilitate and improve air navigation.

To this end the International Civil Aviation Organization shall adopt and amend from time to time, as may be necessary, international standards and recommended practices and procedures dealing with:

a) Communications systems and air navigation aids, including ground marking;

b) Characteristics of airports and landing areas;

c) Rules of the air and air traffic practices;

d) Licensing of operating and mechanical personnel;

e) Airworthiness of aircraft;

f) Registration and identification of aircraft;

g) Collection and exchange of meteorological information;

h) Logs books;

i) Aeronautical maps and charts;

j) Customs and immigration procedures;

k) Aircraft in distress and investigation of accidents;

and such other matters concerned with the safety, regularity, and efficiency of air navigation as may from time to time appear appropriate.

Article 38

Departures from international standards and procedures

Any State which finds it impracticable to comply in all respects with any such international standard or procedure, or to bring its own regulations or practices into full accord with any international standard or procedure after amendment of the latter, or which deems it necessary to adopt regulations or practices differing in any particular respect from those established by an international standard, shall give immediate notification to the International Civil Aviation Organization of the differences between its own practice and that established by the international standard. In the case of amendments to international standards, any State which does not make the appropriate amendments to its own regulations or practices shall give notice to the Council within sixty days of the adoption of the amendment to the international standard, or indicate the action which it proposes to take. In any such case, the Council shall make immediate notification to all other states of the difference which exists between one or more features of an international standard and the corresponding national practice of that State.

Appendix 4: Excerpts from ICAO Annex 6, *Operation of Aircraft*

The following extract is from Annex 6 Seventh Edition (July 1998), the edition current at the time of interest to this report. Annex 6 Eighth Edition (July 2001) superseded the Seventh Edition with effect from 1 November 2001. However, Annex 6 Eighth Edition made no substantive changes to the requirements outlined below.

Part I – International Commercial Air Transport — Aeroplanes

Chapter 8 – Aeroplane maintenance

8.5 Continuing airworthiness information

8.5.1 The operator of an aeroplane over 5 700 kg maximum certificated take-off mass shall monitor and assess maintenance and operational experience with respect to continuing airworthiness and provide the information as prescribed by the State of Registry and report through the system specified in Annex 8, Part 11, 4.2.5 and 4.2.8.

8.5.2 The operator of an aeroplane over 5 700 kg maximum certificated take-off mass shall obtain and assess continuing airworthiness information and recommendations available from the organization responsible for the type design and shall implement resulting actions considered necessary in accordance with a procedure acceptable to the State of Registry.

Note.- Guidance on interpretation of "the organization responsible for the type design" is contained in the Continuing Airworthiness Manual (Doc 9642)[57].

Part I – International Commercial Air Transport — Aeroplanes

Chapter 11 – Manuals, logs and records

11.2 Operator's maintenance control manual

The operator's maintenance control manual provided in accordance with 8.2, which may be issued in separate parts, shall contain the following information:

a) a description of the procedures required by 8.1.1 including, when applicable:

   1) a description of the administrative arrangements between the operator and the approved maintenance organization;

   2) a description of the maintenance procedures and the procedures for completing and signing a maintenance release when maintenance is based on a system other than that of an approved maintenance organization.

b) names and duties of the person or persons required by 8.1.4;

c) a reference to the maintenance programme required by 8.3.1;

d) a description of the methods used for the completion and retention of the operator's maintenance records required by 8.4;

57 ATSB Note. This information is now included in Volume II, Part A, of the *Airworthiness Manual* (Doc 9760-AN/967, 2001) which has superseded the *Continuing Airworthiness Manual.*

e) a description of the procedures for monitoring, assessing and reporting maintenance and operational experience required by 8.5.1;

f) a description of the procedures for complying with the service information reporting requirements of Annex 8, Part 11, 4.2.5 and 4.2.8;

g) a description of procedures for assessing continuing airworthiness information and implementing any resulting actions, as required by 8.5.2;

h) a description of the procedures for implementing action resulting from mandatory continuing airworthiness information;

i) a description of establishing and maintaining a system of analysis and continued monitoring of the performance and efficiency of the maintenance programme, in order to correct any deficiency in that programme;

j) a description of aircraft types and models to which the manual applies;

k) a description of procedures for ensuring that unserviceabilities affecting airworthiness are recorded and rectified; and

1) a description of the procedures for advising the State of Registry of significant in-service occurrences.

Appendix 5: Excerpt from ICAO Annex 8, *Airworthiness of Aircraft*

The following extract is from Annex 8 Eighth Edition (July 1988), the edition current at the time of interest to this report.

Annex 8 Ninth Edition (July 2001) supersedes the Eighth Edition on 2 March 2004. However, Annex 8 Ninth Edition makes few substantive changes to the requirements outlined below. There is some change to the wording of the opening paragraphs and the revised wording of the Ninth Edition is appended below. In addition, references to "aircraft of over 5 700 kg maximum certificated take-off mass" are changed in the Ninth Edition to read "aeroplanes of over 5 700 kg and helicopters over 3 180 kg maximum certificated take-off mass".

Note: the section numbering of Annex 8 Ninth Edition is slightly changed. For example, section 4.2 *Information related to continuing airworthiness of aircraft,* which is of particular relevance to this report, becomes section 4.3.

Part II – Administration

Chapter 4 – Continuing airworthiness of aircraft

4.1 Determination of continuing airworthiness

a) The continuing airworthiness of an aircraft shall be determined by the State of Registry in relation to the appropriate airworthiness requirements in force for that aircraft.

b) The State of Registry shall develop or adopt requirements to ensure the continued airworthiness of the aircraft during its service life.

Note 1.- These requirements will also cover maintenance requirements of Annex 6.

Note 2.- Guidance on continuing airworthiness requirements is contained in the Continuing Airworthiness Manual[58].

4.2 Information related to continuing airworthiness of aircraft

4.2.1 When a Contracting State first enters on its register an aircraft of a particular type for which it is not the State of Design and issues or validates a Certificate of Airworthiness in accordance with 2.2 of this Part, it shall advise the State of Design that it has entered such an aircraft on its register.

4.2.2 The State of Design of an aircraft shall transmit any generally applicable information which it has found necessary for the continuing airworthiness of the aircraft and for the safe operation of the aircraft (hereinafter called mandatory continuing airworthiness information) as follows:

a) to every Contracting State which has in accordance with 4.2.1 advised the State of Design that it has entered the aircraft on its register; and

b) to any other Contracting State upon request.

58 ATSB Note. This information is now included in Volume II, Part B, of the *Airworthiness Manual* (Doc 9760-AN/967, 2001) which has superseded the *Continuing Airworthiness Manual.*

Note l.- In 4.2. the term "mandatory continuing airworthiness information" is intended to include mandatory requirements for modification, replacement of parts or inspection of aircraft and amendment of operating limitations and procedures. Among such information is that issued by Contracting States in the form of airworthiness directives.

Note 2.- ICAO Circular 95 - The Continuing Airworthiness of Aircraft in Service - *provides the necessary information to assist Contracting Stares in establishing contact with competent authorities of other Contracting States, for the purpose of maintaining continuing airworthiness of aircraft in service.*

4.2.3 The State of Registry shall, upon receipt of mandatory continuing airworthiness information from the State of Design, adopt the mandatory information directly or assess the information received and take appropriate action.

4.2.4 Any Contracting State which has entered on its register an aircraft in respect of which that Contracting State is not the State of Design and for which it has issued or validated a Certificate of Airworthiness in accordance with 2.2 of this Part, shall ensure the transmission to the State of Design of all mandatory continuing airworthiness information originated in respect of that aircraft in the former Contracting State.

4.2.5 The State of Registry shall ensure that in respect of aircraft of over 5 700 kg maximum certificated take-off mass, there exists a system whereby information on faults, malfunctions, defects and other occurrences which cause or might cause adverse effects on the continuing airworthiness of the aircraft is transmitted to the organization responsible for the type design of that aircraft.

Note.- Guidance on interpretation of "the organization responsible for the type design" is contained in the Airworthiness Technical Manual (Doc 9051)[59].

4.2.6 The State of Design shall ensure that, in respect of aircraft over 5 700 kg maximum certificated take-off mass, there exists a system for:

a) receiving information submitted in accordance with 4.2.5;

b) deciding if and when airworthiness action is needed;

c) developing the necessary airworthiness actions; and

d) promulgating the information on those actions including that required in 4.2.2.

4.2.7 The State of Design shall ensure that, in respect of aeroplanes over 5 700 kg maximum certificated take-off mass, there exists a continuing structural integrity programme to ensure the airworthiness of the aeroplane. The programme shall include specific information concerning corrosion prevention and control.

4.2.8 Each Contracting State shall establish, in respect of aircraft over 5 700 kg maximum certificated take-off mass, the type of service information that is to be reported to its airworthiness authority by operators, organizations responsible for type design and maintenance organizations. Procedures for reporting this information shall also be established.

59 ATSB Note. This information is now included in Volume II, Part A, of the *Airworthiness Manual* (Doc 9760-AN/967, 2001) which has superseded the *Airworthiness Technical Manual.*

4.2.9 Where the State of Manufacture of an aircraft is other than the State of Design there shall be an agreement acceptable to both States to ensure that the manufacturing organization co-operates with the organisation responsible for the type design in assessing information received on experience with operating the aircraft.

Revised wording of Annex 8 Ninth Edition (July 2001) sections 4.1 and 4.2 (supersedes the Eighth Edition on 2 March 2004).

4.1 Applicability

The Standards of this chapter are applicable to all aircraft.

4.2 Determination of continuing airworthiness

4.2.1 The State of Registry shall develop or adopt requirements to ensure the continued airworthiness of the aircraft during its service life, including requirements to ensure that the aircraft:

a) continues to comply with the appropriate airworthiness requirements after a modification, a repair or the installation of a replacement part; and

b) is maintained in an airworthy condition and in compliance with the maintenance requirements of Annex 6 and, where applicable, Parts IIIA, IIIB and IV of this Annex.

4.2.2 The continuing airworthiness of an aircraft shall be determined by the State of Registry in relation to the appropriate airworthiness requirements in force for that aircraft.

Note.- Guidance on continuing airworthiness requirements is contained in Volume II, Part B, of the Airworthiness Manual *(Doc 9760).*

Appendix 6: Responsibilities of States under the *Chicago Convention*

This section expands on the material presented in sections 2.1.3 and 2.1.4 of this report.

State of Design

A State of Design is defined by ICAO as the State having jurisdiction over the Organization Responsible for the Type Design of an aircraft.

The State's civil aviation authority normally represents the State of Design. The civil aviation authority regulates the Organization Responsible for the Type Design, as defined in Chapter 3 of Volume II, Part B, of the ICAO *Airworthiness Manual* (Doc 9760-AN/967, 2001).

ICAO Annex 8 contains standards that place obligations on the State of Design. These obligations not only require the State of Design to participate in the flow of information necessary for the international system for continuing airworthiness, but also to ensure that specified systems are established and maintained to support those information flows.

ICAO Annex 8, Part II, p. 4.2.2 requires mandatory airworthiness actions to be promulgated by the State of Design. Mandatory airworthiness actions are intended to include requirements for modification, replacement of parts or inspection of aircraft, and amendment of operating limitations and procedures. Airworthiness directives may be used to promulgate this information, but it can also be promulgated in other forms, such as Instructions for Continued Airworthiness.

The State of Design is required under Annex 8, Part II, p. 4.2.6 to ensure that an adequate system exists for promulgating both mandatory and non-mandatory (advisory) airworthiness actions. Another organisation, such as the design organisation, may have a system for promulgating non-mandatory airworthiness actions that meets the obligations of the State of Design under this standard. In such a case, the State of Design would retain responsibility for ensuring the adequacy of that system.

ICAO Annex 8, Part II, p. 4.2.7, requires the State of Design to ensure that a continuing structural integrity program exists for aeroplanes over 5,700 kg maximum certificated take-off mass.

The State of Design is normally also the State of Manufacture. However, where the States are different, ICAO Annex 8, Part II, p. 4.2.9 requires them to ensure that the manufacturing organisation and the design organisation cooperate in assessing information received from aircraft type operational experience.

State of Manufacture

A State of Manufacture is defined by ICAO as being the State having jurisdiction over the organisation responsible for the final assembly of the aircraft. A State's civil aviation authority normally represents the State of Manufacture.

The prime focus of the State of Manufacture would normally be its responsibility to the State's domestic and international fleet, but the State is also bound by its obligations under the ICAO Annexes. These obligations include a responsibility for assessing the relevance of all service information that has continuing airworthiness implications for the aircraft-type world fleet.

The ICAO *Airworthiness Manual* Volume I, Chapter 3, specifies that in those States with a significant aviation manufacturing industry it will be necessary to establish an aircraft engineering division within the airworthiness section of the civil aviation authority. The functions of the aircraft engineering division will normally include:

- the development of standards and procedures for type certification
- approval of design and manufacturing organisations
- processing of national and foreign type certificates
- issuing design approvals and production certificates
- issuing airworthiness directives for aircraft certificated in that State
- monitoring the continuing structural integrity of aircraft in service
- monitoring service bulletins from the manufacturer
- examination of current and new national and foreign airworthiness design standards
- participation in maintenance review board activity
- recommendation of regulatory changes to the national aviation legislation
- investigation of major defects discovered in aircraft.

Three of the functions of the aircraft engineering division that have particular relevance to this report are the monitoring of continual structural integrity of aircraft, the monitoring of service bulletins and the investigation of major defects, as outlined in pp. 3.2 (m), (n) and (u) of the ICAO *Airworthiness Manual* Volume I, Chapter 3:

> m) monitoring of the continued structural integrity of aircraft in service with a view to determining the need for supplemental inspection to maintain the aircraft in airworthy condition (guidelines on the assessment of the continued structural integrity of aeroplanes and the resulting supplemental inspection document are contained in Volume II of [the *Airworthiness Manual*], Part B, Chapter 6);
>
> n) monitoring of service bulletins from the manufacturer to determine likely effects on the design and continuing airworthiness of the aircraft and powerplant and to decide steps to be taken to avoid or correct difficulties. If as a result of this activity, it is decided that an inspection or modification is necessary to assure continuing airworthiness of the aircraft, a firm and positive direction (in the form of an airworthiness directive) should be published and directed to all operators and, where the aircraft has been exported to other States, to the airworthiness authorities in those States.
>
> u) investigation, in coordination with the AID [aircraft inspecting division], of major defects discovered in aircraft and determination of corrective action to be taken where airworthiness may be affected.

The ICAO *Airworthiness Manual* emphasises the importance of adequate staffing of the aircraft engineering section by sufficiently qualified personnel. It also notes that the staff should be provided with conditions of service and remuneration consistent with their technical knowledge and experience, and the responsibilities of their post.

State of Registry

The State of Registry is defined by ICAO as being the State on whose register the aircraft is entered. A State's civil aviation authority normally represents the State of

Registry. The State of Registry has the only authority to mandate continuing airworthiness requirements for aircraft on its civil register.

The ICAO standards in Annex 8 place obligations on the State of Registry. These obligations not only require the State of Registry to participate in information flows relevant to the international system for continuing airworthiness, but also to ensure that specified systems are established and maintained to support those information flows.

ICAO Annex 8, Part II, p. 4.1 places a requirement on the State of Registry to develop standards against which the continuing airworthiness of an aircraft can be determined, and to measure compliance with those standards. The standards require systems to ensure the flow of all safety-related information on which the operator's continuing airworthiness system depends.

The State of Registry is required under Annex 8, Part II, p. 4.2.3 to assess mandatory information that they receive from a State of Design, and either to adopt it directly, or to assess it and take appropriate action. This obligation requires the State of Registry to maintain a system to receive all relevant mandatory airworthiness information, and to act on it.

Under Annex 8, Part II, p. 4.2.4 a State is required to ensure the transmission of all mandatory continuing airworthiness information to the State of Design for aircraft for which it has issued a Certificate of Airworthiness. This system for transmitting information is an essential element of the continuing airworthiness system. For a State of Registry to satisfy itself that it has met its obligations in relation to this ICAO standard, it will need to monitor the system to ensure that the standards are being maintained.

The State of Registry is required under ICAO Annex 8, Part II, p. 4.2.5 to ensure that a system exists for receiving all information transmitted to the design organisation related to faults, malfunctions, defects and other occurrences which cause or might cause adverse effects on the continuing airworthiness of the aircraft.

The ICAO *Airworthiness Manual* Volume I, Chapter 4, specifies that in all States it will be necessary to establish an airworthiness inspection organisation within the civil aviation authority to meet the requirements of the *Chicago Convention* and of ICAO Annexes 6 and 8. The tasks and responsibilities of the airworthiness inspection organisation will normally include:

- matters concerning the registration of aircraft
- licensing of aircraft maintenance personnel
- periodically reviewing the airworthiness condition and records of aircraft
- investigating major defects discovered in aircraft
- reviewing and acting on foreign service bulletins and airworthiness directives
- developing reliability programs and approving maintenance systems
- conducting periodic surveillance of maintenance facilities
- assessing and monitoring designated approved persons
- participation in type certification board and maintenance review board activities
- preparing and distributing advisory material to the aviation industry
- recommending amendments to national aviation law.

In some cases these functions will also involve the aircraft engineering division if that role is carried out by a separate section of the civil aviation authority.

In relation to inspection of aircraft by the State of Registry the ICAO *Airworthiness Manual* Volume I, Chapter 4, states:

4.3 Detailed Inspection of Aircraft

4.3.1 It should be noted ... that the detailed inspection of aircraft is not listed as a specific task of the AID [aircraft inspection division]. Extensive experience over the years has shown that it is very difficult, if not impossible, for States to successfully undertake such a task in view of the size and complexity of many modern aircraft as well as the large number of aircraft on the register of many States. Furthermore, even if the State had the resources to accomplish the task, it could work to its disadvantage by encouraging the aircraft owner or operator to use the AID inspection as a broad screening authority, thereby avoiding his own maintenance and inspection responsibilities and thus creating a potentially hazardous situation. It should, however, be recognized that it will be necessary for AID inspectors to conduct periodic inspections of selected aircraft in order to sample the work standards of approved maintenance and repair facilities.

4.3.2 Although the AID should not be expected to conduct routine detailed inspections of privately owned aircraft, it will be necessary for it to maintain close surveillance of all such aircraft to ensure that they are properly maintained. If an aircraft is suspected of not being airworthy, it should be regarded as such and its Certificate of Airworthiness should be revoked and the aircraft withdrawn from service. Prior to revalidation of the Certificate of Airworthiness, the aircraft must be given a detailed inspection and any deficiencies corrected by an approved maintenance organization or qualified licensed maintenance personnel.

The *Airworthiness Manual* emphasises the importance of staffing in relation to the aircraft inspection function of a State's civil aviation authority, stating in Volume I, Chapter 4, p. 4.4.1 that:

> The success or failure of a State to maintain a satisfactory level of airworthiness in compliance with the Convention and to protect the public interest depends to a very large extent on the competence of the AID [aircraft inspection division] inspectors. To effectively fulfil its responsibilities, the AID must be properly organized and staffed with qualified personnel capable of accomplishing the required wide range of technical inspection activities.

Appendix 7: ICAO guidance for States in establishing a safety oversight system

The ICAO *Safety Oversight Manual Part A – The Establishment and Management of a State's Safety Oversight System* (Doc 9734-AN/959, 1999), provides guidance on the approach to control and supervision which should be adopted by a civil aviation authority. In particular it notes that the State's approach may range from a stringent regulatory presence to a passive role:

2.4 Balanced Approach to Control and Supervision

2.4.1 In order to discharge its responsibility, each State should enact a basic aviation law which will provide for the development and promulgation of a code of air navigation rules and regulations which should be consistent with the provisions of the Annexes to the Convention. In the development of this code, the State has the option of adopting provisions which will govern its role in the implementation of the operational regulations; this may range from a stringent regulatory presence to a passive role.

2.4.2 In a stringent regulatory role, close day-to-day involvement in industry direction and control of activities would be carried out by the State through an inspection organization. In a passive role, the State would intervene only to institute proceedings or investigatory action in the case of a violation of the regulations.

2.4.3 A State exercising a passive role relies almost completely on the industry's technical competence and commitment to safety. The industry becomes responsible for both the interpretation and the implementation of the regulations, thus becoming essentially self-regulating. The State is not in a good position to assess the adherence of the industry to the regulations, other than by knowledge acquired fortuitously or in the course of accident or incident investigation. Such a system would not enable the State to exercise the necessary preventative and corrective responsibilities required under the convention.

2.4.4 States should also avoid the opposite extreme, the State safety oversight system should not be so rigorous as to amount to a complete domination and dictation of the conduct of operations. Such a system creates an environment where the industry is not empowered with the responsibility and self-sufficiency for safe operations. This can undermine the morale of the industry's personnel, and result in a lowering of safety standards. It is also cost-prohibitive for the State to maintain the large enforcement organization required to sustain this level of oversight.

2.4.5 In practice, neither of these extremes is compatible with the objective of a well-balanced division between the State and the aviation community. The public interest would best be served by a balanced approach, where both the State and the aviation community have responsibilities for the safe and efficient conduct of their functions.

2.4.6 A balanced safety oversight system is one in which both the State and the aviation community share responsibility for the safe, regular and efficient conduct of civil aviation activities. This relationship is established in the primary aviation legislation and aviation regulations, and put into practice as a matter of policy and methodology of the CAA [Civil Aviation Authority]. The characteristics of an effective State oversight system include:

a) a well balanced allocation of responsibility between the State and the industry for the safety of air navigation;

b) economic justification within the resources of the State;

c) maintaining continued State supervision of the activities of operators without unduly inhibiting their effective direction and control of their own organisation; and

d) the cultivation and maintenance of harmonious relationships between the State and the industry.

2.4.7 States need to carefully consider the public interest in establishing the various safety oversight functions and to ensure that a proper system of checks and balances is maintained. The State should retain effective control of important inspection functions. Such functions cannot be delegated; otherwise, aviation personnel, maintenance organisations, general aviation, commercial operators, etc will in effect be regulating themselves and will not be effectively monitored by CAA inspectors.

2.4.8 The aviation industry has the overall responsibility for preserving safe, regular and efficient aircraft operations and maintenance, aviation personnel training and aircraft and aviation equipment manufacture. Some States may share some of the responsibility for monitoring internal safety standards with organizations (operators, approved maintenance organizations, manufacturers, etc.) which have been found to be reliable and to act responsibly. The objective of a safe and orderly civil aviation system cannot be attained unless each designated member of the aviation industry is prepared to readily accept the implications of this policy, including that of committing the necessary resources to its implementation. Crucial to the confidence that the CAA may place in organizations and to the associated freedom and flexibility it can give, is that the organizations establish an adequate quality system which must be reviewed and approved by the CAA.

Appendix 8: Examples of fatal aircraft accidents associated with fatigue damage and structural failure[60]

Stinson A-2W, VH-UYY, Spring Plains near Mia Mia, Australia

Date:	31 January 1945
Aircraft type:	Stinson A-2W
Registration:	VH-UYY
Operator:	Australian National Airways
Nature of flight:	Scheduled Passenger
Location:	Spring Plains near Mia Mia, Australia
Fatalities:	10
Damage to aircraft:	Destroyed

The accident occurred some 18 minutes after the Australian National Airways Stinson A2W aircraft “Tokana” (VH-UYY) departed Essendon for Broken Hill on a scheduled public transport service. The witnesses saw the aircraft descending rapidly and rolling as it descended. In the initial stages of its descent a large portion was seen to become detached, and as the aircraft continued in an uncontrolled dive other large and small portions fell from it. The two crew and all eight passengers died in the accident.

The investigation determined that the left wing lower main front spar boom attachment fitting failed due to the presence of a fatigue crack extending around some 45 per cent of the perimeter of the fitting. It was considered extremely improbable that any visible evidence of the crack was present at the time of the annual overhaul, and that no normal means of inspection in use at the time would have revealed its presence.

As far as could be ascertained at the time, the accident was the first example in Australia of an in-flight failure of an aircraft primary structure attributable directly to fatigue.

Martin M202, N93044, near Winona, Minnesota, USA

Date:	29 August 1948
Aircraft type:	Martin M202
Registration:	N93044
Operator:	Northwest
Nature of flight:	Scheduled Passenger
Location:	Near Winona, Minnesota, USA
Fatalities:	37
Damage to aircraft:	Destroyed

During flight through a thunderstorm area, a structural failure originating in the wing panel attachment fitting occurred. The aircraft then broke apart in the air resulting in fatal injury to all on board.

The US Civil Aeronautics Board determined that the accident was due to the separation in flight of the outer panel of the left wing, as a result of a fatigue crack in the left front outer panel attachment fitting. The fatigue crack had been induced by a faulty design of the fitting and aggravated by severe turbulence encountered in the thunderstorm.

60 Information from various sources including reports by air accident investigating bodies, the UK Civil Aviation Authority *World Airline Accident Summary* (CAP 479), and the (then) Commonwealth Department of Civil Aviation.

De Havilland Dove DH 104, VH-AQO, near Kalgoorlie, WA, Australia

Date:	15 October 1951
Aircraft type:	De Havilland Dove, DH 104
Registration:	VH-AQO
Operator:	Airlines (WA) Ltd
Location:	Near Kalgoorlie, WA, Australia
Nature of flight:	Scheduled Passenger
Fatalities:	7
Damage to aircraft:	Destroyed

The aircraft was on a scheduled flight from Perth to Kalgoorlie. Seven minutes from Kalgoorlie the pilot requested landing instructions. Instructions were transmitted two minutes later, but no acknowledgment or further communication was received from the aircraft. The wreckage of VH-AQO was subsequently found 14 miles west of Kalgoorlie Airport. The aircraft was destroyed on impact.

The investigation concluded that the accident was due to the loss of control when the left wing detached from the aircraft in the air due to structural fatigue failure of the main spar.

During the investigation research was carried out to determine whether the failure could have been predicted from knowledge of the flight loads and the fatigue properties of the structure. It was determined that the design of the aircraft was such that the alternating stresses in the lower boom of the main spar due to normal operation of the aircraft would have resulted in fatigue failure of the material. In addition, the failure would be expected at approximately the period for which the spar of VH-AQO had been in service.

Determining the fatigue life of an aircraft component at the time of the accident was not normal design practice due to a lack of knowledge of the subject, and nor did airworthiness authorities throughout the world stipulate that requirement.

Vickers Viking, VP-YEY, Mtara, Handeni District, Tanganyika

Date:	29 March 1953
Aircraft type:	Vickers Viking
Registration:	VP-YEY
Operator:	Central African Airways
Location:	Mtara, Handeni District, Tanganyika
Nature of flight:	Scheduled Passenger
Fatalities:	13
Damage to aircraft:	Destroyed

The aircraft was operating a flight from Nairobi to Dar-es-Salaam with a crew of five and eight passengers. Whilst in the region of Mtara, the aircraft encountered a sudden gust of wind. The effect of the sudden extra stress due to the gust was to produce a fracture of the right wing lower spar boom, which was rapidly followed by the in-flight break-up of the aircraft.

The investigation determined that the failure was due to fatigue cracking of the right lower spar boom that was advanced considerably by corrosion.

De Havilland Comet DH106, G-ALYP, in the sea, near Elba, Italy

Date:	10 January 1954
Aircraft type:	De Havilland Comet, DH106
Registration:	G-ALYP
Operator:	BOAC
Location:	In the sea, near Elba, Italy
Nature of flight:	Scheduled Passenger
Fatalities:	35
Damage to aircraft:	Destroyed

The aircraft departed Ciampino Airport, Rome, for London. Approximately 20 minutes later, while the aircraft was approaching a height of 27,000 feet, a radio communication to another company aircraft was interrupted in mid sentence. Part of the aircraft was seen to fall into the sea in flames. Approximately 70 per cent of the empty weight of the aircraft was eventually recovered.

Comet aircraft were temporarily removed from service on 11 January 1954. The aircraft were inspected, modified, and tested, and returned to service on 23 March 1954. Then, on 8 April 1954, Comet G-ALYY was lost in similar circumstances to G-ALYP. On 12 April 1954 the UK Certificate of Airworthiness was withdrawn from all Comet aircraft.

The Royal Aircraft Establishment were directed to conduct a full investigation into both accidents. To simulate the conditions of a series of pressurised flights a water tank was constructed to carry out full scale testing of the pressure cabin. The cabin and wings were repeatedly subjected to a cycle of loading as far as possible equivalent to that experienced during take-off and landings. The cabin structure failed during testing at approximately 3,060 pressurised cycles. The starting point of the failure began at the corner of a cabin window. On close examination of the wreckage of G-ALYP the primary failure was confirmed to be the rupture of the pressure cabin. The initiating point was around the high stressed corners of the windows and other cutouts.

The UK Court of Inquiry concluded that the reason for the accident was structural failure of the pressure cabin brought about by fatigue.

De Havilland Comet DH106, G-ALYY, in the sea off Naples, Italy

Date:	8 April 1954
Aircraft type:	De Havilland Comet, DH106
Registration:	G-ALYY
Operator:	South African Airways
Location:	In the sea off Naples, Italy
Nature of flight:	Non-Scheduled Passenger
Fatalities:	21
Damage to aircraft:	Destroyed

The aircraft departed from Rome on a charter flight to Cairo. The allocated cruising altitude was 35,000 feet. The last communication from the aircraft was approximately 33 minutes after departure when the crew reported their estimated time of arrival at Cairo. Some aircraft wreckage, aircraft seats and bodies were recovered. The depth of water where the wreckage was found precluded further recovery of the wreckage.

Owing to the absence of significant wreckage, the Royal Aircraft Establishment was unable to form a definite opinion as to the reason for the accident. However, it was judged that the circumstances were not inconsistent with a fatigue failure of the pressure cabin as occurred with G-ALYP.

Scottish Aviation Twin Pioneer, JZ-PPX, in the sea off Jahen Island, New Guinea

Date:	30 August 1957
Aircraft type:	Scottish Aviation Twin Pioneer
Registration:	JZ-PPX
Operator:	Kroonduif
Location:	In the sea off Jahen Island, New Guinea
Nature of flight:	Training
Fatalities:	3
Damage to aircraft:	Destroyed

The aircraft departed from Mokmer Airport, Indonesia, for an instructional flight. After having carried out a series of take-offs and landings, further manoeuvres were carried out away from the circuit. During these manoeuvres steep left-hand and right-hand turns were executed at a decreasing altitude. After one such manoeuvre the right wing separated from the aircraft. The aircraft entered a right-hand spiral dive and turned several times before falling into the sea.

The investigation concluded that the most likely reason for the accident was the failure of the V-brace strut due to fatigue. The aircraft had carried out many instruction flights at low altitude, many take-offs and landings, and many manoeuvres with high flight loads, possibly up to the maximum loads. The investigation found that the life of the V-brace, as determined by the manufacturer, did not adequately reflect actual operational conditions.

Bristol 170, ZK-AYH, Christchurch, New Zealand

Date:	21 November 1957
Aircraft type:	Bristol 170
Registration:	ZK-AYH
Operator:	Straits Air Express
Location:	Christchurch, New Zealand
Nature of flight:	Scheduled Freight
Fatalities:	4
Damage to aircraft:	Destroyed

The flight was a routine cargo flight from Woodbourne to Timaru via Paraparaumu, New Zealand. On the first leg of the journey a period of asymmetric flying was carried out. During the flight a sudden and severe vibration was felt throughout the aircraft. During the second segment of the flight, at approximately 2,000 feet, the aircraft was seen to experience structural failure in the air. The right outer wing folded upwards and backwards and separated. The remainder of the aircraft performed a series of violent manoeuvres and collided with the ground 1,000 yards beyond the point of wing separation.

The investigation concluded that the accident was the result of the in-flight structural fatigue failure of the right front lower spar boom. The safe-life calculations of that structural member did not truly represent the actual in-service operating conditions.

Scottish Aviation Twin Pioneer, G-AOEO, Fezzan, Libya

Date:	7 December 1957
Aircraft type:	Scottish Aviation Twin Pioneer
Registration:	G-AOEO
Operator:	Scottish Aviation
Location:	Fezzan, Libya
Nature of flight:	Demonstration
Fatalities:	6
Damage to aircraft:	Destroyed

When the aircraft failed to arrive at its destination a series of radio checks were carried out, followed by a widespread air and surface search. The wreckage was sighted the next day. There were no survivors among the two crew and four passengers on board.

The investigation determined that the accident was the result of the fatigue failure of the V-brace structure forward tube in the left wing outer panel. This failure led to the breaking away of the outer panel of the left wing from the aircraft in flight. The aircraft was then rendered uncontrollable and collided with the ground.

Curtiss C46F Commando, N-1300N, Plain City, Utah, USA

Date:	15 October 1960
Aircraft type:	Curtiss C46F, Commando
Registration:	N-1300N
Operator:	Capitol
Location:	Plain City, Utah, USA
Nature of flight:	Non-Scheduled Freight
Fatalities:	2
Damage to aircraft:	Destroyed

The flight departed Tinker Air Force Base for Hill Air Force Base, with a scheduled stop at Rapid City, South Dakota. The flight was apparently routine until the approach to Hill Air Force Base. The investigation determined that the aircraft departed level flight at 6,500 feet, and collided with the ground ten miles from the airport. Examination of the wreckage disclosed that an in-flight separation of the right wing had occurred as the result of fatigue failures of the lower attach angle bolts holding the forward portion of the outer wing panel to the centre wing panel. As a result of the accident an Airworthiness Directive was issued to require the replacement of all wing attach angle bolts at specified service life intervals.

De Havilland Canada DHC-2 Beaver, near Armidale, NSW, Australia

Date:	10 September 1963
Aircraft type:	De Havilland Canada DHC-2, Beaver
Registration:	VH-AAQ
Operator:	Aerial Agriculture
Location:	near Armidale, NSW, Australia
Nature of flight:	Agricultural
Fatalities:	1
Damage to aircraft:	Destroyed

The aircraft was at the end of a superphosphate spreading run when the left wing was seen to separate from the aircraft at a height of approximately 150 feet above the ground. The aircraft immediately rolled to the left and struck the ground. The pilot died in the accident.

The investigation determined that the left lift strut upper attachment fitting failed in flight due to a fatigue crack permitting the left wing to separate from the aircraft. The fatigue crack had substantially reduced the structural strength of the material and may have existed for some months prior to failure.

Fairchild F-27B, N4905, Pedro Bay, Alaska, USA

Date:	2 December 1968
Aircraft type:	Fairchild, F-27B
Registration:	N4905
Operator:	Wien Consolidated Airlines, Inc.
Location:	Pedro Bay, Alaska, USA
Nature of flight:	Scheduled Passenger
Fatalities:	39
Damage to aircraft:	Destroyed
NTSB report:	NTSB-AAR-70-16

The aircraft was operating from Anchorage to Dillingham, Alaska, with three en route stops. When the aircraft was on approach to land, witnesses on the ground observed a large cloud of black smoke and fire behind the aircraft. Shortly afterwards they saw pieces separate from the aircraft and the aircraft descend in a spin. The 36 passengers and 3 crewmembers died in the accident and the aircraft was destroyed. The right outer wing, the empennage, portions of the left wing, and other components of the aircraft structure had separated from the aircraft in flight.

The investigation determined that the in-flight structural failure was the result of an encounter with severe to extreme turbulence. The failure occurred in an area of the right wing, which had been weakened to an indeterminate degree by pre-existing fatigue cracks.

Vickers Viscount 720C, VH-RMQ, near Port Hedland, WA, Australia

Date:	31 December 1968
Aircraft type:	Vickers Viscount 720C
Registration:	VH-RMQ
Operator:	Mac Robertson Miller Airlines
Location:	Near Port Hedland, WA, Australia
Nature of flight:	Scheduled Passenger
Fatalities:	26
Damage to aircraft:	Destroyed

The aircraft was on a regular public transport service from Perth to Port Hedland. The aircraft was established on track, and the Captain reported turbulence during the climb. The flight continued normally, with position reports being transmitted as scheduled. The crew reported to Port Hedland Flight Service just prior to commencing descent from Flight Level 190, and at 30 miles south of Port Hedland they reported leaving 7,000 feet on descent. This was the last message received from the aircraft.

At about the time that the aircraft failed to respond to radio communications from Flight Service, witnesses saw the aircraft descending rapidly and steeply, but were not able to observe the aircraft collide with the ground because of intervening high terrain. Another aircraft in the vicinity searched along the intended route of the accident aircraft and eleven minutes later the burning wreckage was discovered approximately 28 miles south of Port Hedland Airport. A ground party reached the scene of the accident about an hour later. None of the occupants had survived.

The investigation found that the aircraft experienced an in-flight structural failure in which the right wing outboard of the number three engine separated from the aircraft. The primary failure in the wing occurred in the lower boom of the main spar, the principal load bearing component of the wing whilst the aircraft is in flight. It was determined that 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. Metallurgical examination of the fracture surfaces indicated that the fatigue crack extended over some 85 per cent of the cross-sectional area of the spar lower boom.

The fatigue endurance of the boom had been substantially reduced by the insertion of a flared bush at station 143, allowing the boom to fail before its retirement safe-life. As a consequence of the accident the manufacturer reduced the retirement life of all inner wing lower booms. This gave rise to a need for immediate boom changes in a large number of Viscount aircraft in many countries.

De Havilland Dove DH-104, N2300H, in Lake Erie

Date:	28 January 1970
Aircraft type:	De Havilland Dove, DH-104
Registration:	N2300H
Operator:	Tag Airlines, Inc.
Location:	In Lake Erie
Nature of flight:	Scheduled Passenger
Fatalities:	9
Damage to aircraft:	Destroyed
NTSB report:	NTSB-AAR-71-5

The aircraft was on a scheduled service from Cleveland to Detroit when the accident occurred. It was determined that the aircraft had crashed through the ice into Lake Erie and that some parts sank in 80 feet of water.

The investigation determined that the accident was the result of the in-flight failure of the lower right main wing to fuselage attachment fitting due to fatigue. The investigation also found that the Federal Aviation Administration's requirements for the timely replacement of the chromium plated root fittings was inadequate.

Vickers Vanguard, G-APEC, Aarsele, Belgium

Date:	2 October 1971
Aircraft type:	Vickers Vanguard
Registration:	G-APEC
Operator:	British European Airways
Location:	Aarsele, Belgium
Nature of flight:	Scheduled Passenger
Fatalities:	63
Damage to aircraft:	Destroyed
Civil Aircraft Accident Report:	15/72

The aircraft departed from London for Salzburg on a scheduled passenger service. Approximately 35 minutes later the pilot transmitted "We are going down, 706, we're going down", immediately followed by a MAYDAY. Fragmentary and garbled transmissions continued for about a minute. The aircraft was completely destroyed and there were no survivors.

The investigation determined that a major part of both horizontal tail surfaces, with their associated elevators, had detached from the airframe in flight. The rear pressure bulkhead had ruptured in cruise flight when a corrosion initiated crack exceeded the critical crack length, leading to the separation of both tailplanes in flight.

Beechcraft E18S, N42A, Cleveland, Ohio, USA

Date:	22 June 1972
Aircraft type:	Beechcraft E18S
Registration:	N42A
Operator:	Aero Taxi
Location:	Cleveland, Ohio, USA
Nature of flight:	Freight
Fatalities:	1
Damage to aircraft:	Destroyed
NTSB report:	NTSB-AAR-72-33

The accident occurred shortly after take off from Cleveland, Ohio. The pilot, the only occupant of the aircraft, was fatally injured. Two houses where damaged by the aircraft impact and fire.

The investigation determined that the accident resulted from the in-flight failure of the left wing, due to pre-existing fatigue cracking of the left wing lower spar cap at Wing Station 81. The fatigue crack was present during inspections of the spar cap conducted prior to the accident, but it was not detected.

Douglas DC-3, ZK-AOI, Seddon, New Zealand

Date:	23 February 1973
Aircraft type:	Douglas DC-3
Registration:	ZK-AOI
Operator:	Southern Air Super
Location:	Seddon, New Zealand
Nature of flight:	Agricultural
Fatalities:	1
Damage to aircraft:	Destroyed

New Zealand Aircraft Accident Report: No. 73-032

During an aerial top dressing flight the right wing separated from the rest of the structure and the aircraft collided with the ground and disintegrated.

The investigation determined that the accident resulted from the in-flight separation of the right wing. Failure of the wing was due to a loss of structural strength brought about by extensive fatigue cracks in the lower centre wing wraparound and internal doublers inboard of Station 142. Initiation and propagation to failure of the right-hand wing cracks was due to consistent over-stress.

Lockheed L-382, N14ST, near Springfield, Illinois, USA

Date:	23 May 1974
Aircraft type:	Lockheed L-382
Registration:	N14ST
Operator:	Saturn Airways, Inc.
Location:	Near Springfield, Illinois, USA
Nature of flight:	Scheduled Freight
Fatalities:	4
Damage to aircraft:	Destroyed
NTSB report:	NTSB-AAR-75-5

The accident occurred about 2.6 miles southeast of the Capitol Airport, near Springfield, Illinois. There were no survivors and the aircraft was destroyed. The outboard section of the left wing of the aircraft, including the number one engine, separated in flight from the remainder of the wing.

The investigation determined that pre-existing fatigue cracks had reduced the strength of the left wing to the degree that it failed under the aerodynamic loads created by moderate turbulence.

Vickers Viscount 785D, HK-1058, Monte San Isidoro, Columbia

Date:	8 June 1974
Aircraft type:	Vickers Viscount 785D
Registration:	HK-1058
Operator:	Aerolineas TAO
Location:	Monte San Isidoro, Columbia
Nature of flight:	Scheduled Passenger
Fatalities:	44
Damage to aircraft:	Destroyed

The aircraft was on a flight from Bucaramanga to Cucuta, Columbia. The crew reported at 13,500 feet in visual meteorological conditions and were cleared for a visual descent. Their subsequent report at 7,000 feet was the last communication with the aircraft.

The investigation determined that the left tailplane of the aircraft had become detached in flight. Examination of the tailplane found a fatigue fracture of the rear spar top forward boom at the extreme outer vertical and horizontal bolt holes for the attachment fittings.

Hawker Siddley HS 748, LV-HHB, Neuquen Province, Argentina

Date:	14 April 1976
Aircraft type:	Hawker Siddley HS 748
Registration:	LV-HHB
Operator:	Yacimientos Petroliferos Fiscales
Location:	Neuquen Province, Argentina
Nature of flight:	Non-Scheduled
Fatalities:	34
Damage to aircraft:	Destroyed
Aircraft Accident Report:	11/77

The aircraft was making a staff-transfer flight from Cutral-Co to Rincon de los Sauces, Neuquen Province. During the return flight the operation of the aircraft appeared normal and the weather was good. Shortly before the accident the pilot was in contact with another company aircraft operating in the same area. Witnesses saw the right wing separate from the aircraft at an estimated height of between 5,000 and 6,500 feet. All occupants died in the accident.

The investigation determined that the right wing separated in normal flight due to a structural fatigue failure of the wing in the area between stringers 3 and 12 and in the area of the engine outer rib. The fatigue failure initiated in a reinforcing plate and, in particular, its rivet hole. The presence of the fatigue cracks was attributed to stress concentration in the area concerned, resulting in the cracks becoming critical sooner than had been estimated. In addition, the manufacturer's inspection program for the area concerned was not sufficiently precise to ensure that the cracks would be detected and corrected in time.

Boeing 707-321C, G-BEBP, near Lusaka, Zambia

Date:	14 May 1977
Aircraft type:	Boeing 707-321C
Registration:	G-BEBP
Operator:	Dan-Air Services
Location:	Near Lusaka, Zambia
Nature of flight:	Non-Scheduled Freight
Fatalities:	6
Damage to aircraft:	Destroyed
AAIB report:	9/78

The accident occurred during 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 was 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.

McDonald Douglas DC-10, N110AA, Chicago, Illinois, USA

Date:	25 May 1979
Aircraft type:	McDonald Douglas DC-10
Registration:	N110AA
Operator:	American Airlines
Location:	Chicago, Illinois, USA
Nature of flight:	Scheduled Passenger
Fatalities:	273
Damage to aircraft:	Destroyed
NTSB report:	NTSB-AAR-79-17

The aircraft was taking off in clear weather. During the 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 continued to climb to about 325 feet above the ground and then began to roll to the left until the wings were past vertical. During the roll the aircraft's nose pitched down below the horizon. The aircraft collided with the ground in an open field and the wreckage scattered into an adjacent trailer park. Two hundred and seventy-one persons on board and two persons on the ground died.

The investigation found that damage by improper maintenance procedures resulted in an overload fracture and fatigue cracking of the pylon aft bulkhead upper flange. That led to failure of the pylon structure and the separation of the left engine and pylon assembly at a critical time during take-off. Underlying factors to the accident included deficiencies in the design of the pylon attach points and the leading edge slat system, deficiencies in FAA surveillance and reporting systems, and deficiencies in the dissemination of information about previous maintenance damage incidents.

Douglas B-26 Invader, N9417H, near Edwards Air Force Base, California, USA

Date:	3 March 1981
Aircraft type:	Douglas B-26, Invader
Registration:	N9417H
Operator:	
Location:	Near Edwards Air Force Base, California, USA
Nature of flight:	Miscellaneous
Fatalities:	3
Damage to aircraft:	Destroyed
NTSB identification:	LAX81FA054

During manoeuvring flight the left wing separated from the aircraft. The investigation found evidence of fatigue damage at wing station 141 on the lower forward spar.

Boeing 737, B2603, near Taipei, Taiwan

Date:	22 August 1981
Aircraft type:	Boeing 737
Registration:	B2603
Operator:	Far Eastern Air Transport
Location:	Near Taipei, Taiwan
Nature of flight:	Scheduled Passenger
Fatalities:	110
Damage to aircraft:	Destroyed

Fourteen minutes after take-off from Taipei, enroute to the Pescadores Islands, the aircraft broke up at high altitude. All 110 on board died in the accident. The wreckage was scattered over a 5-mile area and post impact fire occurred in some parts of the wreckage.

The investigation found that on 5 August 1981 the aircraft had lost cabin pressure on a flight from Taipei to Kaohsiung. On the flight prior to the accident, the aircraft lost cabin pressure ten minutes after take-off during a flight from Taipei to the Pescadores Islands. The crew returned to Taipei, where repair work was carried out.

The investigation attributed the accident to severe corrosion in the fuselage structure, which led to pressure hull rupture and explosive decompression.

Douglas B-26 Invader, CF-FIM, near Morley, Canada

Date:	13 July 1984
Aircraft type:	Douglas B-26, Invader
Registration:	CF-FIM
Operator:	
Location:	Near Morley, Canada
Nature of flight:	Training
Fatalities:	1
Damage to aircraft:	Destroyed

The aircraft was en route to a target area to do a practice water-bombing run. The left wing failed in flight due to a fatigue crack outboard of the left nacelle. (ICAO Summary 1984-5)

Boeing 747, JA-8119, Mount Ogura, Japan

Date:	12 August 1985
Aircraft type:	Boeing 747
Registration:	JA-8119
Operator:	Japan Airlines
Location:	Mount Ogura, Japan
Nature of flight:	Scheduled Passenger
Fatalities:	524
Damage to aircraft:	Destroyed

The aircraft experienced an explosive decompression while climbing through 23,900 feet. The crew declared an emergency and attempted to return to Tokyo. The flight data recorder output indicated that the aircraft then began to oscillate and roll. The aircraft descended, and after a period of approximately 40 minutes collided with a mountain approximately 400 feet from the summit. The death toll of 524 was the greatest number due to any single-aircraft accident.

The investigation found that a failure of the rear pressure bulkhead had caused a portion of the vertical stabiliser and part of the tail to be blown away, rupturing all four main hydraulic fluid lines. The aft pressure bulkhead ruptured as its strength had been reduced by fatigue cracks. The lower half of the bulkhead had been damaged in a previous tail-strike accident in 1978. Improper repair of the bulkhead resulted in the initiation and propagation of the fatigue cracks in a spliced portion of the bulkhead's webs. The fatigue cracks had not been found during six subsequent maintenance 'C checks'. (ICAO Summary 1987-3)

Piper Cherokee PA-28-181, N8191V, Maralin, Texas, USA

Date:	30 March 1987
Aircraft type:	Piper Cherokee PA-28-181
Registration:	N8191V
Operator:	
Location:	Maralin, Texas, USA
Nature of flight:	
Fatalities:	1
Damage to aircraft:	Destroyed
NTSB identification:	FTW87FA088

The aircraft had been involved in pipeline patrol throughout its history of 7,490 flight hours. Just before the accident, the aircraft was observed in straight and level flight along a pipeline. According to witnesses, the aircraft was at low altitude when a wing separated and the aircraft collided with the ground. The left wing was found approximately 600 feet from the main wreckage. The investigation revealed that it had separated at the wing root due to fatigue failure. The fatigue damage had originated near one of the outboard carry-through attachment bolt holes.

Boeing 737-297, N73711, near Maui, Hawaii, USA

Date:	28 April 1988
Aircraft type:	Boeing 737-297
Registration:	N73711
Operator:	Aloha Airlines, Inc.
Location:	Near Maui, Hawaii, USA
Nature of flight:	Scheduled Passenger
Fatalities:	1
Damage to aircraft:	Substantial
NTSB report:	NTSB-AAR-89-03

The aircraft experienced an explosive decompression and structural failure at 24,000 feet, while en route from Hilo to Honolulu, Hawaii. Approximately 18 feet of the aircraft cabin skin separated in flight from the structure aft of the cabin entrance door and above the passenger floor line. There were 89 passengers and 6 crew members on board. The only loss of life was a flight attendant who was lost overboard during the decompression. Seven passengers and one flight attendant received serious injuries. The flight crew performed an emergency descent and landed at Kahului Airport on the Island of Maui.

The investigation determined that the failure of Aloha Airline's maintenance program to detect the presence of significant disbonding and fatigue damage ultimately led to the failure of the lap joint at S-10L and the separation of the fuselage upper lobe. Significant factors included the failure of the operator's management to properly supervise its maintenance people, the failure of the FAA to properly evaluate the operator's maintenance program, and failure of the FAA to require inspection of all the lap joints proposed by Boeing Alert Service Bulletin SB 737-53A1039.

This accident was pivotal in highlighting the issue of ageing aircraft structures.

A.S.T.A (GAF) Nomad N24A, A18-401, near Mallala, South Australia, Australia

Date:	12 March 1990
Aircraft type:	A.S.T.A (GAF) Nomad N24A
Tail number:	A18-401
Operator:	Royal Australian Air Force
Location:	near Mallala, South Australia, Australia
Nature of flight:	
Fatalities:	1
Damage to aircraft:	Destroyed

During the down wind leg of an approach to the Edinburgh RAAF base the aircraft suddenly went out of control and collided with the ground. The investigation determined that the loss of control was the result of a failure of the aircraft's tail plane. Although the aircraft had completed only about 300 flight hours it had undergone considerable ground running and it is believed that this may have resulted in the growth of fatigue cracks in the tailplane's spar and its subsequent failure in flight.

Ayres S2R-T34, N4017B, Thornton, Mississippi, USA

Date:	26 September 1990
Aircraft type:	Ayres S2R-T34
Registration:	N4017B
Operator:	
Location:	Thornton, Mississippi, USA
Nature of flight:	Agricultural
Fatalities:	1
Damage to aircraft:	Destroyed

The right wing of the aircraft separated in flight while the aircraft was pulling up from an agricultural spraying run. The wing separated due to fatigue failure of the bottom spar cap. The fatigue cracking in the spar cap was the result of a hole drilled into the cap during the installation of a wing mounted air conditioning compressor, six years and 4,130 flight hours before the failure. The air conditioning unit was removed 10 months later and a patch was placed over the area where the hole had been drilled. The hole would not have been visible during inspection unless the patch had been removed.

The investigation concluded that the improper drilling of a hole in the spar cap had resulted in the initiation of fatigue cracking and subsequent failure of the spar cap and in-flight separation of the wing.

Bell 206B Jet Ranger, N213AL, South Marsh 275, Gulf of Mexico, USA

Date:	23 April 1991
Aircraft type:	Bell 206B Jet Ranger
Registration:	N213AL
Operator:	Offshore Logistics Inc.
Location:	South Marsh 275, Gulf of Mexico, USA
Nature of flight:	Non-Scheduled Passenger
Fatalities:	2
Damage to aircraft:	Destroyed
NTSB identification:	FTW91FA070

The pilot did not make a required 15-minute radio check after departure from an offshore oil rig, and a radio and air search was initiated. About two hours later, debris was found floating about three miles from the departure point.

The investigation found that the helicopter had experienced an in-flight separation of the vertical fin and subsequent mast bumping. A metallurgical examination determined that the vertical fin attachment fittings had separated due to fatigue induced by corrosion and corrosion pitting. The examination also revealed that the operator had unsuccessfully attempted to control the corrosion during a refurbishment of the airframe. All of the fatigue fractures appeared old and one had paint in the fracture.

Boeing 747-2R7F, B-198, Wanali near Taiwan

Date:	29 December 1991
Aircraft type:	Boeing 747-2R7F
Registration:	B-198
Operator:	China Airlines
Location:	Wanali near Taiwan
Nature of flight:	Freight
Fatalities:	5
Damage to aircraft:	Destroyed

During climb on a flight from Taipei, Taiwan, to Anchorage, Alaska, the crew reported problems with the number two engine at approximately 5,200 feet. Air traffic control gave left turn flight vectors to direct the aircraft back to the airport. Approximately two minutes later the crew reported that they were unable to turn left and air traffic control gave permission for the crew to turn right. That was the last contact with the aircraft.

The investigation revealed that the aircraft had lost control and crashed into a hill side right wing first. The number three engine had separated from the wing and struck the number four engine, which also separated. The number three engine pylon inboard fitting lugs had failed. Fatigue cracks were found on the pylon lugs.

Boeing 747-200F, 4X-AXG, Bijlmermeer, Amsterdam, Netherlands

Date:	4 October 1992
Aircraft type:	Boeing 747-200F
Registration:	4X-AXG
Operator:	El Al
Location:	Bijlmermeer, Amsterdam, Netherlands
Nature of flight:	Scheduled Freight
Fatalities:	47
Damage to aircraft:	Destroyed

Netherlands Aviation Safety Board: Report 92-11

As the aircraft climbed through 6,500 feet after departure from Schiphol airport, the pilot broadcast a Mayday and requested permission to return to Schiphol. The pilot advised air traffic control that he had a fire on the number three engine and that he had lost thrust on both the number three and four engines. The pilot requested a return to runway 27 and was provided with heading instructions by air traffic control. However, while reducing speed in preparation for the final approach, control was lost and the aircraft collided with the ground 13 km east of the airport. The aircraft impacted two 11-storey apartment blocks in a steep nose down dive and in a more than 90-degree right bank. All four persons on board the aircraft, and 43 people on the ground, died in the accident.

The investigation determined that the number three engine and pylon separated from the wing due to a fracture, initiated by a fatigue crack, of the shear face of the pylon's inboard midspar fuse pin. The number three engine rotated outboard and struck the number four engine, which then also separated. During the separation of the engines extensive damage occurred to the right wing leading edge flaps and the structure of the wing back as far as the front spar.

The investigation concluded that that the design and certification of the B747 pylon was inadequate to provide the required level of safety because the fail-safe analysis of the nacelle and pylon did not consider a fatigue failure or partial failure of a structural element. In addition, the system to ensure structural integrity by inspection had failed.

Piper PA-25 Pawnee, N6453Z, Essex, Iowa, USA

Date:	21 May 1993
Aircraft type:	Piper PA-25, Pawnee
Registration:	N6453Z
Operator:	
Location:	Essex, Iowa, USA
Nature of flight:	Agricultural
Fatalities:	1
Damage to aircraft:	Destroyed

The aircraft was on a spray run when the right wing failed, and the aircraft rolled into a descent and collided with the ground. Examination of the aircraft revealed that the forward spar fuselage attachment assembly for the right wing had failed from fatigue.

A factor related to the accident was the lack of a directed inspection procedure that could have been mandated by the issuing of an airworthiness directive. A similar failure of a Piper PA-25 occurred in September 1991. In May 1992, the NTSB made an urgent recommendation to the FAA that an airworthiness directive be issued for Piper PA-25 aircraft to be inspected immediately for corrosion and cracking of the attachment assembly and that periodic inspection requirements be established to detect cracks before they become critical. In July 1992, the FAA agreed with the intent of the recommendation, but at the time of the accident no inspection procedure was in effect.

MBB BK117B-1, N909CP, 60th Street Heliport, New York, USA

Date:	15 April 1997
Aircraft type:	MBB BK117B-1
Registration:	N909CP
Operator:	Colgate-Palmolive Co.
Location:	60th Street Heliport, New York, USA
Nature of flight:	Private
Fatalities:	1
Damage to aircraft:	Destroyed
NTSB identification:	NYC97FA076

After take-off the helicopter climbed vertically to a height of about 30 feet and the pilot prepared to transition to horizontal flight. However, as the pilot lowered the nose there was a loud bang from the rear of the helicopter which then began to rotate to the right. Control was not regained and the helicopter crashed into the waters of the East River. A subsequent inspection of the helicopter's tail boom discovered what appeared to be a low-vibration, high-cycle fatigue crack originating in a rivet hole in the vertical fin spar cap. The crack had extended completely across the spar cap and web resulting in the fin failure.

Ayres S2R-T34, N3103D, Corning, Arkansas, USA

Date:	14 June 1997
Aircraft type:	Ayres S2R-T34
Registration:	N3103D
Operator:	Hatley Flying Service
Location:	Corning, Arkansas, USA
Nature of flight:	Agricultural
Fatalities:	1
Damage to aircraft:	Destroyed

The left wing of the aircraft separated in flight while the aircraft was manoeuvring during an aerial application flight. A witness observed the wing falling to the ground and the aircraft cork-screwing to the ground.

A metallurgical examination of the fractured wing revealed that the separation of the lower spar cap was the result of a fatigue crack that emanated from the 1/4 inch diameter hole for the centre splice fitting. The examination also revealed that the material used in the manufacture of the lower spar cap was below specification and inadequate. Tensile strengths for the left wing spar cap were lower than that specified in the engineering drawing provided by the manufacturer. In addition, a review of the airframe records revealed that the operator had not complied with an Ayres service bulletin. The service bulletin included procedures for accomplishing a magnetic particle inspection of the lower spar cap bolt holes.

Beech T-34A, N140SW, Rydal, Georgia, USA

Date:	19 April 1999
Aircraft type:	Beech T-34A
Registration:	N140SW
Operator:	Sky Warriors, Inc.
Location:	Rydal, Georgia, USA
Nature of flight:	Combat Simulation
Fatalities:	2
Damage to aircraft:	Destroyed

The right wing of the aircraft separated from the airframe while the pilot was performing a descending and turning manoeuvre during a simulated combat flight. Examination of the aircraft disclosed fatigue cracking in the spar material in the vicinity of the wing spar fracture face.

The investigation found that the safety pilot exceeded the airframe design limits resulting in the overload failure of the right wing. A factor was fatigue cracking in the failed wing spar.

Cessna 402C, N819BW, Goldsby, Oklahoma, USA

Date:	27 April 1999
Aircraft type:	Cessna 402C
Registration:	N819BW
Operator:	Texas Air Charters, Inc.
Location:	Goldsby, Oklahoma, USA
Nature of flight:	Non-Scheduled Passenger
Fatalities:	1
Damage to aircraft:	Destroyed

The aircraft collided with the ground in an uncontrolled descent following the in-flight separation of the right wing during a normal descent. The aircraft had accumulated a total time of 20,457 hours and had been flown 52 hours since the most recent annual inspection three weeks prior to the accident. 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.

The investigation concluded that the fatigue failure was due to inadequate quality control during manufacture of the spar, and inadequate inspection of the right wing.

Air Tractor 502A, N15466, Queen Creek, Arizona, USA

Date:	22 April 2000
Aircraft type:	Air Tractor 502A
Registration:	N15466
Operator:	San Tan Dusters, Inc.
Location:	Queen Creek, Arizona, USA
Nature of flight:	Agricultural
Fatalities:	1
Damage to aircraft:	Destroyed

The aircraft was being used in aerial spraying when the left wing separated in flight during a level spray pass. The lower spar cap of the left wing had fractured in fatigue in the area of the inboard attachment block bolt hole. Multiple origin sites were identified within the bolt hole bore, with corrosion pitting evident at the origin points. Air Tractor service documentation specified a detailed inspection of the spar caps for cracks every 2,000 hours or 3 years. Based on available records, the aircraft was believed to have flown only 1,500 hours since the inspection.

The investigation concluded that the fatigue failure and in-flight separation of the left wing was due to the manufacturers underestimation during the aircraft design process of the time interval from fatigue crack initiation to failure, and the manufacturers subsequent specification of an inadequate inspection interval.

Lockheed C130A, N130HP, Walker, California, USA

Date:	17 June 2002
Aircraft type:	Lockheed C130A
Registration:	N130HP
Operator:	Hawkins and Powers, Aviation, Inc.
Location:	Walker, California, USA
Nature of flight:	Fire fighting
Fatalities:	3
Damage to aircraft:	Destroyed

The aircraft, operated by the Forestry Service for fire fighting, broke apart in flight while executing a fire retardant delivery. During the retardant drop the aircraft's wings folded upward at the centre wing-to-fuselage attachment point and separated. The three flight crewmembers were fatally injured and the aircraft was destroyed.

The investigation revealed fatigue cracks in parts of wing structure. The aircraft was delivered to the Air Force in 1957 and acquired by the U.S. Forest Service in 1988. At the time of the accident the aircraft had accumulated about 21,863 flight hours.

The NTSB investigation is continuing. It will include consideration of whether the event was unique or a sign of systemic problems with military surplus aircraft now in public use operations. The investigation will review continuing airworthiness issues including the original design intent, engineering support, mission profile, operating limits, inspection intervals and techniques and life limits, in the context of the current mission for which the Forest Service is using the aircraft.

Consolidated-Vultee P4Y-2, N7620C, Estes Park, Colorado, USA

Date:	18 July 2002
Aircraft type:	Consolidated-Vultee P4Y-2
Registration:	N7620C
Operator:	Hawkins and Powers, Aviation, Inc.
Location:	Estes Park, Colorado, USA
Nature of flight:	Fire Fighting
Fatalities:	2
Damage to aircraft:	Destroyed

The aircraft, operated by the Forestry Service for fire fighting, was making a 15–20 degree left bank in preparation to drop retardant on a forest fire when the aircraft's left wing failed just inboard of the number two engine. The wing fractured at the wing-to-fuselage attachment point along the lower left spar cap. The aircraft was destroyed upon impact and the two crewmembers on board were fatally injured. A post-crash fire ensued.

Fatigue cracks were found in pieces of wing structure. The aircraft was manufactured in 1944 and was obtained by the operator in 1969. Total flight hours are unknown but from 1969 to the time of the accident the aircraft had accumulated 8,200 flight hours.

The NTSB investigation is continuing. It will include consideration of the factors outlined above in relation to the crash of Lockheed C130A, N130HP, on 17 June 2002.

Appendix 9: US regulations concerning Instructions for Continued Airworthiness

Code of Federal Regulations, Title 14, Aeronautics and Space

Chapter I, Part 25, *Airworthiness standards: Transport category airplanes*

§ 25.1529 Instructions for Continued Airworthiness.

The applicant must prepare Instructions for Continued Airworthiness in accordance with appendix H to this part that are acceptable to the Administrator. The instructions may be incomplete at type certification if a program exists to ensure their completion prior to delivery of the first airplane or issuance of a standard certificate of airworthiness, whichever occurs later.

[Amdt. 25-54, 45 FR 60173, Sept. 11, 1980]

Appendix H to Part 25 -- Instructions for Continued Airworthiness

H25.1 *General*.

(a) This appendix specifies requirements for the preparation of Instructions for Continued Airworthiness as required by § 25.1529.

(b) The Instructions for Continued Airworthiness for each airplane must include the Instructions for Continued Airworthiness for each engine and propeller (hereinafter designated "products"), for each appliance required by this chapter, and any required information relating to the interface of those appliances and products with the airplane. If Instructions for Continued Airworthiness are not supplied by the manufacturer of an appliance or product installed in the airplane, the Instructions for Continued Airworthiness for the airplane must include the information essential to the continued airworthiness of the airplane.

(c) The applicant must submit to the FAA a program to show how changes to the Instructions for Continued Airworthiness made by the applicant or by the manufacturers or products and appliances installed in the airplane will be distributed.

H25.2 *Format*.

(a) The Instructions for Continued Airworthiness must be in the form of a manual or manuals as appropriate for the quantity of data to be provided.

(b) The format of the manual or manuals must provide for a practical arrangement.

H25.3 *Content*.

The contents of the manual or manuals must be prepared in the English language. The Instructions for Continued Airworthiness must contain the following manuals or sections, as appropriate, and information:

(a) *Airplane maintenance manual or section*.

    (1) Introduction information that includes an explanation of the airplane's features and data to the extent necessary for maintenance or preventive maintenance.

(2) A description of the airplane and its systems and installations including its engines, propellers, and appliances.

(3) Basic control and operation information describing how the airplane components and systems are controlled and how they operate, including any special procedures and limitations that apply.

(4) Servicing information that covers details regarding servicing points, capacities of tanks, reservoirs, types of fluids to be used, pressures applicable to the various systems, location of access panels for inspection and servicing, locations of lubrication points, lubricants to be used, equipment required for servicing, tow instructions and limitations, mooring, jacking, and leveling information.

(b) *Maintenance instructions.*

(1) Scheduling information for each part of the airplane and its engines, auxiliary power units, propellers, accessories, instruments, and equipment that provides the recommended periods at which they should be cleaned, inspected, adjusted, tested, and lubricated, and the degree of inspection, the applicable wear tolerances, and work recommended at these periods. However, the applicant may refer to an accessory, instrument, or equipment manufacturer as the source of this information if the applicant shows that the item has an exceptionally high degree of complexity requiring specialized maintenance techniques, test equipment, or expertise. The recommended overhaul periods and necessary cross references to the Airworthiness Limitations section of the manual must also be included. In addition, the applicant must include an inspection program that includes the frequency and extent of the inspections necessary to provide for the continued airworthiness of the airplane.

(2) Troubleshooting information describing probable malfunctions, how to recognize those malfunctions, and the remedial action for those malfunctions.

(3) Information describing the order and method of removing and replacing products and parts with any necessary precautions to be taken.

(4) Other general procedural instructions including procedures for system testing during ground running, symmetry checks, weighing and determining the center of gravity, lifting and shoring, and storage limitations.

(c) Diagrams of structural access plates and information needed to gain access for inspections when access plates are not provided.

(d) Details for the application of special inspection techniques including radiographic and ultrasonic testing where such processes are specified.

(e) Information needed to apply protective treatments to the structure after inspection.

(f) All data relative to structural fasteners such as identification, discard recommendations, and torque values.

(g) A list of special tools needed.

H25.4 *Airworthiness Limitations section*.

(a) The Instructions for Continued Airworthiness must contain a section titled Airworthiness Limitations that is segregated and clearly distinguishable from the rest of the document. This section must set forth --

(1) Each mandatory replacement time, structural inspection interval, and related structural inspection procedures approved under § 25.571; and

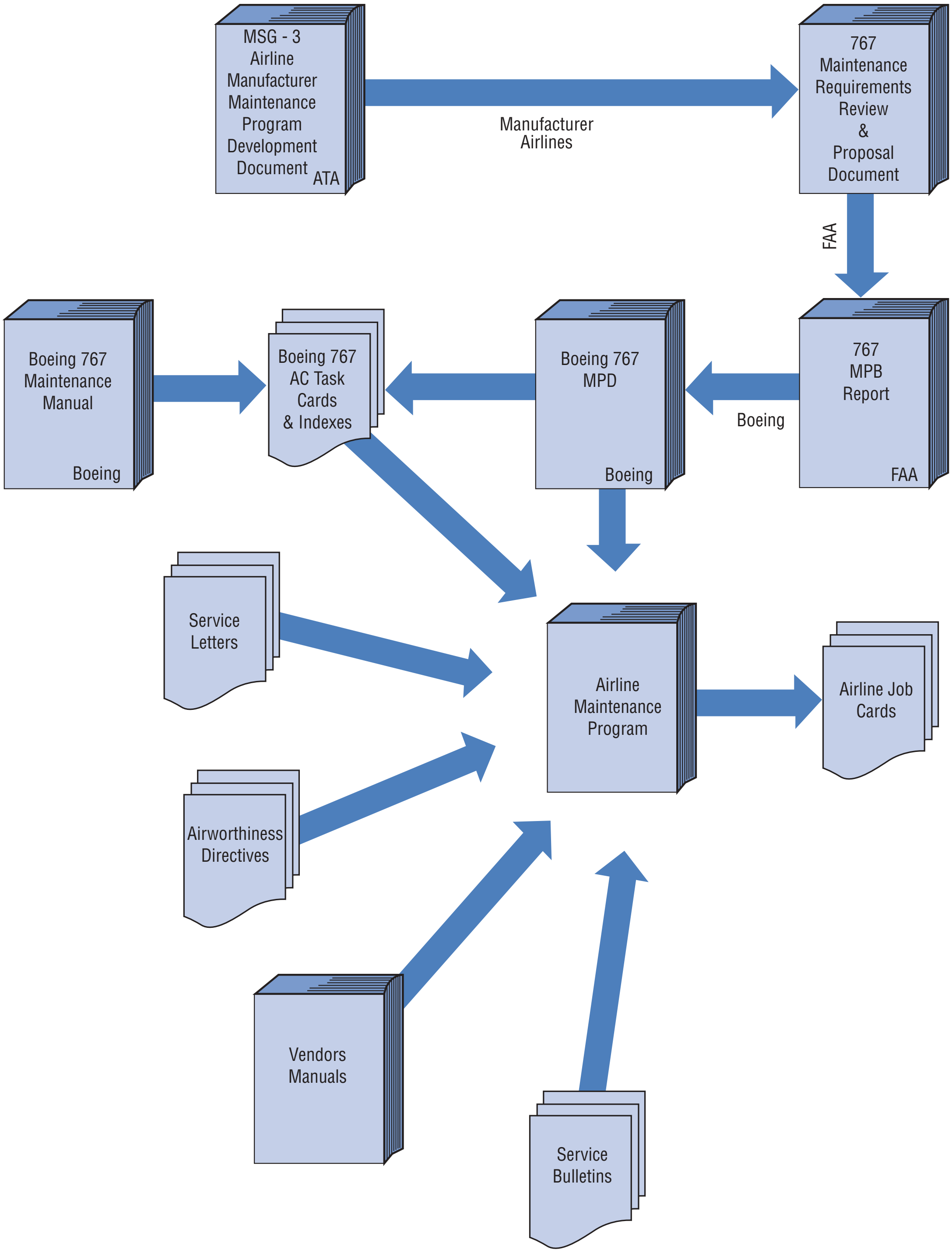
(2) Each mandatory replacement time, inspection interval, related inspection procedure, and all critical design configuration control limitations approved under § 25.981 for the fuel tank system.

(b) If the Instructions for Continued Airworthiness consist of multiple documents, the section required by this paragraph must be included in the principal manual. This section must contain a legible statement in a prominent location that reads: "The Airworthiness Limitations section is FAA-approved and specifies maintenance required under § § 43.16 and 91.403 of the Federal Aviation Regulations, unless an alternative program has been FAA approved."

[Amdt. 25-54, 45 FR 60177, Sept. 11, 1980, as amended by Amdt. 25-68, 54 FR 34329, Aug. 18, 1989; Amdt. 25-102, 66 FR 23130, May 7, 2001]

Appendix 10: Boeing 767 maintenance program development

Information published in the Boeing 767 *Maintenance Planning Data Document* outlines the B767 maintenance program development (D622T001, February 1994, section 1, page 1.0-8).



Appendix 11: Regulations enabling airworthiness directives

Australian Civil Aviation Regulations 1998

Part 39, *Airworthiness directives*

39.1 CASA may issue airworthiness directives.

(1) CASA may issue an airworthiness directive for a kind of aircraft, or a kind of aeronautical product, if:

   (a) an unsafe condition exists in an aircraft or aeronautical product of that kind; and

   (b) the condition exists, or is likely to exist, or could develop, in other aircraft or aeronautical products of that kind.

USA Federal Aviation Regulations

Code of Federal Regulations, Title 14, *Aeronautics and Space*

Chapter I, Part 39, *Airworthiness directives*

39.1 Applicability.

This part prescribes airworthiness directives that apply to aircraft, aircraft engines, propellers, or appliances (hereinafter referred to in this part as "products") when:

   (a) An unsafe condition exists in a product; and

   (b) That condition is likely to exist or develop in other products of the same type design.

Note: Following revision of Federal Aviation Regulations Part 39 on 22 July 2002 the information previously in section 39.1 now appears in sections 39.3 and 39.5.

Appendix 12: FAA determination of compliance times and grace periods

Excerpt from FAA *Airworthiness Directives Manual*

FAA-AIR-M-8040.1
Chg. 99-1, incorporated 28 October 1999.
http://av-info.faa.gov/ad/ADManual/Manual99.doc

Section 12. Text of AD's [airworthiness directives]

123. COMPLIANCE TIME OR PERIOD.

a. General. In determining compliance times for AD's, usually two types of analyses are necessary:

- First, a compliance "threshold" must be established, based on an engineering assessment of when action should be taken to detect or prevent the unsafe condition. For example, if service experience indicates that fatigue cracking has been detected on airplanes with 10,000 landings, the engineer might determine that repetitive inspections should be initiated prior to the accumulation of 5,000 landings. For some types of unsafe conditions, such as computer software errors or certain manufacturing defects, the unsafe condition may exist on new products. In these cases, the threshold would be zero.

- Second, for those products that have already exceeded the threshold, a "grace period" must be established to preclude products from being grounded unnecessarily. In determining the appropriate grace period, the degree of urgency of the unsafe condition must be balanced against the amount of time necessary to accomplish the required actions, the availability of necessary replacement parts, operators' regular maintenance schedules, and other factors affecting the ability of operators to comply. In some cases it may be necessary to ground aircraft, but in most cases the grace period can be selected to avoid grounding and interference with normal maintenance schedules, while still obtaining expeditious compliance.

  (1) Similarly, in selecting repetitive inspection intervals, compliance times should be chosen to ensure that the unsafe condition can be detected before it can become critical, but without imposing unnecessary burdens on operators.

  (2) Combining these factors, a typical compliance time provision might state:

  Prior to the accumulation of 5,000 landings or within the next 1,000 landings after the effective date of this AD, whichever occurs later; and thereafter at intervals not to exceed 2,000 landings, inspect....

b. Time-in-Service.

  (1) The simplest expression of compliance time is in terms of a specific number of hours of operation at which compliance is required for all affected products, that is, hours of time-in-service (TIS). Using the phrase "within the next [*X*] hours TIS" means up to and including [*X*] hours. The phrase "prior to the accumulation of [X] hours TIS" means up to but not including [*X*] hours. Examples:

  Compliance: Required within the next [*100 hours*] time-in-service (TIS) after the effective date of this AD.

Compliance: Required within the next [*300 hours*] time-in-service (TIS) after the effective date of this AD, or prior to the accumulation of [*5000 hours*] TIS, whichever occurs [*later*].

(2) When the compliance times relate to hours of time-in-service and are complex, the statement "compliance is required as indicated" should be used and the actual compliance times given in the body of the AD. Avoid stating compliance times that create overlapping requirements. Example that avoids overlap:

Prior to the accumulation of [*3,000*] hours time-in-service (TIS), or within the next [*300*] hours TIS after the effective date of this AD, whichever occurs later, inspect in accordance with paragraph (*x*) of this AD.

c. Calendar Times and Dates.

(1) Calendar times (e.g., "within six months after the effective date of this AD") may be used to express compliance times when a direct relationship between calendar time and airworthiness (including corrosion) can be established; an aircraft's utilization rate varies greatly throughout the fleet; or logistical support considerations (parts availability, repair facility availability) dictate that compliance be accomplished on an attrition basis with a calendar deadline established to minimize impact on operators (that is, avoid unnecessary grounding of aircraft).

(2) Where compliance times are specified as a period of time after the effective date, the time is measured from the effective date. For example, if the compliance time is "within 12 months after the effective date" and the effective date is January 15, 1991, the deadline for compliance is January 15, 1992. Where compliance times are specified as a number of calendar months after the effective date, the time is measured from the end of the month during which the AD becomes effective. For example, if the compliance time is "within 12 calendar months after the effective date" and the effective date is January 15, 1991, the deadline for compliance is January 31, 1992.

(3) Calendar dates (e.g., "before January 1, 1993") should be used to express compliance times only when engineering analysis establishes a direct relationship between the date and either the compliance "threshold" or the "grace period." In most cases, this relationship does not exist.

Compliance thresholds are usually a function of utilization, which is unrelated to calendar dates. Grace periods are a function of the amount of time necessary after the effective date to accomplish the required actions. During the period of time that an AD is developed, effective dates cannot usually be determined with any precision, especially at the NPRM stage. Therefore, citing a calendar date is not usually an appropriate method of specifying a grace period.

(4) In some cases, however, a direct analytical relationship can be established and it is appropriate to use calendar dates. In these cases, the relationship should be explained briefly in the preamble. The mere fact that a manufacturer's service document or an international civil aviation authority's AD references a calendar date does not provide a justification for the use of a calendar date in a U.S. AD.

d. Number of Landings.

(1) The number of landings may be used to express compliance time if the problem is related to landing cycles such as in landing gear, flaps, or fatigue aggravated by landing, or if the problem is related to pressurization, such as fatigue cracking. Example:

Compliance: Required prior to the accumulation of [*100 landings*] after the effective date of this AD.

(2) For operators that do not keep landing records, the following statement may be used:

Subject to acceptance by [*appropriate FAA official*], operators that do not have landing records may determine the number of landings by dividing the number of hours of time-in-service of each airplane by the time of the average flight for the aircraft of that type in the operator's fleet.

e. Engine Cycles.

(1) For AD's affecting turbine engines, the compliance time may be expressed in cycles. The use of engine cycles in an AD compliance requirement shall be in accordance with the standard cycle definition and cycle counting methodology specified in the approved service document for the applicable engine model. For the purposes of an AD, when the cycle definition or counting methodology differs from that prescribed in the applicable approved service documents, the cycle definition or the cycle counting methodology shall be included in the body of the AD.

(2) In no case may the engine cycle compliance requirement prescribed in the AD cause or allow an approved cyclic retirement life (as specified in the applicable approved service document) to be exceeded.

Appendix 13: Examples of Australian registered transport aircraft

Class A refers to an aircraft with a Certificate of Airworthiness issued in the transport category, or an aircraft which is used for regular public transport operations.

Explanatory information from CASA Advisory Circular AC 21.1(1) (December 2000) *Aircraft Airworthiness Certification Categories And Designations Explained* states:

8.1 Transport Category:

(a) transport category applies to multi-engined aircraft primarily intended for the regular public transport of passengers and/or cargo for hire or reward;

(b) transport category generally applies to aircraft with a maximum take-off weight (MTOW) in excess of 5700 kg. Such aircraft must meet the airworthiness standards of CASR Part 25 (for aeroplanes) or CASR Part 29 (for rotorcraft), or be automatically accepted from a CASA-recognised country, or comply with the predecessors or equivalents of these standards. It also includes aircraft which comply with the requirements of Civil Aviation Order (CAO) 101.4, and the now repealed CAOs 101.2, 101.5, 101.6, 101.8 or 101.10;

(c) there are some exceptions to the requirements outlined in (b) above:

(i) nothing precludes a multi-engined aircraft of less than 5700kg MTOW being certificated in the transport category, if that is the election of a manufacturer. However, the aircraft type must still meet CASRs Part 25 or Part 29;

(ii) commuter category aircraft may be in excess of 5700 kg MTOW;

(iii) some normal category types may be in excess of 5700 kg MTOW e.g. aircraft certificated under Special FAR (SFAR) Part 41;

(d) the Australian airworthiness standards include a transport category of aircraft based on FAR Part 23 (normal) certification, as long as certain minimum design features (such as multi-engined configuration) are met. This is allowed for under CAO 101.4 ("Airworthiness Certification Requirements — Imported Aeroplanes Not above 5700 kg in the Transport Category").

The following table lists typical aircraft types on the Australian civil register that include aircraft with Certificate of Airworthiness issued in the transport category.

The table, based on July 2002 data, shows aircraft types for which five or more aircraft were registered in the transport category. The information is for indicative purposes only. Detailed current data can be obtained from the CASA website (http://www.casa.gov.au).

Table 7:
Examples of Australian aircraft with a Certificate of Airworthiness issued in the transport category July 2002

Aircraft make and type	*No. of aircraft*
Boeing 737	73
Boeing 767	44
Boeing 747	34
De Havilland DHC-8 Dash 8	34
British Aerospace BAe 146	29
Saab 340	25
Sikorsky S-76	18
Kawasaki BK117	16
Airbus A320	14
Douglas DC3	13
Cessna 550 Citation II	12
Bell 412	11
Embraer EMB-120 Brasilia	11
Boeing 717	10
Fokker F27 Friendship	8
De Havilland DHC-6 Twin Otter *	7
Israel 1124 Westwind	7
Cessna 441 Conquest *	6
Cessna 500 Citation	6
Eurocopter AS332 Super Puma	6
Boeing 727	5
Cessna 404 Titan *	5
Eurocopter SA365 Dauphin	5
Short SD3-60	5

* Aircraft of this type are not usually registered in the transport category (for example, less than 50 per cent of aircraft of this type on the Australian civil register in July 2002 held a Certificates of Airworthiness in the transport category).

Appendix 14: Certificate of Registration holder responsibilities

Listed below are some of the responsibilities that the Civil Aviation Regulations (CAR) require of Certificate of Registration holders in relation to the maintenance of Class A aircraft.

The Certificate of Registration holder must:

- apply for a Certificate of Airworthiness (CAR 1998, r. 21.173 (1))
- ensure that the aircraft does not fly unless it is fully compliant with all relevant airworthiness directives (CAR 1998, r. 39.3)
- ensure that maintenance required by the approved system of maintenance is carried out when required by that system (CAR 1988, r. 39 (1))
- if aware that the aircraft's approved system of maintenance is not appropriate or is defective, then request the required changes to ensure that the system is appropriate or is no longer defective (CAR 1988, r. 40)
- request approval and changes for the aircraft's approved system of maintenance (CAR 1988, r. 42J(1) and r. 42P(1))
- ensure that maintenance is only carried out on the aircraft by a person who is permitted to carry out that maintenance by the Civil Aviation Regulations (CAR 1988, r. 42ZC)
- in relation to the aircraft's Maintenance Release is required to:
    - pass on information relating to directions, or suspension or cancellation of the maintenance release (CAR 1988, r. 46)
    - annotate the maintenance release if aware that the aircraft is not airworthy (CAR 1988, r. 47)
    - annotate the maintenance release if aware of a permissible unserviceability (CAR 1988, r. 49)
    - annotate the maintenance release if aware of a defect in the aircraft (CAR 1988, r. 50)
- ensure that a log book or alternative to a log book is kept for the aircraft (CAR 1988, r. 50A and r. 50B)
- investigate a defect in the aircraft and report a major defect to CASA (CAR 1988, r. 51 (4)).

Appendix 15: *Civil Aviation Act 1988*, s. 28BE and s. 28BF

28BE Duty to exercise care and diligence

(1) The holder of an AOC must at all times take all reasonable steps to ensure that every activity covered by the AOC, and everything done in connection with such an activity, is done with a reasonable degree of care and diligence.

(2) If the holder is a body having legal personality, each of its directors must also take the steps specified in subsection (1).

(3) It is evidence of a failure by a body and its directors to comply with this section if an act covered by this section is done without a reasonable degree of care and diligence mainly because of:

(a) inadequate corporate management, control or supervision of the conduct of any of the body's directors, servants or agents; or

(b) failure to provide adequate systems for communicating relevant information to relevant people in the body.

(4) No action lies, for damages or compensation, in respect of contravention of this section.

(5) This section does not affect any duty imposed by, or under, any other law of the Commonwealth, or of a State or Territory, or under the common law.

28BF Organisation, personnel etc.

(1) The holder of an AOC must at all times maintain an appropriate organisation, with a sufficient number of appropriately qualified personnel and a sound and effective management structure, having regard to the nature of the operations covered by the AOC.

(2) The holder must establish and maintain any supervisory positions in the organisation, or in any training and checking organisation established as part of it, that CASA directs, having regard to the nature of the operations covered by the AOC.

Appendix 16: Excerpts from B767 *Maintenance Planning Data Document* section 9

June 2000 revision, selected pages only.

BOEING

767 MAINTENANCE PLANNING DATA

SECTION 9.

AIRWORTHINESS LIMITATIONS AND CERTIFICATION MAINTENANCE REQUIREMENTS

767

Maintenance Planning Data (MPD) Document
Section 9
Airworthiness Limitations and Certification Maintenance Requirements (CMRs)

D622T001-9

REVISION: JUNE 2000

COMPILED AND PUBLISHED BY:
MAINTENANCE AND GROUND OPERATIONS SYSTEMS
CUSTOMER SUPPORT

BOEING COMMERCIAL AIRPLANE GROUP
SEATTLE, WASHINGTON

AIRWORTHINESS LIMITATIONS - STRUCTURAL INSPECTIONS [continued]

SSI #	DTR CHECK FORM TITLE	ZONE	AIRPLANE APPLICABILITY	TYPE & THRESHOLD
53-50-I06D	SINGLE EMERGENCY EXIT CUTOUT - SILL INNER CHORD AT FRAME INTERSECT AT BS 859.5 AND BS 883.5.	241, 242	200	TYPE 2 50,000 CYCLES
53-50-I06E	SINGLE EMERGENCY EXIT CUTOUT - SILL OUTER CHORD.	241, 242	200	TYPE 2 50,000 CYCLES
53-50-I06F	SINGLE EMERGENCY EXIT CUTOUT - SILL OUTER CHORD AT FRAME INTERSECT.	241, 242	200	TYPE 2 50,000 CYCLES
53-50-I11	BS 1043 FRAME SPLICE WITH THE LANDING GEAR FITTING - BS 1043, BL 92, WL 193 TO WL 199.	141, 142	ALL	TYPE 2 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
53-50-I13A	FUSELAGE REAR SPAR BULKHEAD - BULKHEAD FITTING INBOARD PRONG ATTACHMENT TO WING REAR SPAR.	DELETED		
53-50-I13B	FUSELAGE REAR SPAR BULKHEAD - BULKHEAD FITTING INNER CHORD S-20 TO S-21 AT SEAT TRACK BRACKET.	131, 132	ALL	TYPE 1 25,000 CYCLES
53-50-I13C	FUSELAGE REAR SPAR BULKHEAD - INBOARD CHORD FLANGE - BS 955, BL 91, S-18 TO S-20.	241, 242	ALL	TYPE 2 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
53-50-I14A	AFT WHEEL WELL BULKHEAD BS 1065 - VERTICAL BEAM BL 26 INTERCOSTAL UPPER CHORD SPLICE.	143, 144	ALL	TYPE 2 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
53-50-I14B	AFT WHEEL WELL BULKHEAD BS 1065 - HIDDEN DETAILS AT CHORD SPLICES S-27 TO S-28 & S-35 TO S-36.	151, 152	ALL	TYPE 1 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)

BOEING
767 MAINTENANCE PLANNING DATA

AIRWORTHINESS LIMITATIONS - STRUCTURAL INSPECTIONS [continued]

SSI #	DTR CHECK FORM TITLE	ZONE	AIRPLANE APPLICABILITY	TYPE & THRESHOLD
53-50-I14C	AFT WHEEL WELL BULKHEAD BS 1065 - HIDDEN DETAILS AT CHORD BETWEEN S-29 &S-34.	151, 152	ALL	TYPE I 25,000 CYCLES
53-50-I18 53-50-I24 53-50-I28	SECTION 45 STUB FRAMES - BS 808 - 933 FRAME INNER CHORD AT STUB BEAM.	131, 132	200 300 PASS 300F	TYPE 2 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F)
53-50-I19	MLG WHEEL WELL - BS 1021TRANSVERSE FLOOR BEAM LOWER CHORD - FROM LBL 33 TO LBL 60 & RBL 33 TO RBL 60.	143, 144	PASS	TYPE 2 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (400)
53-50-I19B	MLG WHEEL WELL TRANSVERSE FLOOR BEAM BS 1021 LOWER CHORD - FROM LBL 33 TO LBL 60 & RBL 33 TO RBL 60.	DELETED		
53-50-I22A	DUAL EMERGENCY EXIT CUTOUT - FRAME INNER CHORDS.	241, 242	200 300 PASS	TYPE 2 50,000 CYCLES
53-50-I22B	DUAL EMERGENCY EXIT CUTOUT - FRAME INNER CHORD AT SILL INTERSECT.	241, 242	200 300 PASS	TYPE 2 50,000 CYCLES
53-50-I22C	DUAL EMERGENCY EXIT CUTOUT - SILL INNER CHORD .	241, 242	200 300 PASS	TYPE 2 50,000 CYCLES
53-50-I22D	DUAL EMERGENCY EXIT CUTOUT - SILL INNER CHORD AT FRAME INTERSECT.	241, 242	200 300 PASS	TYPE 2 50,000 CYCLES
53-50-I22E	DUAL EMERGENCY EXIT CUTOUT - UPPER SILL INNER CHORD AT BS 859.5 AND BS 903.5.	241, 242	300 PASS	TYPE 2 50,000 CYCLES
53-50-I22F	DUAL EMERGENCY EXIT CUTOUT - SILL OUTER CHORD.	241, 242	200 300 PASS	TYPE 2 50,000 CYCLES

AIRWORTHINESS LIMITATIONS - STRUCTURAL INSPECTIONS [continued]

SSI #	DTR CHECK FORM TITLE	ZONE	AIRPLANE APPLICABILITY	TYPE & THRESHOLD
53-80-I01A	AFT PRESSURE BULKHEAD - CIRCUMFERENTIAL ATTACHMENT OF WEB TO Y-RING.	165, 166, 251, 252, 253, 254	ALL	TYPE 2 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
53-80-I01B	AFT PRESSURE BULKHEAD - RADIAL WEB LAP SPLICES	311, 312	ALL	TYPE 2 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
53-80-I01C	AFT PRESSURE BULKHEAD - RADIAL WEB LAP SPLICES	311, 312	ALL	TYPE 2 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
53-80-I01D	AFT PRESSURE BULKHEAD - CIRCUMFERENTIAL TEAR STRAP SPLICE	311, 312	ALL	TYPE 2 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
53-80-I01E	AFT PRESSURE BULKHEAD - CIRCUMFERENTIAL TEAR STRAP	311, 312	ALL	TYPE 2 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
53-80-I03	SECTION 48 - JACKSCREW FITTING LUG - UPPER BULKHEAD AT STA 1702.	311, 312	ALL	TYPE 1 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
53-80-I13	SECTION 48 - PIVOT FITTING LUG.	313, 314	ALL	TYPE 1 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
53-80-I15 53-80-I16 53-80-I17	BS 1809.5 BULKHEAD OUTBOARD CHORD	313, 314	ALL	TYPE 1 25,000 CYCLES

AIRWORTHINESS LIMITATIONS - STRUCTURAL INSPECTIONS [continued]

SSI #	DTR CHECK FORM TITLE	ZONE	AIRPLANE APPLICABILITY	TYPE & THRESHOLD
53-80-I25	HORIZONTAL STABILIZER FITTING HINGE PINS - BS 1809, BL 41.5	313, 314	ALL	TYPE 1 25,000 CYCLES
54-50-I01 54-50-I04	TYPICAL MIDSPAR CHORD CONSTRUCTION - JT9D STRUT.	432, 434, 436, 442, 444, 446	7R4	TYPE 2 50,000 CYCLES
54-50-I01 54-50-I04	TYPICAL MIDSPAR CHORD CONSTRUCTION - PW4000 STRUT.	432, 434, 436, 442, 444, 446	4000	TYPE 2 25,000 CYCLES
54-50-I01 54-50-I04	TYPICAL MIDSPAR CHORD CONSTRUCTION - CF6-80A STRUT.	432, 434, 436, 442, 444, 446	80A	TYPE 2 50,000 CYCLES
54-50-I01 54-50-I04	TYPICAL MIDSPAR CHORD CONSTRUCTION - CF6-80C STRUT	432, 434, 436, 442, 444, 446	80C (EXCEPT -400)	TYPE 2 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F)
54-50-I01a	FORWARD MIDSPAR CHORD - CF6-80C STRUT	432, 442	80C (-400) < 8 HOURS	TYPE 2 40,000 CYCLES/ 90,000 FLT. HRS.
54-50-I01a	FORWARD MIDSPAR CHORD - CF6-80C STRUT	432, 442	80C (-400) ≥ 8 HOURS	TYPE 2 40,000 CYCLES/ 90,000 FLT. HRS.
54-50-I01c	FORWARD MIDSPAR (VISIBLE PORTIONS) - CF6-80C2 STRUT	432, 442	80C (-400) < 8 HOURS	TYPE 2 40,000 CYCLES/ 90,000 FLT. HRS.

AIRWORTHINESS LIMITATIONS - STRUCTURAL INSPECTIONS [continued]

SSI #	DTR CHECK FORM TITLE	ZONE	AIRPLANE APPLICABILITY	TYPE & THRESHOLD
54-50-I17e	AFT UPPER SPAR CHORD (VERTICAL FLANGE, VISIBLE RHS) - CF6-80C STRUT	434, 436, 444, 446	80C (-400) $\geq$ 8 HOURS	TYPE 2 40,000 CYCLES/ 90,000 FLT. HRS.
54-50-I17f	AFT UPPER SPAR CHORD (VERTICAL FLANGE, VISIBLE) - CF6-80C STRUT	434, 436, 444, 446	80C (-400) < 8 HOURS	TYPE 2 40,000 CYCLES/ 90,000 FLT. HRS.
54-50-I17f	AFT UPPER SPAR CHORD (VERTICAL FLANGE, VISIBLE) - CF6-80C STRUT	434, 436, 444, 446	80C (-400) $\geq$ 8 HOURS	TYPE 2 40,000 CYCLES/ 90,000 FLT. HRS.
54-50-I18	SIDE SKIN/AFT UPPER SPAR CHORD STIFFENER - CF6-80C STRUT	434, 436, 444, 446	80C (-400) < 8 HOURS	TYPE 2 40,000 CYCLES/ 90,000 FLT. HRS.
54-50-I18	SIDE SKIN/AFT UPPER SPAR CHORD STIFFENER - CF6-80C STRUT	434, 436, 444, 446	80C (-400) $\geq$ 8 HOURS	TYPE 2 40,000 CYCLES/ 90,000 FLT. HRS.
55-10-I09	HORIZONTAL STABILIZER UPPER SKIN - AT BBL 41.5 SIDE OF BODY SPLICE.	331, 341	ALL	TYPE 1 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
55-10-I13A	HORIZONTAL STABILIZER PIVOT FITTING LUG.	331, 341	ALL	TYPE 1 50,000 CYCLES (200, 300 PASS) 40,000 CYCLES (300F, 400)
55-10-I13B	HORIZONTAL STABILIZER PIVOT FITTING UPPER & LOWER ATTACHMENTS.	331, 341	ALL	TYPE 1 25,000 CYCLES
55-10-I13C	HORIZONTAL STABILIZER PIVOT FITTING UPPER & LOWER ATTACHMENTS.	331, 341	ALL	TYPE 1 25,000 CYCLES

AIRWORTHINESS LIMITATIONS - STRUCTURAL INSPECTIONS [continued]

SSI #	DTR CHECK FORM TITLE	ZONE	AIRPLANE APPLICABILITY	TYPE & THRESHOLD
57-10-I03B	REAR SPAR LOWER CHORD AND SKIN WING CENTER SECTION - HIDDEN LOCATIONS - BBL 49.5, 62.05 & 73.0 .	133, 134	300F	TYPE 1 25,000 CYCLES/ 80,000 FLT. HRS.
57-10-I03C	REAR SPAR LOWER CHORD AND SKIN WING CENTER SECTION - HIDDEN LOCATIONS - BBL 49.5,62.05 & 73.0 .	133, 134	PASS (200ER, 300 ER) < 8 HOUR	TYPE 1, FLS SEE GRAPH
57-10-I03C	REAR SPAR LOWER CHORD AND SKIN WING CENTER SECTION - HIDDEN LOCATIONS - BBL 49.5,62.05 & 73.0 .	133, 134	PASS (200ER, 300 ER) $\geq$ 8 HOUR	TYPE 1, FLS SEE GRAPH
57-10-I03C	REAR SPAR LOWER CHORD AND SKIN WING CENTER SECTION - HIDDEN LOCATIONS - BBL 49.5, 62.05 & 73.0 .	133, 134	300F	TYPE 1, FLS SEE GRAPH
57-10-I16	LOWER SURFACE SIDE-OF-BODY SPLICE (SECTION 11 & 12) - L-1 TO L-10 INBOARD AND OUTBOARD OF BBL 97.42.	193, 194	ALL < 8 HOURS	TYPE 1 25,000 CYCLES/ 80,000 FLT. HRS.
57-10-I16	LOWER SURFACE SIDE-OF-BODY SPLICE (SECTION 11 & 12) - L-1 TO L-10 INBOARD AND OUTBOARD OF BBL 97.42.	193, 194	ALL $\geq$ 8 HOURS	TYPE 1 25,000 CYCLES/ 80,000 FLT. HRS.
57-10-I20	REAR SPAR LOWER CHORD SOB SPLICE (SECTION 11 & 12) - CHORDS AT SPLICE FITTINGS INBOARD & OUTBOARD OF BBL 97.42.	143, 144	ALL < 8 HOURS	TYPE 1, FLS SEE GRAPH
57-10-I20	REAR SPAR LOWER CHORD SOB SPLICE (SECTION 11 & 12) - CHORDS AT SPLICE FITTINGS INBOARD & OUTBOARD OF BBL 97.42.	143, 144	ALL $\geq$ 8 HOURS	TYPE 1, FLS SEE GRAPH
57-10-I24	UNDERWING LONGERON ATTACHMENT (CENTER SECTION STRUCTURE) - BBL 70 LONGERON FROM FRONT SPAR LOWER CHORD TO STRINGER 18.	133, 134	PASS (200ER, 300 ER) 300F < 8 HOURS	TYPE 1, FLS SEE GRAPH

AIRWORTHINESS LIMITATIONS - STRUCTURAL INSPECTIONS [continued]

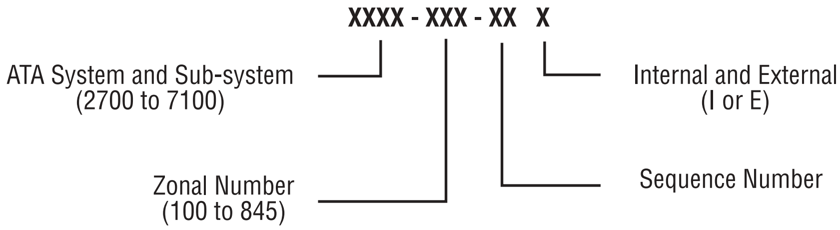
SSI #	DTR CHECK FORM TITLE	ZONE	AIRPLANE APPLICABILITY	TYPE & THRESHOLD
57-20-I12A	OUTBOARD WING TYPICAL STRINGERS LOWER SURFACE - RIB 9 : L-16 (DRY BAY) UNDER NACELLE FAIRING.	437, 447, 533, 633	ALL, EXCEPT -400 ≥ 8 HOURS	TYPE 1, FLS SEE GRAPH
57-20-I12A	OUTBOARD WING TYPICAL STRINGERS LOWER SURFACE - RIB 9 : L-16 (DRY BAY) UNDER NACELLE FAIRING.	437, 447, 533, 633	400 < 8 HOURS	TYPE 1, FLS SEE GRAPH
57-20-I12A	OUTBOARD WING TYPICAL STRINGERS LOWER SURFACE - RIB 9 : L-16 (DRY BAY) UNDER NACELLE FAIRING.	437, 447, 533, 633	400 ≥ 8 HOURS	TYPE 1, FLS SEE GRAPH
57-20-I12B	OUTBOARD WING TYPICAL STRINGERS LOWER SURFACE - RIB 9 : L-17 AT OUTBOARD SIDE LOAD FITTING UNDER NACELLE FAIRING.	533, 633	ALL, EXCEPT -400 < 8 HOURS	TYPE 1, FLS SEE GRAPH
57-20-I12B	OUTBOARD WING TYPICAL STRINGERS LOWER SURFACE - RIB 9 : L-17 AT OUTBOARD SIDE LOAD FITTING UNDER NACELLE FAIRING.	533, 633	ALL, EXCEPT -400 ≥ 8 HOURS	TYPE 1, FLS SEE GRAPH
57-20-I12B	OUTBOARD WING TYPICAL STRINGERS LOWER SURFACE - RIB 9 : L-17 AT OUTBOARD SIDE LOAD FITTING UNDER NACELLE FAIRING.	533, 633	400 < 8 HOURS	TYPE 1, FLS SEE GRAPH
57-20-I12B	OUTBOARD WING TYPICAL STRINGERS LOWER SURFACE - RIB 9 : L-17 AT OUTBOARD SIDE LOAD FITTING UNDER NACELLE FAIRING.	533, 633	400 ≥ 8 HOURS	TYPE 1, FLS SEE GRAPH
57-20-I15A	OUTBOARD WING LOWER SURFACE SPLICE STRINGER - L- 6 & 10. L-10: BETWEEN RIB 7 & 20 (EXCEPT UNDER NACELLE FAIRING) & L-6: SOB TO RIB 3.	531, 532, 541, 631, 632, 641	ALL < 8 HOURS	TYPE 1 25,000 CYCLES/ 80,000 FLT. HRS.

AIRWORTHINESS LIMITATIONS - STRUCTURAL INSPECTIONS [continued]

SSI #	DTR CHECK FORM TITLE	ZONE	AIRPLANE APPLICABILITY	TYPE & THRESHOLD
57-20-I15A	OUTBOARD WING LOWER SURFACE SPLICE STRINGER - L-6 & 10. L-10: BETWEEN RIB 7 & 20 (EXCEPT UNDER NACELLE FAIRING) & L-6: SOB TO RIB 3.	531, 532, 541, 631, 632, 641	ALL ≥ 8 HOURS	TYPE 1 25,000 CYCLES/ 80,000 FLT. HRS.
57-20-I15B	OUTBOARD WING LOWER SURFACE SPLICE STRINGER - L-10 UNDER NACELLE FAIRING.	532, 632	ALL < 8 HOURS	TYPE 1 25,000 CYCLES/ 80,000 FLT. HRS.
57-20-I15B	OUTBOARD WING LOWER SURFACE SPLICE STRINGER - L-10 UNDER NACELLE FAIRING.	532, 632	ALL ≥ 8 HOURS	TYPE 1 25,000 CYCLES/ 80,000 FLT. HRS.
57-20-I15C	OUTBOARD WING LOWER SURFACE SPLICE STRINGER - L-6,10 & 15 UNDER NACELLE STRUT AT EXTERNAL DOUBLERS, FITTINGS & ANGLES.	532, 533, 541, 632, 633, 641	ALL, EXCEPT -400 < 8 HOURS	TYPE 1 25,000 CYCLES/ 80,000 FLT. HRS.
57-20-I15C	OUTBOARD WING LOWER SURFACE SPLICE STRINGER - L-6,10 & 15 UNDER NACELLE STRUT AT EXTERNAL DOUBLERS, FITTINGS & ANGLES.	532, 533, 541, 632, 633, 641	ALL, EXCEPT -400 ≥ 8 HOURS	TYPE 1 25,000 CYCLES/ 80,000 FLT. HRS.
57-20-I15C	OUTBOARD WING LOWER SURFACE SPLICE STRINGER - L-6 & 10 UNDER NACELLE STRUT AT EXTERNAL FITTINGS & SKATE ANGLES.	532, 541, 632, 641	400 < 8 HOURS	TYPE 1 25,000 CYCLES/ 80,000 FLT. HRS.
57-20-I15C	OUTBOARD WING LOWER SURFACE SPLICE STRINGER - L-6 & 10 UNDER NACELLE STRUT AT EXTERNAL FITTINGS & SKATE ANGLES.	532, 541, 632, 641	400 ≥ 8 HOURS	TYPE 1 25,000 CYCLES/ 80,000 FLT. HRS.
57-20-I15D	OUTBOARD WING LOWER SURFACE SPLICE STRINGER - L-15 UNDER NACELLE STRUT AT RIB 9 (SEAL PANS).	530, 630	ALL, EXCEPT -400 < 8 HOURS	TYPE 1, FLS SEE GRAPH

Appendix 17: B767 Maintenance Planning Data Document section 8 item numbers

Section 8 of the *Maintenance Planning Data Document* covers the Boeing 767 Structures Maintenance Program and contains a recommended Supplemental Structural Inspection Program (SSIP) to ensure that all structural elements maintain their damage tolerance for the service life of the aircraft. Each task in the Structures Maintenance Program is assigned a 10 character item number as indicated below:



The Sequence Number allows for multiple items to be associated with each combination of ATA aircraft system and aircraft zone[61]. Boeing allocates Sequence Numbers 1 to 49 to inspection requirements primarily controlled by environmental deterioration or accident damage, Sequence Numbers 50 to 99 relate to supplemental structural inspections where the requirements are determined by crack growth or 'consequences of failure' considerations. If there are less than 10 specific items in a group of supplemental structural inspections associated with a particular ATA aircraft system and zone combination, then all of those inspections will be assigned a sequence number between 50 and 59. Hence, Boeing documentation at times refers to the Supplemental Structural Inspection Program as the '50 series' inspections. For example, the Maintenance Planning Data document June 1997 revision, Section 9 (Page 9.0-4) states that it includes a

> … Revised Airworthiness Limitations section to reflect the reassessment of the "50-series" Supplemental Structural Inspection Program.

Section 8 of the *Maintenance Planning Data Document* indicates the threshold and repeat inspection intervals for each structural inspection task.

61 See ATA iSpec 2200 *Information Standards for Aviation Maintenance* Section 3.1.3 *Numbering Systems.* Note: In 2000, ATA Spec 100 and ATA Spec 2100 were merged to create ATA iSpec 2200.

Appendix 18: Quality assurance and quality control

Quality control

Quality control relates to the science and statistics of sampling an end product to ascertain that the product falls within specified quality limits, with a predetermined degree of confidence based on sample size.

Quality control can traditionally be seen by the testing of random samples of a finished product, prior to dispatch, such as measurement of bolt sizes, quality of stitching in a manufactured garment, or strength testing on samples of material such as steel coupons. Quality control became a necessary part of manufacture when interchangeability was a necessary requirement for mass production final assembly.

Quality assurance

Quality assurance addresses more than quality control. It relates to the capacity of an organisation to be able to monitor its own activities, so that it may remain confident that its product falls within specified quality limits, with a predetermined degree of confidence.

Quality assurance relates to the establishment and maintenance of procedures to ensure the consistency of an organisation's behaviour in the realisation of its product, and the assurance process can traditionally be seen in the assessment of the documentation of an organisation's behaviour, for completeness, accuracy and compliance.

Assessment of consistency and safety of aviation operations

Product-based auditing, such as assessment of a randomised sample of airline flights, or randomised checks of documentation for compliance, is analogous to quality control.

Systems-based auditing, such as assessment of documented procedures for compliance with minimum standards, and the comparison of organisational and individual behaviour against the documented procedures, is analogous to quality assurance principles.

Appendix 19: New Zealand Maintenance Review regulations

New Zealand CAR Part 121.417

121.417 *Maintenance review*

(a) Each holder of an air operator certificate shall ensure that—

  (1) it does not operate an aeroplane unless a maintenance review of the aeroplane has been carried out within the previous 12 months; and

  (2) each maintenance review that is carried out is certified as having been carried out.

(b) The certificate holder shall, before certifying that a maintenance review for an aeroplane has been carried out, ensure that—

  (1) all maintenance specified in the maintenance programme for the aeroplane has been completed within the time periods specified; and

  (2) all applicable airworthiness directives have been complied with; and

  (3) all defects entered in the maintenance records required by Part 43 have been rectified or properly deferred in accordance with the procedures in the certificate holder's exposition; and

  (4) all certifications of release to service required by Part 43.103 have been made in accordance with Part 43.

(c) The certificate holder may certify a maintenance review on the basis of continuing compliance with an internal quality assurance programme acceptable to the Director provided—

  (1) the programme samples all the requirements of paragraph (b) during the review period; and

  (2) the maintenance review is individually certified for each of the certificate holder's aeroplanes.

(d) The certificate holder shall ensure that the maintenance review—

  (1) is certified by an authorised person with experience in respect of that type of aeroplane, that is at least equal to the experience required for the grant of an aircraft maintenance engineer licence rating; and

  (2) contains the certifying person's signature, authorisation number, and the date of entry; and

  (3) contains the following statement:

The maintenance review of this aeroplane and such of its equipment as is necessary for its continued airworthiness has been carried out in accordance with the requirements of the Civil Aviation Rules for the time being in force.

Appendix 20: FAA airworthiness directives to change airworthiness limitations

Excerpt from FAA *Airworthiness Directives Manual*

FAA-AIR-M-8040.1
Chg. 99-1, incorporated 28 October 1999.
http://av-info.faa.gov/ad/ADManual/Manual99.doc

Section 14. Text for Specialized AD [airworthiness directive] Subjects

158. AD's TO CHANGE AIRWORTHINESS LIMITATIONS.

a. In accordance with airworthiness standards requiring "damage tolerance assessments" (current Section 1529 of FAR Parts 23, 25, 27, and 29; Section 4 of FAR Parts 33 and 35; Section 82 of FAR Part 31; and the Appendixes referenced in those sections), all products certificated to comply with those sections must have Instructions for Continued Airworthiness (or, for some products, maintenance manuals), that include an airworthiness limitations section. This section must set forth mandatory replacement times for structural components, structural inspection intervals, and related approved structural inspection procedures necessary to show compliance with the damage-tolerance requirements. Compliance with the terms of airworthiness limitations sections is required by FAR Sections 43.16 (for persons maintaining products) and 91.403 (for operators).

b. Based on inservice data or post certification testing and evaluation, the manufacturer may revise the Airworthiness Limitations Section to include new or more restrictive life limits and inspections, or it may become necessary for the FAA to impose new or more restrictive life limits and structural inspections, in order to ensure continued structural integrity and continued compliance with damage tolerance requirements. In order to require compliance with these inspection requirements and life limits, the FAA must engage in rulemaking. Because loss of structural integrity would constitute an unsafe condition, it is appropriate to impose these requirements through the AD process.

c. For products certificated to comply with the referenced damage tolerance requirements, one method to reduce life limits or to impose new or different structural inspection requirements is to issue an AD requiring a revision to the airworthiness limitations section. Once that section is revised, as required, the AD has been fully complied with, and the life limit or structural inspection change remains enforceable as a part of the airworthiness limitations section. (This is analogous to AD's requiring changes to the operating limitations section of the airplane flight manual.) It should be noted that, simultaneously with the issuance of the AD, the responsible ACO should revise the type certificate data sheet for the product to indicate the change in the airworthiness limitations.

d. Requiring revision of the airworthiness limitations, rather than requiring individual repetitive inspections, is advantageous for operators because it allows them to record AD compliance status only at the time that they make the revision, rather than after every inspection. It also has the advantage of keeping all airworthiness limitations, whether imposed by original certification or by AD, in one place within the operator's maintenance program, thereby reducing the risk of non-compliance because of oversight or confusion.

e. The following is sample AD language to revise airworthiness limitations:

a. Revise the airworthiness limitations section of the Instructions for Continued Airworthiness, as follows: __________

b. Thereafter, except as provided in paragraph c. of this AD, no alternative replacement times or structural inspection intervals may be approved for this [part].

c. (Alternative method of compliance).

Paragraph b. is necessary because FAR Part 91.403 would otherwise permit operation in accordance with alternative inspection intervals set forth in approved operations specifications or inspection programs, which might conflict with the intervals referenced in the AD.

Appendix 21: Organisational mindfulness

The concept of organisation mindfulness is described in detail in Weick and Sutcliffe (2001). Weick outlines five processes that characterise organisational mindfulness (Weick et al 1999, p. 89):

- A preoccupation with failure - recognising that failures, no matter how minor, provide the opportunity to learn about potential disasters. Mindful organisations see "the reality of danger in a near miss" (p. 93).
- Reluctance to simplify interpretations - using complex systems to manage their complex environment and by encouraging diverse views and approaches to operations.
- Sensitivity to operations - ensuring that someone in the organisation has a clear understanding of the 'big picture' of operations at all times.
- Commitment to resilience - a commitment to ensuring that the organisation can cope with unexpected dangers.
- Underspecification of structures - they do not rely on hierarchical structures, particularly in problem solving, when experience and expertise become more important than rank in the management hierarchy.

The concept of organisational mindfulness has recently been applied in an Australian context by Hopkins (2000).

Hopkins A (2000). *Lessons from Longford: The Esso gas plant explosion.* CCH Australia: Sydney, Australia.

Weick K E and Sutcliffe K M (2001). *Managing the unexpected: Assuring high performance in an age of complexity*. Jossey-Bass: San Francisco, USA.

Weick K E, Sutcliffe K M, and Obstfeld D (1999). *Organizing for high reliability: processes of collective mindfulness.* Research in Organizational Behavior. 21:81-123.