When the Bureau makes recommendations as a result of its investigations or research, safety (in accordance with our charter) is our primary consideration. However, the Bureau fully recognises that the implementation of recommendations arising from its investigations will in some cases incur a cost to the industry. The cost of any recommendation must always be balanced against its benefits to safety, and aviation safety involves the whole community. Such analysis is a matter for the CAA and the industry.

ISBN: 0 642 20150 1 FEBRUARY 1994

This report was produced by the Bureau of Air Safety Investigation (BASI), PO Box 967, Civic Square ACT 2608.

The Director of the Bureau authorised the investigation and the publication of this report pursuant to his delegated powers conferred by Air Navigation Regulations 278 and 283 respectively. Readers are advised that the Bureau investigates for the sole purpose of enhancing aviation safety. Consequently, Bureau reports are confined to matters of safety significance and may be misleading if used for any other purpose.

CONTENTS

EXECUTIVE SUMMARY

In attempts to gain a greater understanding of the air safety occurrences which it investigates the Bureau of Air Safety Investigation (BASI) undertakes systemic investigations. In some cases these systemic investigations consider groups of occurrences rather than each in isolation.

The analytical framework used for systemic investigations is that developed by James Reason of the University of Manchester, United Kingdom. The model focuses on the human contribution to errors in complex systems such as Air Traffic Services (ATS). Reason distinguishes between active and latent failures.

Active failures are associated with the performance of "front line" operators, eg Air Traffic Controllers, and as such immediately affect the functioning of the system. Latent failures are removed in both time and space from the air safety occurrence, and flow from the actions and decisions of the managers and designers of the system. Latent failures may lie dormant within the system for a considerable time, only becoming evident when they combine with other factors to breach the system's defences. Managers' and designers' decisions and the impact that they have on the organisation are considered by Reason to produce preconditions which lead line workers to take actions which are inherently unsafe. In most instances these unsafe acts do not breach the system's defences as other parts of the system, eg pilots, identify the error and act to protect the system's integrity.

Air safety occurrences occur when a number of the system defences, be they mechanical, procedural or human, break at a particular point in time. While individual investigations may identify specific failures, combining the results of a group of occurrences may make it possible to assess the vulnerability of the system to both human and mechanical error. To undertake this assessment it is necessary to consider each element of the system, ie design, quality of management, procedures, training etc.

In June and July of 1991, 31 incidents which were reported to BASI were classified as airmisses, ie occurrences in which there was the potential for collision between aircraft. Eight of these incidents were identified by the Bureau as being serious occurrences, as they involved regular passenger transport (RPT) aircraft, occurred in controlled airspace, and involved actual/potential breakdown in separation standards. These incidents, although the primary basis of the analysis, were supplemented by data from the other airmiss occurrences to aid the analytical process. Although each incident was investigated separately there were sufficient commonalities to warrant an analysis of the incidents as a group. The objective was to identify broader systemic factors which may not have been apparent considering each airmiss in isolation.

The analysis revealed a wide variety of active errors or unsafe acts which precipitated each air safety incident. These included failure of the ATC to maintain situational awareness, flight data processing errors and reliance on expected aircraft performance.

A number of preconditions seemingly existed within the CAA at the time of the occurrences which increased the propensity for unsafe acts. These included excessive self reliance on the part of each controller, focus on tactical rather than defensive control, and workload which was either excessive or which was insufficient to maintain sufficient attention to monitor the traffic situation.

The investigations revealed four distinct, yet overlapping, organisational deficiencies. These deficiencies were a lack of strategic planning for air traffic management, a lack of strategic planning for training, a limited quality assurance function, and an organisational climate which was characterised by ambiguity, uncertainty and lack of standardisation between the regions.

In September 1991, the CAA and BASI engaged Ratner and Associates to conduct a comprehensive evaluation of the ability of the ATS system to maintain safety levels through to the introduction of TAAATS. The Ratner Review presented the CAA with a number of recommendations.

During the systemic investigation covered by this report there was regular communication between BASI and the CAA to ensure that the ATS Management and staff could contribute to the study and their safety concerns could be addressed.

Consequently, the Civil Aviation Authority (CAA) embarked on a series of initiatives which address many of the issues identified in this report and the Ratner review. The CAA has implemented an integrated ATS training program, which will improve the quality of ab-initio training, concentrate on skill and competencies within all training and provide refresher training and development programs during a career with ATS. The ATS Division of the CAA has also adopted an active approach to the standardisation of procedures and traffic management. This has included the design of Standard Terminal Arrival Routes (STARS), integrated with Standard Instrument Departures (SID).

While these initiatives are welcomed by the Bureau, there are some aspects, of the ATS system operation and management which still require attention.

The Bureau has suggested that the CAA should:

a) introduce further initiatives based on the Reason model;
b) adopt a safety philosophy similar to that used by the United Kingdom's Civil Aviation Authority; and
c) undertake an assessment of ground and airborne techniques for collision avoidance.

The report also emphasises that the aircrew play a vital role in the "defensive"mechanisms of the ATS system and that the CAA should explore ways of enhancing the aircrews detection of errors in the controllers actions.

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

The Australian Air Traffic Service (ATS) system provided by the Civil Aviation Authority (CAA) is responsible for the provision of a safe, efficient, and cost effective air traffic control and advisory service to the aviation industry within domestic and international (oceanic) airspace.

As part of the Bureau of Air Safety Investigation's (BASI) pro-active approach to aviation safety, a program of selective investigation was introduced along with active monitoring of certain safety indicators. One of the safety indicators scrutinised was that of ATS related occurrences. In this regard, BASI attempted to gain deeper insights into the functioning of the ATS system by utilising a systemic approach to investigation. This document reports the results of this work.

1.2 THE NEED FOR A SYSTEMIC APPROACH

In the past the Bureau conducted its investigations by individually analysing each occurrence and identifying contributory factors. While such methodology is necessary and has the potential to identify safety deficiencies, the Bureau was also aware that there were significant advantages to be achieved by examining occurrences in combination. This approach would allow safety issues or problems which may be deeper within a system to be identified. To achieve the most benefit this approach needs to be structured and to be based on a particular theoretical model.

1.2.1 Ratner Review

In 1991 BASI, in conjunction with the CAA, commissioned a detailed review of the safety of the ATS system. This review has become synonymous with its author and is known as the Ratner Review[1].

The report of the Ratner Review released in April 1992 and this BASI study were coincident in both time and subject area. Consequently there may be some similarity in the conclusions which are reached. However, the reviews differ in methodology and also in the manner in which the information gained was structured.

---

1. Ratner Review of ATS System Number 2

The Ratner Review's objectives were to provide the CAA and BASI with advice on the safety level of the present system and to evaluate the capability of the system to maintain safety during the major restructure now under way.

1.3 METHODOLOGY

Many ATS incidents have the potential to reveal failures within the system. Some incidents reflect significant deficiencies and present a greater risk to the general public. The vulnerability of the ATS system is perhaps most clearly revealed through airmiss[2] occurrences, and as such they were identified as being a relevant subject for systemic review.

The airmisses, which were taken as the primary basis of the analysis, occurred in June and July of 1991. At that time the CAA was undergoing considerable change. There was significant ambiguity regarding the future ATS structure, particularly in regard to the presence of Terminal Control Units (TCUs) and Area Approach Control Centres (AACCs) in regional localities.

For ease of categorisation and therefore investigation response, the risk of collision between aircraft is classified by BASI according to collision potential (see Appendix A). In June and July of 1991, 31 reported incidents[3] were classified as airmisses, ie occurrences in which there was the potential for collision between aircraft. Categorisation also takes into account the safety benefits which may be gained from an investigation. Consequently the risk of collision may not have been serious in each case, but the safety deficiency which the incident exposes may be substantial.

The Bureau investigated each of the airmiss occurrences in accordance with its selective investigation policy. This policy involves a varying level of investigation depth depending upon the severity and potential of the occurrence. An integral part of the selective investigation policy is the emphasis on pro-active research and special studies. This involves monitoring occurrences and trends, gathering intelligence about the safety health of the aviation system and assessing the risks so that research may be directed to the areas with the most potential for safety deficiencies.

From the preliminary results of the investigation of the airmiss occurrences, the Bureau identified the need for an "in-depth" systemic investigation and analysis of the ATS system.

---

2 Definition of an airmiss is contained in Appendix A

3. Details of the 31 incidents are contained in Appendix B

This BASI study conducted during 1992 was aimed at understanding the organisational factors and system characteristics, and the underlying failures which lead to certain ATS occurrences. BASI's endeavour was to provide the CAA with a method which would allow the cause of a particular problem to be tracked to its origin. Thus potential remedial action could be applied at the source of the problem.

Eight of the 31 airmisses were identified by the Bureau as being serious occurrences. The reasons for the selection of those incidents were that they:

(a) involved regular public transport (RPT) aircraft ;
(b) occurred in controlled airspace; and
(c) involved actual/potential breakdown in separation standards.

Summaries of the eight incidents involved are provided in Appendix C.

These eight incidents, although the primary basis of the analysis, were supplemented by other airmiss occurrences to aid the analytical process. A listing is given in Appendix B, which identifies the incidents which were used in the analysis.

CHAPTER 2

A METHOD OF ATS SYSTEM ANALYSIS

2.1 INTRODUCTION

Incidents within the ATS system occur when a number of threads within the safety net[4] break at a particular point in time. In most instances, incidents reveal failures in a number of differing parts of the system and at many levels. While individual investigations may identify specific failures, combining the results of a group of failures may make it possible to assess the vulnerability of the system to both human and mechanical error. However to achieve this assessment it is necessary to structure the findings. One model which offers significant potential in this regard is that developed by Professor James Reason of the University of Manchester, United Kingdom[5]. Before considering the applicability of the model to the ATS environment, it is necessary to understand the assumptions behind it.

2.2 INCIDENTS WITHIN A COMPLEX SYSTEM

There is a growing consensus of opinion that errors in complex systems, such as the ATS system, can only be understood by considering the whole organisation, ie design, quality of management, procedures, training etc.

When the human contribution to errors in such systems is considered, researchers are increasingly distinguishing between two kinds of failure:

> "*Active errors* whose effects are felt almost immediately, and *latent errors* whose adverse consequences may lie dormant within the system for a long time only becoming evident when they combine with other factors to breach the system's defences. In general, active errors are associated with the performance of "front line" operators of a complex system: pilots, air traffic controllers, ships' officers, control room crews and the like. Latent errors, on the other hand, are most likely to be spawned by those whose activities are removed in both time and space from the direct control interface: designers, high-level decision makers, construction workers, managers and maintenance personnel". (Reason, 1990)

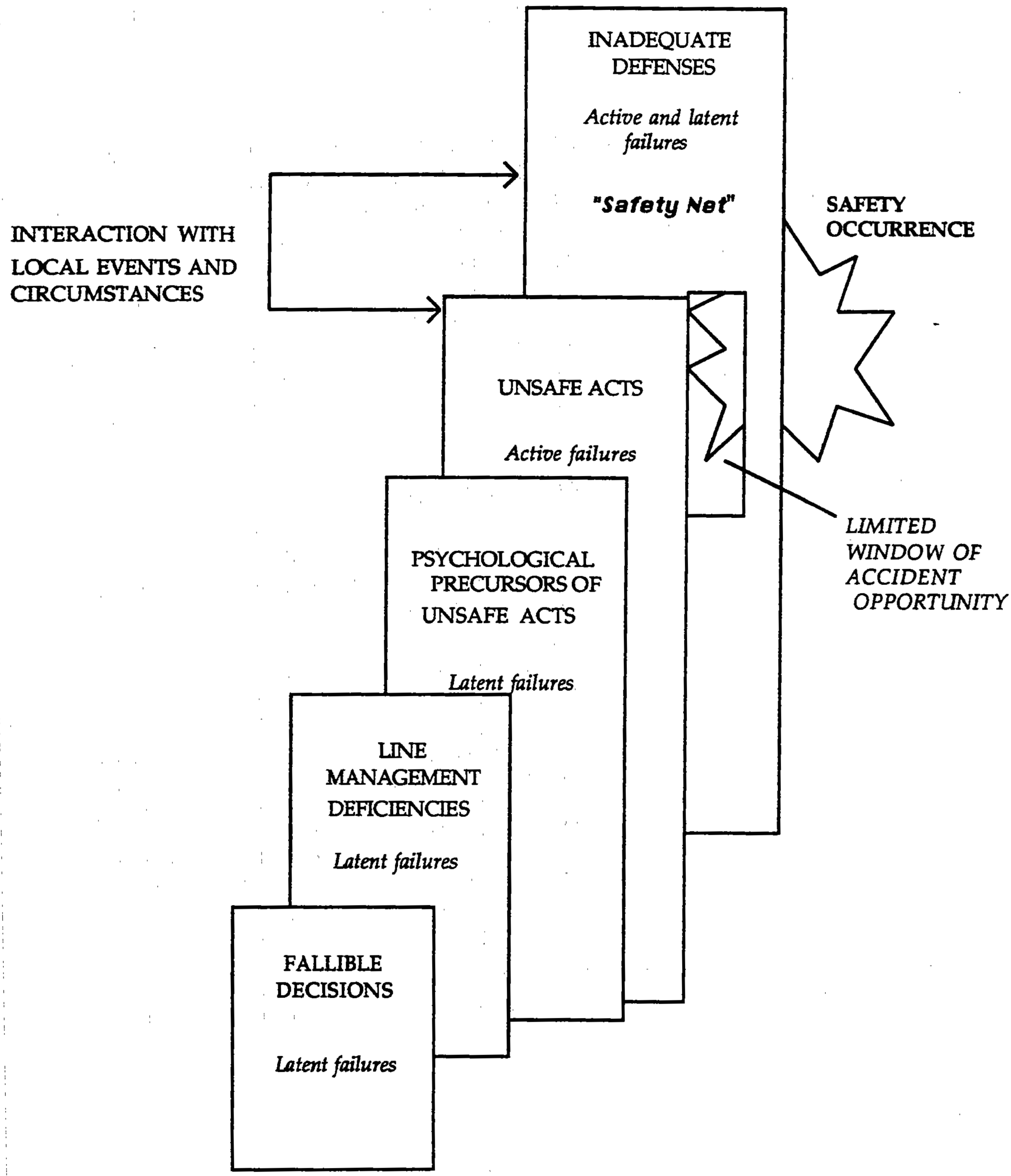
Active and latent errors are therefore associated with differing parts of the system, as shown in Figure 1. A basic premise of the framework is that system

---

4 The safety net may be considered to be the mechanical, procedural and human defences which are built into the system to catch unsafe acts by human operators or mechanical faults.

5 Reason JT (1990) "Human Error" (see Reference)

Figure 1 HUMAN CONTRIBUTIONS TO THE BREAKDOWN OF COMPLEX SYSTEM



Adapted from: "Human Error" Reason J.T. (1990)

failures have their primary origins in the fallible decisions made by the designers, and management at line and senior levels. Such decisions are often made when the management team is not fully aware of the facts or have competing pressures for the organisation's resources. These decisions and the impact that they have on the organisation produce psychological precursors or preconditions which lead line workers to take decisions or actions which are inherently unsafe. If the system is designed correctly then it should have defences to prevent the unsafe act resulting in a failure of the system and undermining safety. Safety occurrences are the result of these defences being breached.

2.3 ORGANISATIONAL FAILURE TYPES

When failures of complex organisations are reviewed, there is considerable similarity regardless of the nature of the system. Organisational aspects such as poor planning, inadequate control and monitoring, and design failures figure strongly. The type of failure can be categorised according to whether it is related to the organisation's goals, structure, management, design, construction, operation or maintenance of the system. This is shown in Table 1, along with the General Failure Types (GFTs) which have been identified.

Table 1

GENERAL FAILURE TYPES CATEGORISED ACCORDING TO ORGANISATIONAL PROCESS[6]

PROCESS	GENERAL FAILURE TYPE
Goals	Incompatible goals
Organise	Inappropriate structure
Manage	Poor communications and planning Inadequate control and monitoring
Design	Design failures Inadequate defences
Build	Unsuitable materials Inadequate defences
Operate	Poor operating procedures Poor training
Maintain	Poor maintenance management

Having summarised the model, it is necessary to describe its applicability to the ATS environment.

6. Adapted from: "Identifying the Latent Causes of Aircraft Accidents Before and After the Event" Reason JT 1991

2.4 APPLICATION OF REASON'S MODEL TO ATS

The model promoted by Reason has been modified somewhat to enhance its relevance to the ATS system.

2.4.1 Unsafe Acts

The ATS system is reliant on the human operator to process traffic in a safe and expeditious manner. In most instances this is carried out without error. However, humans are fallible and on occasions a controller or pilot may commit an act which is detrimental to safety.

When considering such acts, a distinction can be made between violations and errors. The categorisation is based on whether the act was intentional or unintentional. Such categorisation is useful when considering the unsafe acts perpetrated by both controllers and pilots.

2.4.1.1 Errors

According to Reason (1991), there are two distinct types of errors:

(a) *attentional slips* and *memory lapses*, these involve unintended deviation of actions from what may be a perfectly good plan; and
(b) *mistakes*, where the actions follow the plan but the plan deviates from some adequate path to the desired goal.

Air traffic control is primarily based on the processing of information provided in aural, visual or written form. In such a complex cognitive and mental operational environment it is understanding that controllers on occasion do not fully consider the ramifications of some element of the traffic sequence or misapply some rule, despite their high degree of training and the standardisation of the procedures. The vast majority of unsafe acts which occur within the ATS system are likely to be categorised under the error classification.

2.4.1.2 Violations

A deliberate deviation from regulated codes or procedures (violations) may occur occasionally, within the ATS environment. Three types of violations exist:

(a) *routine violations*, involving short cuts between points within a task;
(b) *optimising violations*, in which the individual seeks to optimise some goal other than safety; and
(c) *exceptional violations*, one-off breaches of regulations seemingly dictated by unusual circumstances.

Violations which are probably most common within the ATS system are those which attempt to make the system more efficient or increase the traffic capacity eg, if the published separation standards are allowed to be infringed temporarily.

2.4.1.3 Summary

The error/violation categorisation is useful in assessing unsafe acts made by controllers, as the remedial action would differ depending on the type of error or violation. The imperfect cognitive functioning associated with error should not be categorised in the same way as violations. Violations have a motivational basis and can only be understood in an organisational context. Violations can be reduced by changing attitudes, norms, morale etc. Errors may be overcome by training, improved design of the workplace etc.

2.4.2 Psychological Precursors of Unsafe Acts

Preconditions may exist within an organisation which influence the occurrence of unsafe acts. Some may be directly related to the organisation, others may be a product of the worker's private life. Some of the preconditions which may exist according to Reason are: insufficient or excessive workload; poor human-system interface; conflict between management and staff; group norms which condone violations; a culture which encourages risk-taking; disturbed sleep patterns.

2.4.3 Organisational Deficiencies (Line Management Decisions)

Reason states that management decisions over a long period of time may have created certain inherent flaws within the organisation. Such decisions, may be based on lack of information or resources, time pressures, higher level decision making, enforced decisions brought about by restructuring etc. The consequences of these decisions may take considerable time to manifest themselves, and in most cases are evident in the psychological preconditions indicated above.

The interaction between organisational deficiencies and psychological precursors of unsafe acts may be complex. An example used by Reason (1990) illustrates this point: "deficiencies in the training department can manifest themselves as a variety of preconditions: high workload, undue time pressure, inappropriate hazard recognition, ignorance of the system and motivational difficulties".

In effect, the Ratner Review was tasked with identifying the organisational deficiencies which could affect safety in the transition to the completion of the Australian Advanced Air Traffic System (TAAATS). Examples of deficiencies identified were an inadequate ATS Quality Assurance function, lack of documentation and staff training in the operation of a two-tier safety regulation and surveillance scheme, and little formal accountability for safety at a managerial level.

2.4.4 Corporate Actions (Senior Management Decisions)

Actions of the most senior management and the board of the CAA, like that of any large organisation, have the potential to impact, however indirectly, on the actions of the ATS operators at the workface. Decisions such as future directions, resource allocation, and even publicly stated goals all have influences, and the ramifications of such decisions may lie dormant within the system for years before some combination of events exposes the weakness.

2.4.5 Inadequate Defences

A properly designed system has in-built defences to protect it from human or mechanical error. The ATS system has a number of these defences. These include instruction readback, position reports, single direction routes, standard levels, Standard Instrument Departures (SIDs) etc, to ensure that the potential for error on the part of either a pilot or a controller is minimised. At present the majority of these defences are dependent upon the controller's mental model of the present and future traffic situation, ie awareness of the "big picture".

2.4.6 Safety Occurrence

In practice only a very small percentage of unsafe acts lead to an occurrence which is detrimental to the safety of the system. In most instances the various layers of the safety defences act to protect the system, eg if a controller clears the wrong aircraft to a higher altitude, the pilot may recognise that the clearance is not applicable, the controller may realise his/her error when reviewing the flight strips or when the pilot reads back the clearance.

In instances where the layers of defence are breached, a number of factors must occur in conjunction to produce an incident or, in some extreme cases, an accident.

Such an accident occurred at Los Angeles International Airport in February 1991[7], when a Boeing 737 collided with a Metroliner. The Boeing was cleared to land on a runway where the Metroliner was lined up waiting for a take-off clearance.

The accident occurred at night and the lights of the Metroliner were indistinguishable from all the other lights associated with the runway and taxi ways.

A number of factors contributed to the accident: there was confusion on the part of ATS personnel over call signs of several Metroliner aircraft which were manoeuvring on the airfield: the view of the runway threshold from the control tower was obstructed; and the flight strip for the Metroliner involved in the accident was missing.
In this accident, the local controller failed to maintain an adequate awareness of

7. NTSB Report /AAR-91/08

the traffic situation, which culminated in the inappropriate landing clearance. This occurred at a time when the Metroliner's conspicuity to both the Boeing 737 aircrew and the tower cabin personnel was significantly reduced. When the accident scenario is reviewed, the controller's error could have been detected on numerous occasions by a number of different people, eg the controller, the Boeing 737 pilots, the pilot of the Metroliner involved, or the crew of another Metroliner which the controller had confused with the aircraft involved in the accident.

The National Transportation Safety Board (NTSB) determined that the probable cause of the accident was "the failure of the Los Angeles Air Traffic Facility Management to implement procedures that provided redundancy comparable to the requirements contained in the National Operational Position Standards and the failure of the FAA Air Traffic Service to provide adequate policy direction and oversight to its air traffic control facility managers.... Contributing to the cause of the accident was the failure of the FAA to provide effective quality assurance of the ATC System."

2.5 INCIDENT DATA AS A SOURCE OF INFORMATION FOR SYSTEMIC ANALYSIS

Both individual and aggregrated data from ATS incidents has the potential to provide information with regard to the functioning of the many components of the ATS system. Perhaps the most immediately apparent is an appreciation of the nature of active failures made by controllers and pilots, and how the safety net/defences of the ATS system can be breached. Investigations of occurrences can also provide insight into latent failures within the ATS system.

Using incident data to assess the contributions made by the various levels in the Reason model may be difficult. The chain of causality in complex organisational systems may itself be complex and is generally subject to ambiguity. In a single incident what one observer may see as clear evidence for conflicting organisational goals, another might view as after-the-fact rationalisation of error. Considering a number of incidents as a group helps resolve some of these difficulties. By combining data from a number of investigations the underlying patterns become increasingly apparent. Consequently a better understanding of the organisational factors is formed.

Historically this systemic approach has not normally been applied to accident investigations. Readers of accident reports expected to be given a clear logical connection between the factors contributing to the accident and the accident itself. When the factors under consideration are proximate to the accident ie those events and actions which immediately precede the accident, then such an approach is appropriate. This method of analysis is well understood and documented in the ICAO Accident Investigation Manual. However, this systemic approach to investigation aimed at determining the fundamental, underlying causes of safety occurrences, is only now becoming accepted.

CHAPTER 3

ANALYSIS OF ATS SAFETY

3.1 INTRODUCTION

In the previous chapter, the role of the various elements of Reason's model were discussed. This chapter describes the analysis of the safety of the ATS system based on the model.

Safety deficiencies are identified and are illustrated with incidents for each of the facets of the model. The facets under consideration are unsafe acts, psychological precursors to unsafe acts, organisational deficiencies and inadequate defences. Actions which could be taken to rectify the identified deficiencies are also examined. Chapter 4 indicates the actions which the CAA has taken in relation to the deficiencies identified by BASI prior to the publication of this analysis.

The objective of this analysis was to gain a better appreciation of the unsafe acts and psychological precursors, and thus identify the systemic issues which lead to unsafe acts. The objective was not to find solutions either to eliminate or to modify the impact of the identified unsafe acts; determination of solutions is the responsibility of the CAA.

3.2 UNSAFE ACTS

In the course of the investigations it was apparent that the errors or violations which may lead to air safety incidents are numerous and wide ranging. This situation in not unique to Australia. A summary of the most significant unsafe acts is given in Table 2.

Table 2

UNSAFE ACTS IDENTIFIED DURING INCIDENT INVESTIGATIONS

- No, or inadequate, plan for traffic processing
- Excessive reliance on "expected aircraft performance" or "aircraft performing as anticipated"
- Failure to maintain the traffic picture (situational awareness)
- Inappropriate use of flexibility to vary procedures
- Providing service without checking outcomes
- Inattention to primary task
- Coordination failures
- Flight data processing errors

3.2.1 Planning

Air traffic control involves a continuous process of devising "game" plans to meet current and future traffic requirements, along with assessing and reassessing the plans and making adjustments as events unfold. For example, the plans should cater for an aircraft failing to clear a particular flight level in time, or should ensure the required traffic separation. An unsafe act can occur if the controller does not have a contingency plan for dealing with eventualities. In most instances such planning failures do not lead to a reduction in safety standards as the sequence of events does not require any fall back actions. However, it is worth noting that in Canada, the ATS authority, Transport Canada, defines a planning failure as a reportable operational incident.

When planning failures were considered in depth there seemed to be an apparent focus on solving immediate problems and to some extent "getting-by". This lack of a defensive posture may even occur in low workload situations when, at the initiation of the traffic sequence, the various possible contingencies are not assessed. The planning in such situations seemed to be dependent, to a considerable degree, on expected aircrew actions and aircraft performance (see Insert 1). While the "getting-by" attitude is not necessarily widespread it requires a conscious effort by controllers toward "separation assurance" rather than simply achieving separation. This is supported by Ratner in his 1992 Review of the ATS System.

3.2.2 Reliance on expected aircraft performance

A significant category of unsafe acts was the controllers' reliance on expected aircraft performance during the formulation of "game plans". It is understood that all controlling has to be based on expected outcomes of action by aircrews and aircraft. However an integral part of good control is being alert to the possibility that such expectations may not materialise. Safety within the system is maintained by planning to ensure that an "escape hatch" is available should the expected performance of the aircraft not eventuate, and adjustment of the plan to take account of actual aircraft performance. There are indications that on occasions controllers rely too heavily on expected aircraft performance, and fail to adequately monitor the situation as it unfolds (see Insert 1 and 2).

Insert 1 B/911/3134 BRISBANE 6th June 1991

This occurrence was reported as a breakdown of radar separation standards within the terminal area between a Cessna C210 (C210) conducting an Instrument Flight Rules (IFR) training flight and a McDonnell Douglas DC10 operating an international Regular Public Transport (RPT) flight. Recorded radar data indicated that the aircraft passed with less than one nautical mile horizontal separation when they were at approximately the same altitude of 3700 feet.

The DC10 had departed Brisbane on a Standard Instrument Departure (SID). The C210 departed Archerfield for Maroochydore and had been cleared to climb to 6000 feet without restriction on the direct track by the approach (APP) Controller. The DC10 failed to commence its turn at the point specified in the SID. This was brought to the attention of the APP controller by the tower controller.

APP then turned the C210 onto a heading of 270 degrees and DC10 onto a heading of 340 degrees. The instruction required the C210 to turn towards high terrain, although the controller did not know whether the aircraft had sufficient height to clear the terrain. Once the aircraft flight paths had diverged, the C210 was then turned back onto its original track. This may have resulted in the C210 flying through the wake turbulence of the DC10.

The investigation found that the APP controller, assuming that the DC10 would follow the SID, failed to adequately monitor the actual flight path. The APP controller had no other traffic for processing at the time of the occurrence. There were no traffic capacity problems restricting alternative vectoring options. However, other options may have involved additional coordination.

3.2.3 Situational awareness

Awareness of the traffic disposition is an essential element of air traffic control. This situational awareness may on occasion be degraded. In most instances such degradation will have little impact on traffic processing as controllers are able to quickly rebuild the "picture" through radar or reviewing the flight progress strips. However, it is possible for degradation of situational awareness to reach a level at which it can contribute to a breach of separation standards. Controllers have on occasions overlooked or disregarded the presence of another aircraft under their jurisdiction (see Insert 3), or one which had been recently transferred to another sector (see Insert 4). A number of specific investigations reviewed by BASI identified an apparent association between lack of situational awareness and incomplete monitoring. When the controller's attention was directed back to the unfolding situation, minimal time was available to effect a satisfactory outcome.

Insert 2 B/914/3071 ADELAIDE 17th July 1991

An Airbus A320 (EA32) departed Adelaide enroute to Brisbane. The aircraft was given an unrestricted climb to flight level (FL) 370 via air route T77 to Brisbane. Adelaide control was asked by Melbourne to ensure that the aircraft was at FL330 by 20 nautical miles (nm) south west of Mildura as a Boeing 747 (B747) was tracking on a crossing route at FL310.

A Boeing 767 (B767) was flying from Sydney to Adelaide via Mildura maintaining FL310 on the reciprocal heading to the EA32, and appeared on the Adelaide control radar approximately 124nm from Adelaide.

Adelaide Sector 4 (SEC 4) contacted the EA32 and requested that the aircraft maintain best rate of climb to FL330. The objective was to climb the EA32 above the B767, using a radar standard.

Approaching FL310, the EA32 experienced an increase in ground speed, increasing the closing speed with the B767. Following this the airspeed of the EA32 fell below the minimum manoeuvring speed and the Captain reduced the climb angle to accelerate the aircraft. By the time the aircraft had passed, the EA32 had regained the best rate of climb, however the applicable separation standard had been breached.

The SEC 4 controller had monitored the climb of the EA32 until the aircraft was approximately 40nm west of the B767. At the displayed climb rate, he believed that the EA32 should have been at FL330 by the estimated time of passing. He had then turned his attention to another aircraft. When he returned to the EA32/B767 he noticed that the radar returns had merged. The aircraft had passed at approximately 110 nm east of Adelaide with less than the required separation standard.

Insert 3 B/911/3141 CAIGUNA 12th June 1991

In this occurrence two jet RPT aircraft were operating on the same one way route in procedurally controlled airspace when the controller approved a higher flight level request from the following, faster aircraft. This resulted in a breakdown of procedural separation standards.

Both aircraft in this occurrence had initially been cleared to climb to Flight Level 370. The Sector controller requested that the Arrivals controller modify the flight level of the second aircraft, a Boeing 747-400 (B747-400). The Boeing was therefore recleared to FL 350.

While both aircraft were under the jurisdiction of the Sector controller, he assisted another Sector controller with plotting separation standards for two other aircraft. When the crew of the B747-400 requested the availability of FL390, the controller said "affirm descend to FL 290 ... correction was that FL 290 or 390?". The crew responded "three nine". The controller immediately cleared the aircraft to FL390, failing to recognise the significance of the level change request, nor the proximity of the other aircraft at FL370.

Insert 4 B/913/3158 EILDON WEIR 18th July 1991

An Airbus A320 (EA32) and a Boeing 727 (B727) were operating scheduled domestic RPT flights to Melbourne with arrival sequencing being conducted in the vicinity of Eildon Weir (ELW). During the subsequent vectoring, a breakdown of separation standards occurred between the EA32 and the B 727.

In this instance, the Boeing had been transferred to the Arrivals (ARR) controller and had reduced speed as requested to 230kts. The EA32 was required to enter the holding pattern, and it was instructed to turn onto a converging course, towards the B727, then descending to FL160. The radar screens labels available to the controller included a readout of aircraft level and ground speed. These would have provided evidence that the closing speed between the two aircraft was approximately 180kts. However, the proximity of the two aircraft was only brought to the attention of the Sector controller when the EA32 was instructed to contact ARR. The crew acknowledged the instruction and requested the level of the preceding aircraft. The Sector controller then realised that separation had been lost between the EA32 and the slower B727.

3.2.4 Flexibility to vary procedures

Some degree of flexibility is built into the ATS system to allow traffic to be processed in the most efficient manner possible. If this flexibility is used to excess or at an inappropriate point in time then safety standards may suffer. Insert 5 gives an example of a situation in which the original departure clearance was modified on two occasions, resulting in a differing expectation between the Departure cell and the Tower.

Insert 5 B/916/3018 SYDNEY 13th July 1991

After the initial departure instructions were given to the Sydney control tower for an Airbus A300 (EA30), the departure sequence was changed twice, with two aircraft sequenced ahead of the EA30. Immediately following the departure of the second of these aircraft , a British Aerospace 146 (BAe146), Departure Radar (DEP) indicated that the EA30 could be unrestricted. The tower understood the instruction to mean cancel the previous departure instruction, however the DEP controller only intended cancellation of the altitude restriction.

3.2.5 Coordination

The effective transfer between sectors of aircraft information is vital to the safe and efficient operation of the ATS system. For this reason coordination between sectors is bound by procedures specifying when and how information should be transferred. In a system so dependent on the transfer of verbal information it is not surprising that on occasion controllers fail to recognise the implications of coordinated information, such as advice that both aircraft were operating on the same track or departure instructions had been amended in part or in full (see Insert 5). In such instances the expectation of traffic movement can be different for each contiguous controller. If the error is not detected in subsequent coordinations, a breach of the system's defences can occur because of the lack of technological defences. Insert 6 is an example in which a controller failed to detect that two aircraft were operating on the same route.

> <u>Insert 6</u> B/911/3197 NE PERTH 11th July 1991
>
> This breakdown in separation standards involved two Boeing 737(B737) RPT aircraft which were thought to have been operating on two different (but converging) air routes within controlled airspace. Controllers with jurisdiction for the aircraft were providing separation based on dissimilar and incorrect flight progress strip information. The error remained undetected until both aircraft passed on the same track on the peripheral range of the Perth radar display.
>
> The flight progress strips for the inbound aircraft prepared for Perth Arrivals (ARR) showed the aircraft would arrive via route W43. However the strips for Perth area control Sector 2 (SEC 2) displayed the correct route T31.
>
> SEC 2 coordinated the arrival of the inbound aircraft with the Perth Arrival Procedural (ARR (P)) controller, based on an estimated time at 160 nautical miles (nm) from Perth. This was the limit of radar coverage. Coordination for an aircraft operating on W43 was also required by SEC2 to provide for an estimate at 160nm. Neither the ARR(P) controller, nor his trainee, noticed that the route was different to that displayed on the ARR(P) strip.

3.2.6 Service without checking outcomes

Air traffic controllers provide a "service" to the aviation industry. However, in providing this "service" safety standards may be undermined if controllers fail to check the outcome of their instructions. This type of unsafe act is characterised by the rapidity of the controller's response to requests. If the controller responds immediately it is probable that a complete assessment of the effect and outcome of the change to the traffic condition could not have been achieved (see Insert 3). Similarly, the apparently high incidence of unrestricted operations and track shortening events (see Insert 1) may indicate that "service" is paramount and pilot requests may have been accommodated without a complete assessment of the ramifications and appropriate defensive planning.

3.2.7 Inattention to primary task

Air traffic control is dependent on each operator being able to undertake a number of differing tasks simultaneously in order to develop an integrated traffic processing plan. A further integral aspect of good control is the controller's ability to divide and prioritise attention in an appropriate manner. The fluid and dynamic environment in which controllers work may on occasion lead to situations in which attention is not focussed on the primary task at hand. The controllers may be distracted by the absence of flight progress strips, or by plotting separation standards for other controllers (see Insert 3). In other circumstances attention may also been affected by noise levels within the working environment or discussions not related to the traffic situation.

3.2.8 Flight data processing errors

Flight progress strips provide controllers with a representation of the expected traffic and traffic disposition, which allows them to anticipate and identify potential traffic conflicts. Errors in flight strip information may provide controllers with an incorrect mental picture of traffic disposition or the expected outcomes. While such errors do not have a primary role in the development of an unsafe act, they may contribute to the development of an unsafe situation. Insert 6 gives an example where controllers with jurisdiction for two aircraft on differing (but converging) routes, were providing separation based on dissimilar and incorrect flight progress strip information. This example and other cases involving omissions in flight data preparation increase the opportunity for an unsafe act to develop and penetrate the systems defences. The result is the diversion of attention from the primary task, or an incorrect picture of traffic disposition.

3.2.9 Review of Findings - *Regarding Unsafe Acts*

Unsafe acts provide evidence as to the fallibility of human performance. It can be argued that the controllers who were involved in the incidents which are represented in this investigation are a product of the system which has selected and trained them. Working within the ATS system has instilled attitudes and a culture which makes it acceptable and perhaps relatively common to rely excessively on aircraft performance, to overlook separation assurance, to use flexibility to an excess and to work around system deficiencies. The inference is that the system is overly reliant on controller skill.

Such unsafe acts are not uncommon in the ATS system. It is the frequency with which they result in a breach of the system's defences which is rare.

There may be little to be gained from tackling the identified issues in isolation. The underlying attitudes and organisational culture which are discussed in more detail, must be addressed by management initiatives.

3.3 PREDISPOSING PSYCHOLOGICAL FACTORS

Predisposing psychological factors are latent states, which create the potential for the unsafe acts which have been discussed above. Such factors may be viewed collectively as the organisational climate which engenders errors or violations.

The psychological precursors of unsafe acts, sometimes referred to as "thought influences", which were identified in the course of the investigations are indicated in Table 3.

3.3.1 Excessive self-reliance

Controllers are trained to rely on their ability to make decisions about complex and dynamic situations. This training however does not cover human performance capabilities and the limitations which effect decision making. In some instances this reliance on decision making has led to situations in which controllers have failed to utilise the facilities available to ease their workload or reduce the complexity of the traffic processing. Controllers seemed unwilling to route an aircraft through another controller's sector. This was particularly relevant in terminal areas (see Insert 1). Similarly they appear reluctant to ask for assistance in cases where the traffic configuration increased in difficulty and overwhelmed the capacity of the sector and the controller.

Table 3

PREDISPOSING PSYCHOLOGICAL FACTORS IDENTIFIED DURING THE INVESTIGATIONS

- Excessive self-reliance
- Focus on tactical rather than strategic control
- Anticipation used to excess
- Workload (excessive/minimal)
- Acceptance of frequent distractions in the work environment
- Ambiguity regarding the service/safety trade-off
- Work around system deficiencies
- Uncertainty regarding future (1991)

3.3.2 Focus on tactical rather than strategic or defensive control

The second psychological precursor under consideration is the focus on tactical rather than strategic (defensive) control. Planning is the base of all air traffic control, with controllers being trained to anticipate potential traffic conflicts. However, there seems to be a tendency for controllers to act in an reactive mode, solving problems as they occur (see Insert 1), with little planning effort directed to solving the "What if" question at the initiation of a traffic sequence.

3.3.3 Anticipation used to excess

Controllers are frequently required to base plans on their expectation's of aircrews' actions, aircraft performance and the actions of other ATS personnel actions. In the majority of cases these judgements or "gambles" are correct. However, this may increase the likelihood that the controller will come to rely too heavily on these expectations when making decisions.

The role of aircraft performance in the incidents under review has been discussed previously, as have the coordination problems in which controllers incorrectly assume that they each hold the same picture of traffic disposition.

3.3.4 Workload

Ratner, in the initial review of the Air Traffic Services system, published in April 1987, noted that "Human errors are more likely to occur during certain kinds of operational situations, such as those of high traffic complexity and level, and very low traffic levels, and circumstances where coordination is complex". All such situations are reflected in the occurrences under review.

A direct correlation between traffic density and workload does not exist. Factors such as experience, foresight, procedures, working environment etc also play a role. High density traffic combined with a number of peripheral tasks may result in a controller being unable to adequately assess the traffic and hence recognise the potential conflict. In other situations, the level of traffic may not be extreme, but the actual configuration of the airspace or the work station configuration results in a level of task complexity which reduces the operator's ability to perform without error. Limited traffic levels may lead to situations in which the controller's full attention is diverted from the primary task, ie controlling traffic, to other ancillary activities, eg plotting separation standards for another controller or discussing industrial issues (see Inserts 1 and 3). In low stimulus environments maintenance of attention and vigilance are difficult.

3.3.5 Acceptance of frequent distractions in the work place

As has been previously indicated, a controller's attention can be diverted from his/her primary task prior to the airmiss occurrences. Distraction within the workplace may be responsible for such inappropriate division of attention. If the cases under review are representative, it is apparent that undertaking supplementary tasks for fellow controllers or conversing with other controllers at the console is routine. Equally, noise levels can on occasion reach a level that makes it difficult to concentrate, particularly during a shift change (previously identified by Ratner in 1987).

Indications were that "on the job training" (OJT) unintentionally introduces distraction, and additional workload, which is associated with the checking of the trainee's action and the requirement for explanation. In some instances this led to situations in which the trainer was unable to see the "whole picture". OJT also poses an element of distraction for ATS personnel working in association with the trainee/trainer combination. Instances were identified where:

(a) ATS personnel found it necessary to clarify co-ordination details. The trainee and trainers failed to recognise the ramifications of the information provided, eg that both aircraft were on the same air route.

(b) ATS personnel took on tasks such as plotting separation for a training combination, which diverted attention from their primary tasks.

While the Bureau does not wish to imply that controllers should work in a sterile environment, in which assistance to others and discussion does not take place, it is believed that the frequency and magnitude of distractions is detrimental to the essentially cognitively based task of controlling aircraft. It is therefore essential that management acts to limit the amount of distraction in the workplace as documented in the standard operating procedures.

3.3.6 Working around system deficiencies

Aircraft control techniques and procedures are necessarily adapted for the particular ATS system. It was found that controllers were forced to adapt their mode of operation to accommodate deficiencies which were inherent in the system. These deficiencies ranged from the ergonomic design of work stations, the quality of the radar, the limits of VHF range, to the poor phraseology used by some controllers. Other deficiencies included the limited capacity of routes because of inadequate radar facilities, and the increased complexity of traffic processing because of the route structure and the design of sectors.

While some of these deficiencies directly impinge on the potential for unsafe acts by increasing workload, coordination, etc, others such as the quality of the radar or the physical environment may impact on staff morale and motivation, which may also affect prevalence of unsafe acts.

In this case the psychological factor is the acceptance of the requirement to work around inappropriate design features of a system. As traffic increases in number and complexity the "work arounds" in themselves may become serious safety deficiencies.

3.3.7 Ambiguity regarding the service/safety trade-off

The operation of all complex systems involves a trade-off, between service and safety. In the ATS system this involves a trade-off between providing an economically viable service, while maintaining safety. It is always possible to increase the safety margins by increasing costs or alternatively reduce costs by reducing the service, and thereby possibly reducing safety.

In some circumstances, the balance which the organisation wishes to achieve between service and safety is not clearly communicated to all personnel. At the time of this study the Bureau considers that such ambiguity existed, and was reflected in instances where controllers, not wishing to inconvenience aircrews, or with the aim of shortening track miles, inadvertently reduced separation standards below the specified minima.

The service ethos was also demonstrated in the speed at which controllers provided clearances following requests for altitude changes. As previously indicated, the rapidity of response was such that complete processing of effect and outcome could not have been achieved.

During the study period 1991-1992, the line between the provision of service and the maintenance of safety was ambiguous. This ambiguity is discussed in detail in section 3.4.3.

3.3.8 Uncertainty regarding future

In the period in which the majority of the incidents under consideration took place, there was considerable uncertainty regarding the restructuring and upgrading of the ATS system. Evidence of this affect on performance was that some controllers were discussing possible postings and industrial issues at the time when safety standards were breached.

This aspect is discussed further in section 3.4.3.

3.3.9 Review of findings *regarding psychological precusors*

It is apparent from a review of the psychological preconditions to unsafe acts that they are, inter-related and that many interact to induce an unsafe act.

The evaluation also provides a profile of the typical controller who has developed within the Australian ATS environment. The image is of a controller over reliant on his or her knowledge of the workings of the system, and expectations of aircraft performance.

The organisational culture which has evolved in the Australian ATS System will resist change unless the new air traffic management principles and training philosophy are developed in concert and are reinforced with a change with a concurrent education and training program.

3.4 ORGANISATIONAL DEFICIENCIES

Management must be focused on identifying and rectifying those organisational deficiencies which have the greatest influence upon system safety.

The investigations revealed four distinct yet overlapping organisational deficiencies. These deficiencies are: strategic planning for air traffic management; strategic planning for training; the organisational climate; and quality assurance. The elements on which such conclusions are drawn are indicated in Table 4.

Table 4

ORGANISATIONAL DEFICIENCIES IDENTIFIED DURING INVESTIGATIONS

• Route Structure made controlling more difficult	
• Complex, ad hoc route structure	*STRATEGIC PLANNING FOR AIR TRAFFIC MANAGEMENT*
• Five regional systems, not one	
• Inadequate planning for traffic changes	
• Training and air traffic management did not have consistent objectives	
• OJT and ab initio training not coordinated	*STRATEGIC PLANNING FOR TRAINING*
• Inadequate management of OJT content and direction	
• Little training to reduce human error	
• Excessive reliance on controller skill	
• Failure to effectively limit controller distractions	*ORGANISATIONAL CLIMATE*
• Ambiguity within organisation	
• Inadequate quality assurance to provide ongoing feedback on key issues	*QUALITY ASSURANCE*

3.4.1 Strategic Planning for Air Traffic Management

The Australian air route structure has many of the characteristics of a system which has evolved in an ad hoc way rather than one which has been developed to strategic guidelines to meet changing needs. Two major trends reflected the approach of ATS management at the time of the investigation.:

Local fixes: As incidents and other events revealed apparent failings in the system, fixes were applied. In many cases such fixes were devised and implemented at a local level. Neither the ramifications of the identified problem, nor the implications of the local fix, appeared to have been fully considered on a national system wide basis.

Five systems: The policy of regional devolution of ATS management and responsibility led to the opportunity for the development of five differing philosophies within the ATS system. This meant that local solutions have not only differed in their details, but also in their underlying approach to the problems.

As evidenced by the incidents under review the lack of strategic planning resulted in a trunk route structure which was overly complicated. In many cases, this complexity served to make the task of safely separating aircraft harder than it need have been. In the past such complexity was accommodated by reliance on the skills of controllers. However, as traffic levels have grown, controllers have been placed increasingly in situations where they had less and less room to manoeuvre, and were forced on occassions to adopt non-standard procedures to separate the traffic.

A further result of this incremental approach to air traffic management was a failure to adequately plan for traffic shifts. This forced air traffic management into an increasingly reactive mode especially in an environment in which the industry was demanding a more efficient service.

A more subtle issue within the realm of air traffic management was that the design criteria did not appear to place sufficient emphasis on failsafe design. The inevitability of human error should be taken into account in the design of ATS systems as it is in many areas of aviation and in other industries. Many aspects of Australia airspace do not exhibit this characteristic.

3.4.2 Strategic Planning for Training

During the investigation of incidents and the analysis of systemic factors contributing to them, various aspects of the training of controllers were identified as potential deficiencies. Considered in total, these deficiencies highlight an overall need to regard training as a strategic issue, that is, to view the process and delivery of training as a set of national strategies aimed at achieving the CAA's objectives in the ATS arena. This issue will be further discussed in terms of corporate directions later in this report.

Evidence from this systemic investigation suggests that the training process to develop and consolidate the skills of an air traffic controllers suffered from serious deficiencies. For example:

- "on the job training" (OJT), in terms of quality of training which the trainee receives, was not adequately managed, and standards were not established and met;
- "inexperienced" controllers were used as OJT instructors leading to an overall reduction in the depth of knowledge and experience passed on to the trainees;
- consolidation of skills following ratings have been hampered by a lack of facilities (eg simulators) and by the difficulties of giving OJT trainees quality time;
- there was a lack of formal selection and training processes for OJT trainers.

Lack of long term strategic planning was reflected in the cyclic flow of ab initio trainees into the ATS system, the resources available to conduct training within the AACCs and the type of training. Recruitment of ab initio trainees was out of phase with the requirements for controllers. In recent years, the CAA has been somewhat distanced from the ab initio trainee in location and organisation, and seemingly has had little control over the quality of the "trainee" which it received.

Often the ab initio trainees were initially based in AACCs where there had been little recent experience of training such individuals, and little external support for check and training officers. Evidence suggests that the critical support functions such as the selection and training of trainers was insufficient, and even if resources had been available for training there was little capacity within the system to release the training officers for training courses. Even such rudimentary items such as training manuals seemed to be insufficient to meet the needs of the training officers.

The potential of training aids such as simulators also seems to have been neglected. The simulators in situ at a number of the AACCs were unable to provide the complexity and variety of traffic conditions which can test trainees or rated controllers.

In the Ratner Review (1987), problems of defensive control, decision-making and judgement were identified. The suggestion was made in 1987 that whilst ATS staff were trained in the basic skills and procedures necessary for performing their various duties, training was deficient in strategic aspects. It was not providing controllers with an understanding of their limitations with regard to information processing.

The development of controllers, once they were part of the ATS system, seemed to have been overlooked, as the emphasis was placed on checking rather than training.

3.4.3 Organisational Climate

The nature of the incidents reviewed reflects that the system is unduly reliant on the skill of the controller. The system has bred and continues to breed a population of controllers who take considerable pride in being able to handle high traffic densities, and who are unwilling to accept modifications which may reduce the challenges.

The climate within an organisation may be viewed, in part, as a product of the higher echelons of the system. In the case of the ATS system in the period under review, there were elements of ambiguity and uncertainty within the organisations. It was a climate in which devolution of responsibility to the regions had resulted in a lack of standardisation at the workface. The management did not ensure that the devolution was handled and directed in a controlled manner.

In the specific period under review ambiguity for controllers existed not only in regard to their role in the present system, but also to their place in the future

ATS system. Uncertainty regarding job positions and location, along with a lack of information regarding the introduction of the "Two Centre Concept" (2CC), resectorisation, and local management changes led to dissatisfaction and a questioning of job worth. Uncertainty and dissatisfaction have the potential to impact on any controller's ability to operate at the highest level of efficiency and safety because of distraction, sub conscious influences and concern.

3.4.4 Quality Assurance

In 1991, the ATS system gave the appearance of five independent systems attempting to work as one. There was a lack of standardisation between these five "systems". In this environment, the responsibility for the Quality Assurance (QA) function within the CAA was restricted to one full time officer. The resources available limited the operation of the function to audits of various facilities in which the majority of the manpower was seconded to the QA function for the period of the audit (usually one week). Reviews were also conducted following serious incidents. This situation of limited dedicated resources meant that the QA function was unable to:

(i) achieve the oversight role which was necessary for the standardisation of operation and training;
(ii) determine whether facilities met the established operating standards; and
(iii) consider the system safety implications of projects.

3.4.5 Review of Findings - *organisational deficiencies*

Reviewing the organisational deficiencies, it becomes apparent that the General Failure Types which can be identified at this level are: poor planning in certain areas; inadequate overall monitoring of the total system; and inadequate quality assurance. It could also be to argued that the ambiguity which existed between service and safety reflected an incompatibility of organisational goals.

In practice, to reduce the need for controllers to make operational decisions purely based on their knowledge of the system, which can lead to unsafe acts, it is necessary to provide an environment in which the need to make such decisions is limited. Such an environment can be achieved by a coordinated approach to training and air traffic management, ensuring that training is relevant, timely and appropriate.

3.5 INADEQUATE DEFENCES

Human or mechanical failures in the ATS system are not infrequent. Studies overseas for example have reported that up to 25% of clearances were found to be in error. However when an error or breakdown does occur the system should be immune to the impact of the event by detecting the error before it leads to an occurrence. The present analysis has revealed that the defences of the ATS system were inadequate. There were few procedures or technological aids which protected against controller error (see Table 5).

Table 5

INADEQUATE DEFENCES WHICH WERE IDENTIFIED DURING INVESTIGATIONS

- Controller must act as own safety net
- Aircrew role not emphasised/understood
- Inadequate monitoring
- Inadequate verification or validation of data
- System has few "failsafes"
- Collision avoidance not planned

The safety of the ATS system is dependent to a considerable extent on the error free performance by the controller: when an error is made, such as an incorrect clearance, in the majority of cases only the sector controller will be fully conversant with the situation, and therefore will be the only ATS operator in the system who can detect the error. At the present time, aircrew seem to be unwilling to fully scrutinise the controllers' actions. Thus, the vital part which pilots can play in detecting error is under utilised. The technical defences currently available, to the ATS officers overseas are "conflict alert", or "conflict probe". An airborne system such as Airborne Collision Avoidance System (ACAS) which has the capability to detect potential conflicts is available for pilots. The present Australian ATS system has few failsafe sub-systems, and even in places where failsafe systems could and should exist, the Bureau has identified elements which "fail unsafe".

For example, the flight data processing errors previously discussed in section 3.2.8. indicate the problems which are associated with manually transcribing information on to flight strips, and then transferring that information to controllers who have no way of validating the information provided. Therefore there are no specific defences to protect the ATS System from consequences of errors in flight strips.

3.6 CORPORATE DIRECTION

A fundamental premise of the Reason model is that the corporate level has a vital part to play in the safety health of an organisation. The analysis of the safety health of the CAA ATS Division has identified some key deficiencies. While BASI recognises that the CAA has gone a considerable way in attempts to redress problem areas, the Bureau believes that the Authority has further areas to address. These areas are shown in Table 6.

In the shorter term the CAA is introducing programs aimed at:

- team leader and team training with the emphasis on leadership, team building, staff development, standards, performance assessment, care of staff and productivity;
- enhancing the quality of instruction;
- developing cost effective use of computer based training systems;
- more comprehensive and structured use of simulators to provide more effective training before entering the OJT system; and
- building ATC's awareness of human performance capabilities, their limitations and other human factors in the operational environment.

Other initiatives taken by the CAA include the participation of ATCs on Aircrew Team Management courses conducted by the airlines and discussions with the RAAF on the use of the Tower training facility at East Sale.

4.3 STANDARD PROCEDURES AND TRAFFIC MANAGEMENT

The CAA sent a team on a two week fact finding visit to the United States to examine Standard Terminal Arrival Routes (STARS). The terms of reference for the project included:

- the establishment of a draft policy for the use of STARS within Australia;
- the criteria for the design implementation and publication of STARS for use at Brisbane, Sydney and Melbourne;
- the design of terminal area and enroute procedures to maximise the efficiencies to be gained from STARS; and
- the identification of coincident changes needed for the implementation of STARS.

The CAA team have recommended to the CAA that STARS be implemented whenever efficiencies in aircraft operations, traffic management and ATS workload/coordination can be gained. The United States FAA Order 7100.9A should form the basis of the CAA policy.

The team have also recommended that the requirement to include controlled airspace boundaries in the design of Standard Instrument Departures, be reviewed. Other recommendations involve Traffic Management, Procedures, standards, Publications, Control Tower Operations and Equipment. These recommendations are reproduced in Appendix D to this report.

Many of these recommendations address areas identified in the previous BASI incident investigations and this systemic study.

4.4 QUALITY ASSURANCE (QA)

The CAA have developed the Quality Assurance Unit by expanding its role and staffing. There is recognition and senior management commitment that the QA unit should play a vital part in the ATS management. The main impetus for this change in the QA Unit has come from the 1991 Ratner Review of the ATS System. Senior Management are publicly committed to the implementation of the Ratner Review. Consequently the QA Unit has played an important role in the CAA's implementation of the Ratner recommendations.

An integrated strategic plan for quality assurance reviews of the ATS facilities has been developed by the QA unit. These reviews commenced in 1993 by teams under the direction of the QA officers, including participation by other officers from agencies such as BASI, RAAF and the Airways Corporation of New Zealand.

4.5 MANAGEMENT

The CAA has changed the ATS management structure to align with the changes in the ATS regional sub-divisions. The Assistant General Managers (AGMs) have been moved closer to the regional ATS facilities where practicable. Similarly, where possible their officers have been relocated to the airport complexes to ensure better feedback and awareness of issues at the "work face".

CHAPTER 5

SAFETY ACTIONS AND RECOMMENDATIONS

The objective of this analysis was to identify system deficiencies within the ATS system. Unsafe acts and psychological precursors have been identified, as have the deficiencies in the organisational factors of the system. The areas identified by BASI as having deficiencies were the CAA's strategic planning of both air traffic management and training. Equally, an effective quality assurance function was necessary to enhance the safety of the system. Since the period used as the basis of the analysis, the CAA management initiatives have addressed some of the problems. Other initiatives are going to be taken as resources and opportunities arise. However, the Bureau believes that a number of further initiatives are required. These are presented below, with more specific recommendations emanating from individual investigations being presented in Appendix E.

5.1 STRATEGIC PLANNING

5.1.1 What is apparent is the need for a coordinated integrated systems approach to the planning of air traffic services, involving the Directorate of Aviation Safety Regulation (DASR). This approach would involve assessing the risks associated with any changes during planning, monitoring of the implementation of special projects, feedback once the initiatives have been implemented, and ensuring that the full potential of each new developments realised.

Safety Advisory Notice:
The Bureau of Air safety Investigation suggests that this should be the role of a dedicated strategic planning unit.

5.1.2 It is the Bureau's contention that the CAA should take a proactive approach to identify, and continuously monitor areas of weakness within the system. As indicated in Reason's analysis of British Rail "negative outcome data (accidents, incidents etc) are too sparse, too late and too statistically unreliable to support effective safety management[8]". More valid indicators of an organisation's safety health are required, in which the intrinsic resistance to combinations of weakened or breached defences and unsafe acts can be measured.

Safety Advisory Notice:
It is suggested that the CAA has a requirement for a structured approach which can monitor the vital signs of the health of the organisation while providing feedback on the success of the new initiatives at the same time. The proposed "system safety" group, operating across both ATS and DASR, should be considered to fulfil this requirement.

---

8. Reason JT PRISM Handbook

5.1.3 Following reviews by Reason and his colleagues, British Rail, Shell and British Airways have adopted system safety measures which can be applied routinely in a proactive mode, and intermittently in a reactive mode (ie following an accident or incident). The indices utilised include planning, communication, and training procedures. The adequacy of the current state of each index, and the potential for safety problems, are assessed by every layer of the organisation from trainee to the Board of Directors. BASI would be willing to provide assistance with the development and implementation of a proactive approach.

Recommendations:
The Bureau recommends that the Civil Aviation Authority:-

1. Coordinates and integrates the planning and implementation of special projects and evaluates the success of the projects once the initiatives have been implemented; and

2. Evaluates the potential of such a proactive approach, which attempts to provide valid ongoing indicators of the organisation's safety health (eg PRISM, MESH, TRIPOD) in aiding the QA function.

5.2 CORPORATE DIRECTIONS

5.2.1 There have been fundamental and wide ranging changes in the ATS system during the period under review. These have been achieved by a number of initiatives taken by the CAA at the corporate level, particularly in the areas of air traffic management and training. The development of an effective Quality Assurance function has also been an integral part of these initiatives. However, in this period of change there is still a need for further initiatives to promote the safety health of the organisation.

Safety Advisory Notice:
The Bureau suggests that the Civil Aviation Authority considers adopting a similar safety philosophy to that utilised by the United Kingdom's Civil Aviation Authority, which was highlighted in the 1991 Ratner Review.

The Bureau continues to work closely with the CAA ATS Quality Assurance Unit. A series of regular meetings as initiated after the joint Ratner Review, to ensure better communication and liaison between the two organisations. These meetings have proved very effective and it was through this channel that the progress reports and results of this systemic investigation were promulgated.

5.3 SAFETY NET

5.3.1 Recommendation:

Given the limitations of human performance, the Bureau recommends that the CAA:

1. Undertakes an active assessment of ground and airborne technologies for collision prevention.

5.3.2 Recommendations:

Obviously such technological systems are long term and costly solutions. While the safety net cannot be substantially improved in the short term, the Bureau recommends that the CAA:

1. Continues to optimise controller workload by standardisation of procedures and resectorisation, with the aim of reducing the number of unsafe acts; and

2. In conjunction with Australasian Airlines Flight Safety Council and the Australian Aviation Industry Association promulgates the role which aircrew can play in the detection of controller error.

CHAPTER 6

CONCLUSIONS

In 1991 a number of airmisses occurred at the time that the Civil Aviation Authority ATS system was undergoing considerable change. During June and July 1991, 31 incidents were reported, of which eight were considered to be serious.

Each occurrence was investigated individually. However, as part of the BASI proactive approach to aviation safety, a systemic investigation of these airmiss occurrences was conducted.

The systemic investigation was based on the structured approach developed by Reason. The investigation examined active and latent failures of the ATS system which were associated with the occurrences. These unsafe acts (active failures) have been categorised as errors or violations. In addition psychological precursors to unsafe acts, organisational deficiencies and corporate actions have also been identified.

Deficiencies in the CAA's strategic planning of the air traffic management and training were found to be major factors in these active and latent failures. The formation and operation of an effective Quality Assurance function has been highlighted as one of the major improvements by the CAA to the ATS system.

A number of initiatives have been introduced by the CAA since the airmiss incidents considered in this systemic investigation. These initiatives have addressed many of the problems. However there remain some aspects which still require attention.

The Bureau has suggested that the CAA should:

a) introduce further system safety initiatives based on the MESH, TRIPOD and PRISM models used by organisations such as British Airways;

b) adopt a similar safety philosophy to that used by the Civil Aviation Authority in the United Kingdom; and

c) undertake an assessment of ground and airborne technology for collision prevention.

The report also emphasised that the aircrew play a vital role in the "defensive" mechanisms of the ATS System. The Bureau therefore recommends that the CAA explores ways of enhancing the aircrew's detection of errors in the controller's actions.

APPENDIX B

REPORTED AIRMISS OCCURRENCES: 1 JUNE - 31 JULY 1991

Reference Number: B/916/3008

Aircraft Make :	**Model :**	**Registration :**
McDonnell Douglas	DC10	COA16
De Havilland	DHC6	VH-KZN

Date/Time (Local) : 3 June 1991 1720

Class of Operation : RPT/RPT

Location : Sydney NSW

Remarks : Breakdown of separation.

Reference Number: B/911/3134

Aircraft Make :	**Model :**	**Registration :**
Cessna	C210	VH-TWD
McDonnell Douglas	DC10	MAS26

Date/Time (Local) : 5 June 1991 1530

Class of Operation : AWK /RPT

Location : Brisbane QLD

Remarks : Breakdown of separation.

Reference Number: B/916/3010

Aircraft Make :	**Model :**	**Registration :**
Saab	SF340	VH-OLN
Beechcraft	BE200	VH-MSU

Date/Time (Local) : 10 June 1991 1210

Class of Operation : RPT/Unknown

Location : Broken Hill NSW

Remarks : Airmiss. During a DME arrival, VH-OLN passed overhead VH-MSU with a vertical separation of 400 feet.

Reference Number: B/911/3141

Aircraft Make:	Model:	Registration:
Boeing	B747	VH-OJG
Boeing	B737	VH-TAU

Date/Time (Local): 12 June 1991 0801

Class of Operation: RPT/RPT

Location: Abeam Caiguna WA

Remarks: Breakdown of separation.

Reference Number: B/916/3012

Aircraft Make:	Model:	Registration:
Fokker	FK28	VH-EWA
Piper	PA28	VH-LMB

Date/Time (Local): 21 June 1991 1440

Class of Operation: RPT/PVT

Location: Sydney NSW

Remarks: Breakdown of separation.

Reference Number: B/912/3154

Aircraft Make:	Model:	Registration:
Piper	PA44	VH-JON
Socata	TB20	VH-JTW

Date/Time (Local): 22 June 1991 1646

Class of Operation: AWK/Unknown

Location: Near Mount McQuoid NSW

Remarks: Airmiss. Traffic confliction OCTA.

Reference Number : B/912/3155

Aircraft Make :	**Model :**	**Registration :**
Boeing	B747	Unknown
Boeing	B727	VH-TBN

Date/Time (Local) : 22 June 1991 1110

Class of Operation : RPT/RPT

Location : Waypoint MULID NSW

Remarks : Possible breakdown of separation.

Reference Number : B/911/3153

Aircraft Make :	**Model :**	**Registration :**
McDonnel Douglas	FA18	Unknown
Beechcraft	BE200	VH-XRF

Date/Time (Local) : 24 June 1991 1117

Class of Operation : MIL/RPT

Location : Townsville QLD

Remarks : Breakdown of separation. 8 x RAAF F18s penetrated CTA.

Reference Number : B/916/3016

Aircraft Make :	**Model :**	**Registration :**
Lockheed	C130	Unknown
Embraer	E110	VH-WPE

Date/Time (Local) : 28 June 1991 1818

Class of Operation : MIL/RPT

Location : Richmond NSW

Remarks : Breakdown of separation.

Reference Number : B/915/3068

Aircraft Make :	**Model :**	**Registration :**
Cessna	C210	VH-TYG
Cessna	C182	VH-ITS

Date/Time (Local) : 28 June 1991 0830

Class of Operation : CHTR/PVT

Location : Loongana WA

Remarks : Airmiss. Traffic confliction OCTA.

Reference Number : B/913/3140

Aircraft Make :	**Model :**	**Registration :**
Mooney	M20	VH-CYG
Piper	Unknown	Unknown

Date/Time (Local) : 29 June 1991 1520

Class of Operation : PVT/Unknown

Location : Moorabbin VIC

Remarks : Airmiss. Piper passed approx 15 feet below and one wing span (35ft) to the left of VH-CYG.

Reference Number : B/913/3146

Aircraft Make :	**Model :**	**Registration :**
Piper	PA31	VH-OZM
Piper	PA28	VH-WMJ

Date/Time (Local) : 5 July 1991 1900

Class of Operation : RPT/PVT

Location : Moorabbin VIC

Remarks : Airmiss. Both aircraft less than 2 km apart nose to nose.

Reference Number : B/913/3141

Aircraft Make :	Model :	Registration :
Piper	PA28	VH-BUN
Piper	PA28	VH-HHU

Date/Time (Local) : 2 July 1991 1615

Class of Operation : AWK/AWK

Location : Moorabbin VIC

Remarks : Airmiss. Aircraft passed vertically separated by 100-150 feet.

Reference Number : B/912/3175

Aircraft Make :	Model :	Registration :
Macchi	MC32	Unknown
Boeing	B767	Unknown

Date/Time (Local) : 5 July 1991 1140

Class of Operation : MIL/RPT

Location : Nowra NSW

Remarks : Military aircraft operating in CTA without clearance.
Possible breakdown of separation.

Reference Number : B/913/3147

Aircraft Make :	Model :	Registration :
Boeing	B737	VH-CZH
Steen	Unknown	Unknown

Date/Time (Local) : 7 July 1991 1441

Class of Operation : RPT/Unknown

Location : Melbourne VIC

Remarks : Airmiss with unidentified aircraft.

Reference Number : B/912/3178

Aircraft Make :	**Model :**	**Registration :**
Piper	PA28	VH-HLE
Piper	PA38	VH-FTX

Date/Time (Local) : 8 July 1991 1253

Class of Operation : Unknown/Unknown

Location : Bankstown NSW

Remarks : Airmiss in the circuit area.

Reference Number : B/913/3148

Aircraft Make :	**Model :**	**Registration :**
Boeing	B747	ZK-NBS
British Aerospace	BA46	VH-EWN

Date/Time (Local) : 9 July 1991 1755

Class of Operation : RPT/RPT

Location : Melbourne VIC

Remarks : Airmiss. Aircraft passed with 400 feet vertical separation and 6 km horizontal separation.

Reference Number : B/916/3017

Aircraft Make :	**Model :**	**Registration :**
Piper	PA31	VH-WZW
Piper	PA31	VH-LIL

Date/Time (Local) : 11 July 1991 0928

Class of Operation : RPT/RPT

Location : Taree NSW

Remarks : Airmiss. Traffic confliction OCTA.

Reference Number: B/911/3197

Aircraft Make :	**Model :**	**Registration :**
Boeing	B737	VH-TAF
Boeing	B737	VH-TAH

Date/Time (Local) : 11 July 1991 1201

Class of Operation : RPT/RPT

Location : NE Perth WA

Remarks : Co-ordination breakdown. (Possible breakdown of separation standards).

Reference Number: B/916/3018

Aircraft Make :	**Model :**	**Registration :**
Airbus Industrie	EA30	VH-YMK
British Aerospace	BA46	VH-EWS

Date/Time (Local) : 13 July 1991 0935

Class of Operation : RPT/RPT

Location : Sydney NSW

Remarks : Breakdown of separation.

Reference Number: B/912/3193

Aircraft Make :	**Model :**	**Registration :**
Piper	PA31	VH-LHG
Beechcraft	BE200	VH-AMS

Date/Time (Local) : 12 July 1991 2113

Class of Operation : RPT/AWK

Location : Coffs Harbour NSW

Remarks : Airmiss. Traffic confliction OCTA.

Reference Number: B/911/3186

Aircraft Make :	Model:	Registration :
Cessna	C182	VH-JQE
Piper	PA28	VH-PEJ

Date/Time (Local) : 12 July 1991 1410

Class of Operation : PVT/Unknown

Location : Coolangatta QLD

Remarks : Reported Airmiss in CTA.

Reference Number: B/912/3182

Aircraft Make :	Model:	Registration :
Piper	PA28	VH-JHX
Robinson	R22B	VH-NGU

Date/Time (Local) : 15 July 1991 1025

Class of Operation : PVT/Unknown

Location : Sydney NSW

Remarks : Breakdown of separation. (Visual separation maintained).

Reference Number: B/914/3071

Aircraft Make :	Model:	Registration :
Airbus Industrie	EA32	VH-HYF
Boeing	B767	VH-EAK

Date/Time (Local) : 17 July 1991 2205

Class of Operation : RPT/RPT

Location : Adelaide SA

Remarks : Breakdown of separation.

Reference Number : B/913/3158

Aircraft Make :	Model :	Registration :
Airbus Industrie	EA32	VH-HYB
Boeing	B727	VH-TBN

Date/Time (Local) : 18 July 1991 1734

Class of Operation : RPT/RPT

Location : Eildon Weir VIC

Remarks : Breakdown of separation.

Reference Number : B/912/3185

Aircraft Make :	Model :	Registration :
Lockheed	C141	MAC60193
Boeing	B737	VH-CZC

Date/Time (Local) : 19 July 1991 0858

Class of Operation : MIL/RPT

Location : Sydney NSW

Remarks : Breakdown of separation.

Reference Number : B/916/3025

Aircraft Make :	Model :	Registration :
Cessna	C152	VH-KKS
Piper	PA30	VH-PMG

Date/Time (Local) : 19 July 1991 1620

Class of Operation : PVT/CHTR

Location : Coffs Harbour NSW

Remarks : Breakdown of separation.

Reference Number: B/912/3187

Aircraft Make:	**Model:**	**Registration:**
Piper	PA28	VH-SWU
Unknown	Unknown	Unknown

Date/Time (Local): 21 July 1991 1252

Class of Operation: PVT/Uknown

Location: Near Picton NSW

Remarks: Airmiss. Traffic confliction OCTA. Pilot of VH-SWU observed an ultralight aircraft 100 metres to the right and at the same altitude.

Reference Number: B/912/3188

Aircraft Make:	**Model:**	**Registration:**
Beechcraft	BE76	VH-XHT
Cessna	C150	VH-SLL

Date/Time (Local): 21 July 1991 1405

Class of Operation: AWK/Unknown

Location: Abeam Warwick Farm NSW

Remarks: Airmiss. Traffic confliction OCTA. Pilot of VH-XHT reported VH-SLL crossed in front of him close enough to read the registration. Avoiding action was taken.

Reference Number: B/916/3023

Aircraft Make:	**Model:**	**Registration:**
Shorts	SH36	VH-MJU
Aerospatiale	TB20	VH-JTW

Date/Time (Local): 21 July 1991 1723

Class of Operation: RPT/Unknown

Location: Orange NSW

Remarks: Airmiss. Traffic confliction OCTA.

Reference Number: B/911/3204

Aircraft Make:	**Model:**	**Registration:**
Boeing	B767	VH-OGE
Airbus Industrie	EA32	VH-HYJ

Date/Time (Local): 27 July 1991 1515

Class of Operation: RPT/RPT

Location: Near Taroom QLD

Remarks: Breakdown of separation.

APPENDIX C

AIRMISS INVESTIGATIONS

The summaries of the eight incidents which were primarily used in the analysis are given below. It should be recognised that these summaries may not contain elements which are represented in the full report.

B/911/3134	**Brisbane**	**C210/DC10**
Aircraft Make :	**Model :**	**Registration :**
Cessna McDonnell Douglas	C210 DC10	VH-TWD MAS26
Date/Time (Local) :	6 June 1991	1530
Class of Operation :	AWK /RPT	
Location :	Brisbane QLD	

Synopsis

This occurrence was reported as a breakdown of radar separation standards within the terminal area, between a Cessna C210 (C210) conducting an Instrument Flight Rules (IFR) training flight and a McDonnell Douglas DC10 operating an international Regular Public Transport (RPT) flight. Recorded radar data indicated that the aircraft passed with less than one nautical mile (1 nm) horizontal separation when they were at approximately the same altitude of 3700 feet.

Investigation Summary

The C210, VH-TWD, had departed Archerfield for Maroochydore and had been cleared to climb to 6000 feet without restriction on the direct track. The C210 was in Instrument Meteorological Conditions (IMC) between 3500 feet and 3800 feet, when the pilot was instructed by the Brisbane Approach (APP) Controller to turn left onto a heading of 270 degrees. The C210 supervising pilot stated that he looked to his right and saw the landing lights of a large jet coming towards him on what appeared to be a collision course. He instructed the trainee to increase the rate of turn in order to get clear of the jet's anticipated flight path. He continued to observe the jet which passed close behind at what appeared to be the same altitude.

The DC10, identification Malaysian 26 (MAS26), had departed Brisbane runway 19 on a Radar Standard Instrument Departure (SID), and had been instructed to turn right onto a heading of 300 degrees to expedite early intercept of the outbound track. This particular SID requires the aircraft to commence the turn at, but not below 600 feet. After MAS 26 became airborne the tower controller noticed that the aircraft had not commenced a turn at 600 feet, but was continuing on runway heading. Having observed the radar return of the approaching C210, the tower controller immediately alerted the Approach Controller (APP). It was at this point that APP turned the C210 onto a heading of 270 degrees to attempt to achieve separation. When MAS26 contacted APP, the pilot was issued with an instruction to turn further right onto a heading of 340 degrees, but by the time this was achieved the aircraft flight paths had begun to diverge.

Departing aircraft were required to make an automatic frequency change from tower to the control sector providing the departures function. There was no clear definition of the time, or place, at which the departure call should be initiated nor was there a specific requirement for the tower to direct that frequency change.

The APP controller had no other traffic for processing at the time of the occurrence. There were no traffic capacity problems restricting alternative planning of vectoring options, nor were there any early confliction detection facilities. However, other options may have involved additional co-ordination. The controller had been discussing an industrial matter with adjacent officers at the time of the occurrence. The APP controller had extensive experience both in Australia and overseas, but had only recently returned from an overseas post and been rated at Brisbane. Since obtaining his Brisbane APP ratings he considered that he had not had adequate 'hands-on' time to consolidate that rating. He had not noticed MAS26 maintain the runway heading until about the same time as the tower controller intervened.

Submissions from the aircrew of MAS26 indicated that they had read back prior to take-off and had flown a SID different to that assigned. The APP controller had expected the flight paths of both aircraft to be separated by the required standard at the time of crossing.

B/911/3141 **Abeam Caiguna B747/B737**

Aircraft Make :	**Model :**	**Registration :**
Boeing	B747	VH-OJG
Boeing	B737	VH-TAU
Date/Time (Local) :	12 June 1991	0801
Class of Operation :	RPT/RPT	
Location :	Abeam Caiguna WA	

Synopsis

In this occurrence, two jet Regular Public Transport (RPT) aircraft were operating on the same one way air route in procedural controlled airspace when a controller approved a higher flight level request from the following and lower aircraft. This resulted in a breakdown of procedural separation standards.

Investigation Summary

Both aircraft involved in this occurrence had initially been cleared to climb to standard flight level 370 (FL370) on route T6 after departing Perth. However, the Perth Sector 2 (SEC 2) controller requested Perth Arrivals (ARR) controller to reclear the second aircraft, Qantas flight 24 (QFA24), to another level to provide separation with the preceding Boeing B737, VH-TAU. Accordingly, QFA24 was recleared to an amended, non standard, FL350. Perth ARR sector is responsible for traffic to approximately 150 miles from Perth at which point aircraft then transfer to SEC 2.

The SEC 2 controller had held Perth Sector ratings for only a few months. Workload was described as light and the controller was operating a combined workstation configuration with responsibilities for both Sector 2 and Sector 3 airspace. Sector 1 was also active with a rated controller and trainee on duty.

At 0727, the pilot of VH-TAU contacted SEC 2 to report passing waypoint T6E (150 nautical miles east of Perth) at time 0726, FL370, estimating the next way point T6D at 0801. QFA24 was still on ARR frequency at this time.

At 0733, QFA24 contacted SEC 2 on the same frequency as VH-TAU and reported passing waypoint T6E at time 0729, FL350, estimating T6D at 0803. These estimates for T6D were co-ordinated with Adelaide control by SEC 2 at 0746. At 0755, QFA24 was cruising in ciroform cloud when the crew requested the availability of FL390. The controller said "affirm descend to flight level 290, ... correction was that flight level 290 or 390?" QFA24 responded with "three nine". The controller then immediately cleared QFA24 to climb to non standard FL390. The crew of VH-TAU did not intervene. They did not recognise the significance of the level change request, or the proximity, of QFA24.

SEC 2 subsequently co-ordinated the amended flight level for QFA24 with Adelaide control. QFA24 and VH-TAU were both given frequency change instructions on which to maintain communications with SEC 2 at waypoint T6D. Shortly after both aircraft had reported at waypoint T6D, the crew of QFA24 asked for confirmation that VH-TAU was on the same route and had reported at T6D at 0801. This was confirmed by SEC 2.

The controller had inadvertently cleared QFA24 to climb through the flight level (FL370) occupied by VH-TAU without the prescribed separation. The investigation found that for a considerable period surrounding the occurrence, SEC 2 had become engaged in assisting the SEC 1 controller and trainee with an operational matter. It was also considered that having made an initial error in the request from QFA24 to descend, SEC 2 may have been particularly eager to redeem the situation and accommodate the request by responding with an immediate level change. Conflict avoidance in this occurrence was dependent upon human performance to detect and resolve. There were no terrestrial, or airborne, systems to provide protection against human error.

B/911/3197	**Perth**	**B737/B737**
Aircraft Make :	**Model :**	**Registration :**
Boeing Boeing	B737 B737	VH-TAF VH-TAH
Date/Time (Local) :	11 July 1991	1201
Class of Operation :	RPT/RPT	
Location :	NE Perth WA	

Synopsis

This occurrence was reported as a breakdown of separation. It involved two Boeing B737 jet Regular Public Transport (RPT) aircraft which were thought to have been operating on two different (but converging) air routes within controlled airspace. Controllers with jurisdiction for the aircraft were providing separation based on dissimilar and incorrect flight progress strip information. The error remained undetected until both aircraft passed on the same track on the peripheral range of the Perth radar display.

Investigation Summary

VH-TAH departed Alice Springs for Perth at 0940 via the planned air route T31, which is a direct route to Cunderdin and then Perth. The flight progress strips prepared for Perth Arrivals (ARR) showed the aircraft route as W43. Route W43 is a direct route from Alice Springs to Kalgoorlie then Cunderdin and Perth. The flight progress strips prepared for Perth area control Sector 2 (SEC 2) displayed the correct route T31. The FPS for ARR and SEC 2 were prepared from the same flight plan messages, but by different officers.

At 1104 SEC 2 coordinated VH-TAH with Arrivals Procedural (ARR(P)) sector. This co-ordination involved giving an estimated time at 160 nautical miles (nm) from Perth (the limit of radar coverage). This was because there is no published waypoint on route T31 adjacent to the boundary of airspace responsibility between the two units (SEC 2 and ARR). Co-ordination for an aircraft operating on W43 also required SEC 2 to provide an estimate for 160 nm Perth. Although local procedures did not require it, during the co-ordination with ARR(P) the SEC 2 controller specifically indicated that VH-TAH was on the 'T31' route. But neither the ARR(P) controller, nor his trainee, noticed that the co-ordinated route was different to that displayed on the ARR flight progress strips.

VH-TAH was originally at FL350 but progressively descended to FL290. The aircraft was maintaining FL290 at the T31C position at 1140 (the last published waypoint prior to reaching 160 nm Perth). The level change was correctly co-ordinated to ARR(P) by SEC 2.

VH-TAF departed Perth for Alice Springs at 1134 via the planned route T31, and climbed to FL330. This was co-ordinated to SEC 2 by ARR(P). SEC 2, realising that the aircraft would be in conflict on the same air route, T31, (according to his strips), offered to calculate a separation requirement in order to establish VH-TAF 2000 feet above VH-TAH ten minutes prior to the time of passing. But ARR(P), still not aware that the aircraft were on the same air route agreed to separate the aircraft laterally, as would be required if they were on air routes W43 and T31 respectively. Thus the exchanges of information between controllers remained ambiguous as they had not identified the air route tracking discrepancy. The estimated time of passing based on the time intervals would have been 1157.

The Perth Arrivals Radar ARR(R) controller has jurisdiction for aircraft within 160 nm. He was intending to separate VH-TAH, still believed to be inbound on route W43, from VH-TAF outbound on route T31 by radar monitoring VH-TAF clear of the procedural tolerances for the W43 track. The ARR(R) controller followed this course of action and was prepared to radar vector the outbound VH-TAF clear of the tolerances of VH-TAH.

The recorded radar information shows that VH-TAF left FL310 (providing 2000 feet vertical separation with VH-TAH) on climb at 90 nautical miles from Perth on the T31 track. VH-TAF and VH-TAH were unexpectedly observed to pass by radar on the same track (T31) at approximately 165 nautical miles from Perth. At that time VH-TAF was at FL330 and VH-TAH was at FL290. The ARR(R) and ARR(P) controllers had expected VH-TAH to be on the W43 track and consequently the relevant vertical separation standards had not been applied. The occurrence was subsequently reported as a separation breakdown. The workload was described as moderately high due to the presence of trainees, rather than actual aircraft numbers.

Immediate action was been taken by Perth Air Traffic Service management to prevent a recurrence of this nature by amending local instructions related to co-ordination and read back requirements.

B/916/3018	Sydney	EA30/BA46
Aircraft Make :	**Model :**	**Registration :**
Airbus Industrie British Aerospace	EA30 BA46	VH-YMK VH-EWS
Date/Time (Local) :	13 July 1991	0935
Class of Operation :	RPT/RPT	
Location :	Sydney NSW	

Synopsis

VH-EWS (BA46) was operating a Regular Public Transport (RPT) flight and had departed from runway 16 at Sydney for Hamilton Island, followed shortly after by VH-YMK (EA30), operating a RPT flight from Sydney to Perth. The Departure Radar (DEP) Controller on duty at the Sydney Area Approach Control Centre (AACC) believed that a breakdown of the radar separation standard had occurred between the two aircraft shortly after takeoff.

Investigation Summary

The initial departure instructions given to the Sydney control tower for VH-YMK, were "Cancel SID turn right heading 170 maintain 3000". The departure sequence was subsequently changed twice with two aircraft, VH-HVA and VH-EWS sequenced ahead of VH-YMK. Immediately following the issue of the final departure instruction for VH-EWS, the instruction "and YMK can be unrestricted" was passed by DEP to the tower. The tower controller understood the instruction to mean "cancel the previous departure instruction, and the aircraft may now track via the cleared SID with no altitude restriction". The DEP controller, who had only recently been rated for that position, had only intended cancellation of the altitude restriction, but still required the aircraft to depart with a right turn onto a heading of 170 degrees.

The tower controller cleared VH-YMK for take-off, knowing the aircraft would be conducting a "West One for Katoomba" SID and would turn left after reaching 3000 feet. The controller would also visually monitor the separation between VH-YMK and VH-EWS. The Departure Radar (DEP (R)) controllers saw the first radar paint of VH-YMK at a distance of about one nautical mile (1 nm) from the upwind end of the runway, and only some 3.5 nm behind VH-EWS. Believing that VH-YMK was departing on a heading of 170, and that it would rapidly gain on VH-EWS, DEP (R) immediately contacted the tower. The tower controller, knowing, that VH-YMK was on a SID, did not share the same concern. DEP (R) turned VH-EWS right onto a heading of 240 degrees to effect the separation believed to be required.

The investigation determined that VH-YMK was being visually separated by the tower and therefore no breakdown of separation occurred. However, there was a breakdown in co-ordination between the DEP and the tower controllers in that both tower and DEP had different expectations of the outcome of the instructions. The DEP workload at the time of the incident was described as being moderate to high.

B/914/3071	**Adelaide**	**EA32/B767**
Aircraft Make :	**Model :**	**Registration :**
Airbus Industrie Boeing	EA32 B767	VH-HYF VH-EAK
Date/Time (Local) :	17 July 1991	2205
Class of Operation :	RPT/RPT	
Location :	Adelaide SA	

Synopsis

VH-HYF (EA32) was operating on a scheduled domestic Regular Public Transport (RPT) flight from Adelaide to Brisbane and VH-EAK (B767) was operating an international RPT flight sector from Sydney to Adelaide. Both aircraft were on the same two way air route when VH-HYF passed VH-EAK at approximately 110 nm east of Adelaide with less than the required separation standard.

Investigation Summary

VH-HYF departed Adelaide airport on an "Adelaide East 2 Mildura" SID and airways clearance for an unrestricted climb to flight level 370 (FL370), via air route T77 to Brisbane. Because another Boeing B747, an international flight outbound from Melbourne, would be overflying Mildura at FL310 on a crossing track, Melbourne control had co-ordinated a requirement with Adelaide control for VH-HYF to reach FL330 by 20 nautical miles (nm) south-west of Mildura.

VH-EAK was flying from Sydney to Adelaide via Mildura maintaining FL310 on the reciprocal heading to VH-HYF, and appeared on the Adelaide control radar display at approximately 125 nm from Adelaide.

When VH-HYF contacted the Adelaide Sector 4 (SEC 4) Controller, SEC 4 requested the aircraft to maintain best rate of climb to FL330. The objective was to climb VH-HYF above VH-EAK, using radar to maintain a radar separation standard instead of a procedural standard. This would allow VH-EAK to follow an unrestricted descent profile into Adelaide, and for VH-HYF to not be held at a lower level until procedurally separated with the Boeing 747 overflying Mildura.

Approaching FL310 VH-HYF experienced an increase in ground speed due to a strong westerly windshear, increasing the closing speed with VH-EAK. While VH-HYF was maintaining maximum rate of climb, the air speed fell below the minimum manoeuvring speed. With the airspeed trend indicator fluctuating due to turbulence, and causing concern, the Captain reduced the climb angle to accelerate the aircraft. When VH-HYF passed VH-EAK at approximately 110 nm east of Adelaide, there was 800 feet vertical, and 0.4 nm horizontal separation. This was less than the required standard of 2000 feet vertical or 7 nm horizontal separation. VH-HYF regained a normal rate of climb at the time of passing VH-EAK.

The SEC 4 controller had been operating two combined Sectors, with a subsequent increase in workload which he described as heavy. He had monitored VH-HYF during its climb to FL310, at which time it was approximately 40 nm west of VH-EAK. At the displayed climb rate, SEC 4 expected VH-HYF should have been at FL330 by the estimated time of passing. SEC 4 continued his scan of other aircraft on the radar display. When his attention returned to VH-HYF and VH-EAK he noticed that the radar returns had merged, which would be normal as they passed. When the radar returns separated, SEC 4 then noticed that the altitude indication for VH-HYF was correctly displaying FL330. He therefore had no reason to believe that there had been a breakdown of separation.

During the period surrounding this occurrence, SEC 4 probably became distracted by a discussion, which had been in progress with other controllers, regarding industrial matters. This industrial situation was causing him a considerable amount of anxiety and was considered to have been a factor in this occurrence.

B/913/3158	**Eildon Weir**	**EA32/B727**
Aircraft Make:	**Model:**	**Registration:**
Airbus Industrie	EA32	VH-HYB
Boeing	B727	VH-TBN
Date/Time (Local):	18 July 1991	1734
Class of Operation:	RPT/RPT	
Location:	Eildon Weir VIC	

Synopsis

VH-HYB (EA32) and VH-TBN (B727) were operating scheduled RPT flights from Sydney and Canberra respectively to Melbourne with arrival sequencing being conducted in the vicinity of Eildon Weir (ELW). A third RPT aircraft, VH-ANF (B727) was also operating on the air route for sequencing via ELW. During the subsequent arrival vectoring, a breakdown of separation standards occurred between VH-HYB and VH-TBN when separation was reduced to a minimum of approximately 200 feet vertically and 1 nm horizontally.

Investigation Summary

Three aircraft, VH-TBN on descent from FL330 to FL160, VH-HYB maintaining FL240 and VH-ANF maintaining FL280, were tracking towards ELW en route to Melbourne from the north-east. VH-TBN was a few miles ahead of the other two aircraft. VH-ANF and VH-HYB were required to enter the holding pattern at ELW to facilitate sequencing into Melbourne. VH-TBN was cleared to continue, but instructed to reduce speed to 230 kts on descent. VH-TBN was parallelling the flight paths of VH-HYB and VH-ANF and about six nautical miles (nm) to the left to remain separated from the ELW holding pattern traffic.

VH-ANF was sequenced by the Melbourne Flow controller (FLOW) to leave ELW before VH-HYB. The traffic processing plan was to descend the higher level VH-ANF below VH-HYB (still maintaining FL240). Because there was only about 2 nm between these two aircraft on the same track, the Sector 2 (SEC 2) controller instructed VH-HYB to turn 30 degrees left onto a heading of 200 degrees, which was towards VH-TBN, who was on descent to FL160.

SEC 2 co-ordinated the tracking and airspeed restriction details of VH-TBN with the Arrivals (ARR) controller, who was undergoing a rating proficiency check, and then transferred VH-TBN to ARR jurisdiction. VH-ANF was then cleared to commence initial descent to FL250. Details on the amended tracking of VH-HYB were also co-ordinated with ARR, followed by transfer of control responsibility.

When SEC 2 instructed VH-HYB to contact ARR, the crew acknowledged the instruction and requested the level of the preceding aircraft. SEC 2 then realised separation had been lost between VH-HYB and the slower VH-TBN. SEC 2 immediately instructed VH-HYB to turn further left onto a heading of 030 degrees and advised that the aircraft sighted was VH-TBN, about 200 ft below.

The relative positions of VH-HYB and VH-TBN were checked by the training controller when co-ordination and transfer of control jurisdiction of VH-HYB was accepted. The two aircraft were then separated, by about 5.7 nm; at the time, the minimum allowable separation was 5 nm horizontally or 1000 ft vertically.

The training controller and trainee then became involved in other operational aspects of the task and became distracted from the primary task at a critical stage in the development of this occurrence. It was then noticed that the radar returns from VH-TBN and VH-HYB were in close proximity. VH-TBN was immediately instructed to expedite descent. VH-HYB was instructed to make a turn but the aircraft was still on SEC 2 frequency.

The initial instruction to turn VH-HYB left into a heading of 200 degrees was intended to assist the arrival of sequencing, both the pilot and the trainee on ARR.SEC 2 had inadvertently overlooked the potential conflict situation between VH-TBN and VH-HYB who had significantly increased ground speed after turning out of the previous strong headwind. Neither ARR or SEC 2 appeared to recognise the significance of the difference in aircraft speeds and closure rates between VH-TBN and VH-HYB at the time of the co-ordination exchanges. Once the control error had been initiated, the safety net had been eroded. There were no terrestrial or airborne systems to provide protection against human error.

The recorded radar data showed that as the occurrence developed, the closing speed between the two aircraft was approximately 210 kts. The radar screen labels for each aircraft included a readout of level and ground speed. The SEC 2 controller did not detect the high closure speed as the display for the aircraft was not at full lulliance. It was also his normal operating technique to have a low level of radar display label brightness set. This would have made detection of the confliction difficult. The ARR controllers also failed to detect the rapid closing speeds evident from the radar display. The traffic workload at the time was described as moderate.

B/912/3185	**Sydney**	**C141/B737**
Aircraft Make :	**Model :**	**Registration :**
Lockheed	C141	MAC60193
Boeing	B737	VH-CZC
Date/Time (Local) :	19 July 1991	0858
Class of Operation :	MIL/RPT	
Location :	Sydney NSW	

Synopsis

In this occurrence, VH-CZC (B737) was operating on a scheduled domestic Regular Public Transport (RPT) flight from Sydney to Brisbane and MAC60193 (C141) was a United States Air Force military transport aircraft operating a flight sector from Richmond RAAF base to Christchurch, New Zealand. Both aircraft were climbing on crossing tracks when there was a breakdown of both required vertical and horizontal separation standards.

Investigation Summary

Although MAC60193 had flight planned to track via overhead Sydney, the Sydney Approach North (APP (N)) Controller provided radar vectoring for a more direct route passing north of Sydney to re-intercept the Christchurch track. There was some confusion on the flight deck of MAC60193 when instructed to proceed to an unexpected and unplanned waypoint. This took a short time to resolve. The direct track was intended to assist expedite the progress of MAC60193 through other traffic within the Sydney terminal area.

VH-CZC had departed from runway 25 and was being radar vectored by the Sydney Departures North (DEP (N)) controller to intercept the 002 Sydney VOR radial to West Maitland. When it became apparent that the flight paths would conflict, DEP (N) was assigned the task of maintaining specified separation standards between both aircraft. The minimum separation standard required was 1000 feet vertically, or 3 nautical miles laterally.

A climb restriction was applied to VH-CZC, limiting that aircraft to an altitude of 6000 feet. This restriction was applied in anticipation of MAC60193 reaching 7000 feet or higher before lateral spacing was less than 3 nautical miles. However, for a period of about three minutes, the military C141 failed to climb as rapidly as DEP (N) had anticipated. When DEP (N)'s attention returned to monitoring MAC60193 and VH-CZC, it was apparent that a traffic confliction could not be averted. The Sydney radar facilities do not provide for conflict detection.

Both crews were notified of the conflicting traffic and given heading changes. Visual contact was established and the aircraft passed clear of each other at less than the minimum required separation standard.

During the investigation, the DEP (N) controller stated that it was his first operational shift on that position with simultaneous runway operations in use on runways 25 and 34. He felt a level of anxiety in that situation and was somewhat apprehensive because of the limited airspace to the west of runway 25 for manoeuvring northbound departing aircraft. The DEP (N) controller described the workload as light, but the particular runway configuration caused a higher workload than other runway configurations.

B/911/3204	**Near Taroom**	**B767/EA32**
Aircraft Make :	**Model :**	**Registration :**
Boeing	B767	VH-OGE
Airbus Industrie	EA32	VH-HYJ

Date/Time (Local) : 27 July 1991 1515

Class of Operation : RPT/RPT

Location : Near Taroom QLD

Synopsis

VH-HYJ (EA32) was operating a RPT flight between Hamilton Island and Sydney. VH-OGE (B767) was operating an international RPT flight from Brisbane to Singapore. The aircraft flight paths crossed at approximately 200 nautical miles north-west of Brisbane with less than the required horizontal separation while at the same flight level.

Investigation Summary

After departing Hamilton Island, VH-HYJ was tracked via Mackay to Emerald and then air route W82 towards Roma at standard FL370. VH-OGE departed Brisbane and tracked via Taroom and air route A464 towards Longreach at FL370, a non standard level for that track.

The aircraft were being controlled by the Brisbane Sector 5 (SEC 5) Procedural Controller who was undergoing a routine proficiency check with a rated check controller. SEC 5 airspace covers the greater portion of southern Queensland and extends to 150 nm west of Mt Isa.

During the 30 minutes prior to the occurrence the SEC 5 controller had been engaged in co-ordination with other ATS units at Brisbane, Darwin, Townsville, Adelaide, Alice Springs, and Mt Isa. During that time, he had 12 RPT jet aircraft which required separation, co-ordination, and frequency change instructions. SEC 5 airspace has six discrete Very High Frequency (VHF) frequencies, which allows continuous VHF communication to be maintained within the sector. Frequency change points do not coincide with position reporting waypoints thus increasing controller workload, particularly when instructions have to be repeated, or communication with the aircraft is temporarily lost.

Each aircraft had a flight progress strip (FPS) for each position reporting waypoint. The controller estimated that he had approximately 60 FPSs on the procedural workstation which required constant surveillance and updating during the period. There were also some reported omissions in flight data preparation which occupied some time in resolving.

When it became apparent that there was a potential confliction between VH-OGE and VH-HYJ, SEC 5 offered VH-HYJ a climb to non standard level FL390 for separation, but this was unacceptable to the flight crew. SEC 5 then offered VH-

OGE standard FL390 for separation, but that crew was also unable to accept that level. SEC 5 considered that the only alternative was to descend VH-HYJ to non standard FL350. This could not be accomplished until VH-HYJ had reported sighting and passing another aircraft, a Boeing 737 (VH-TAW), on the reciprocal track at FL350. A time of passing was calculated, but VH-HYJ and VH-TAW did not sight and pass each other until two minutes later.

When the sighting and passing was reported, SEC 5 immediately instructed VH-HYJ to descend to non standard FL350. But it then became apparent that the vertical separation standard would not be achieved before VH-HYJ had entered the area of conflict with VH-OGE. The area of conflict is determined by reference to a separation diagram which shows distances from Taroom and Longreach on air route A464, and Emerald and Roma on air route W82. Within these distances (inside the area of conflict), aircraft must be vertically separated by 2000 feet. Regardless of workload and traffic density, conflict detection and resolution in the procedural environment is totally dependent upon controller performance.

The aircraft are estimated to have passed with approximately 30 nm horizontal separation whilst at the same flight level.

The separation breakdown appears to have resulted from the inability of the SEC 5 controller to adequately assess the traffic, and recognise the potential conflict early enough to take appropriate action. This was in part due to the extremely high workload at the time, and the number of additional peripheral tasks required of the controller during a period of high density traffic on crossing routes. The workload was such that the check controller had to assist SEC 5.

Action has already been taken by the Assistant General Manager Air Traffic Services to prevent a recurrence of this nature. Actions included a review of traffic to identify peak periods and a review of the roster to provide an additional controller to reduce workloads during these periods.

APPENDIX D

RECOMMEDATIONS MADE BY THE CIVIL AVIATION AUTHORITY S.T.A.R - PROJECT TEAM

1. That STARS be implemented wherever efficiencies in aircraft operations, traffic management, and ATC workload/coordination can be gained.

2. That the program for the initial implementation of STARS in Australia be as per the details in the CAA report.

3. That FAA Order 7100.9A form the basis of the CAA policy on STARS.

SIDS

4. That the requirement to include controlled airspace boundaries in SID design reviewed.

TRAFFIC MANAGEMENT

Flow Aspects

5. That the CAA examine our current flow system with a view to a distance based flow rather than the existing "time" based method

   : the controller is then doing the fine tuning
   : the US system is distance based heavily supported by computer prediction which capability we do not have as yet
   : STAC to be more involved.

6. That CAA investigate the US system of aerodrome traffic flows whereby the departures are on the crossing runway

   : impediment may be noise abatement requirements
   : the lack of aircraft speed data on some our radar displays
   : airspace constraints - this could effect the size of CTA/CTRS
   (Refer to Appendix C for draft proposal for Sydney)

Sectorisation within the Approach/Departure Function

7. That coincident with revised traffic flows, ATC revise the modis operandi within the terminal areas i.e. the airspace and functions of each Approach and Departures position

   : the concept of a single finals and two feeders/departures controllers may be feasible

PROCEDURES AND STANDARDS

8. That the CAA vigorously pursue the US standard for multipath effects with localiser and glide slope

9. That the CAA pursue a reduction in the terminal area radar separation standards where the current standard is restricted by the rate of scan

   : rate of scan is not a factor in the US
   : this would effect Brisbane, Canberra, Adelaide, Perth and possibly Darwin and Townsville.

10. That the CAA dispense with the Australian restriction on multiple line up on single and/or crossing runways

    : US have no such restriction and a many as three aircraft in the lined up position were observed

11. That the CAA reiterate to industry the advantages of a ground delay programme

12. That the CAA pursue "charted visual approaches" especially for visually flown noise abatement paths (copy of US Order covering these approaches is at Appendix D)

13. That "anticipation" for issuing take-off clearances be permitted.

14. That "auto-release" procedures be develop for departures at major airports.

15. That the Australian priorities system be reviewed so that where possible priority is given on first come basis.

16. That in revising traffic flows, priority be given to minimising controller coordination.

PUBLICATIONS

17. That we investigate the US digest system for advanced notification to industry and publication centres such as Jeppersen.

18. That helicopter routes be developed and published on visual charts.

19. Change the "red arrow" system on charts to a system which indicates the approve direction of flight.

CONTROL TOWER OPERATIONS

20. That control positions be operated on headset.

21. That for future control towers, preference be given to peripheral consoles.

22. Airways Clearance Delivery being operated from the tower.

EQUIPMENT

23. That the CAA monitor developments of the FAA Converging Runway Display Aid (CRDA)

24. That the CAA acquire the Parallel Runway Monitor (PRM) or similar device to maximise throughout on the parallel runways to Sydney.

APPENDIX E

SPECIFIC RECOMMENDATIONS

B911/3197

It is therefore recommended that the CAA:

1. review national airway route structures to identify other similar airways which do not have a published waypoint at airspace boundaries,

2. allocate waypoint names to all such airways, and in the interim

3. include airway identification and readback of that airway during coordination exchanges.

CAA Response

As indicated in your report there was in fact no breakdown in separation, rather, the incident could be more accurately be described as a breakdown in coordination procedures, and your recommendations have focused on this.

I would however like to take this opportunity to address the recommendations stemming from your report:

1) The desirability of having a waypoint at airspace boundaries is acknowledged and where practical has been or will be implemented.

2) It is not possible to assign a waypoint for each and every location where an ATS route crosses an airspace boundary.

For example, on routes near airports where aircraft leave and enter CTA through the control area steps, the multitude of waypoints would be impractical from an ATC perspective, impossible to chart, overload FMC data bases, and difficult to name (ICAO 5 letter designators would not be available) etc.

3) The application of existing Manual of Air Traffic Services co-ordination requirements is considered sufficient.

Your report indicates that the coordination from SEC2 to ARR was incomplete as it only provided an "estimate" for the boundary position of 160 NM.

Had the correct Manual of Air Traffic Procedures coordination procedure been followed, ie position /level/ and estimate, the fact that VH-TAH was on route T31 would have been self evident.

REFERENCES

REASON J.T. (1990) - "Human Error" Cambridge University Press

REASON J.T. (1991) - "Identifying the Latent Causes of Aircraft Accidents Before and After the Event" THE 22nd INTERNATIONAL SOCIETY OF AIR SAFETY INVESTIGATORS CONFERENCE November 4-7 1991, Canberra Australia

WAGENAAR, W.A., HUDSON P.T.W. and REASON J.T. (1990) - "Cognitive Failures and Accidents" APPLIED COGNITIVE PSYCHOLOGY Volume 4 p. 273-294