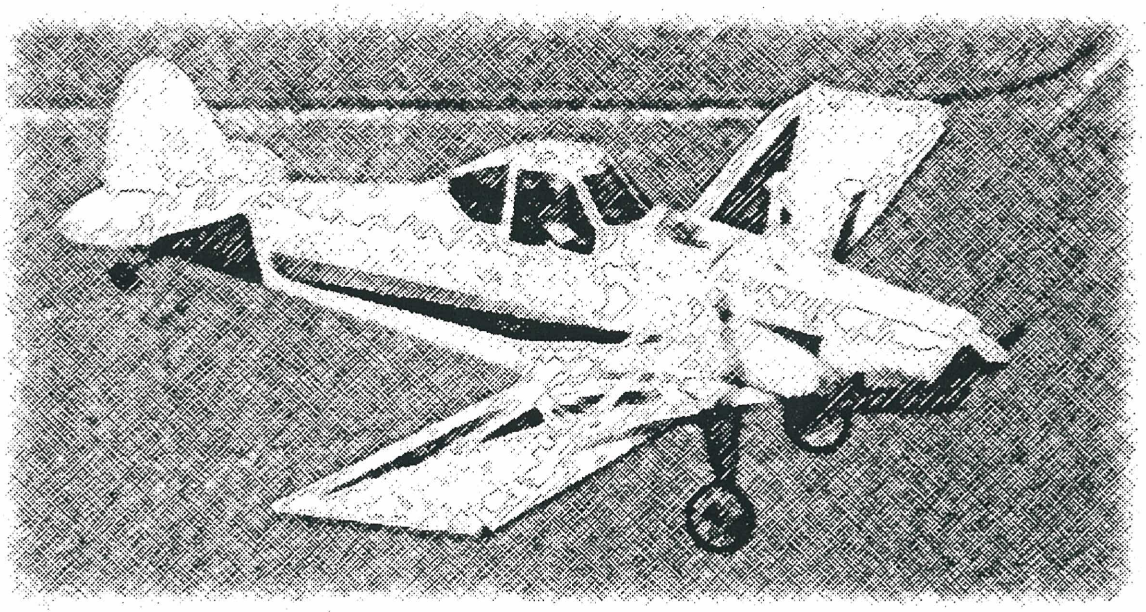
BASI
Bureau of Air Safety Investigation

Air Safety Report

SURVEY OF AUSTRALIAN AGRICULTURAL AVIATION ACCIDENTS & INCIDENTS 1986–1995



INFORMATION PAPER

COMMONWEALTH DEPARTMENT OF
TRANSPORT AND REGIONAL
DEVELOPMENT

Department of Transport and Regional Development

Bureau of Air Safety Investigation

SAB/IP/97/01

Survey of Australian Agricultural Aviation Accidents & Incidents 1986–1995

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CONTENTS

DEFINITIONS

Agricultural operations	Pest and disease control, fertilising, crop seeding, poison baiting and similar operations, excluding aerial spotting of livestock.
AFM	Aircraft Flight Manual.
n	Number of occurrences within a classification.
OASIS	Occurrence analysis and safety information system.
SD	Standard deviation. The standard deviation is a statistical value which provides a measure of the scatter/variance of the raw data.
Work phase	The work phase of the flight is defined as being that portion of the flight where agricultural operations such as crop spraying takes place.
GA	General aviation. All flying by civil aircraft other than airline operations, gliding and sport aviation.
Marker	Distinctive aid placed on a surface location.
Situational awareness	The ability of a pilot to keep abreast of what is happening in their work environment.

EXECUTIVE SUMMARY

In 1995 the Bureau published a survey of agricultural aviation accidents 1985–1992, which has now been updated by including accident and incident data for the period 1993–1995.

The data shows that agricultural aviation accidents accounted for 12% of all Australian aviation accidents during the 10-year period 1986–1995 and that the accident rate continues to be higher than that for other sectors of general aviation.

The majority of accidents occur in the agricultural work phase, whereas with other types of commercial operations most accidents occur in the take-off and landing phases. The largest group of accidents are associated with contacting powerlines or overhead communication lines (commonly called wirestrikes) and are attributed to the pilot either not seeing the powerline, or momentarily forgetting the position of the powerline. These factors are categorised as failures in the pilots' 'perception of their working environment'. The second largest category of accidents was where the investigator assessed that the pilot exercised poor decision making ('incorrect operational decisions').

The number of agricultural aviation incidents reported to the Bureau was relatively small. However, those that were reported involved factors very similar to those associated with the agricultural accidents. There is a need for greater reporting of incidents as a means of increasing safety awareness and improving accident prevention.

1. INTRODUCTION

In July 1995 the Bureau of Air Safety Investigation published a *Survey of Australian Agricultural Aviation Accidents 1985–1992* (SAB/IP/95/03). The survey examined the number of accidents, and the accident rate, for aircraft involved in crop dusting, crop spraying and other agricultural aviation activities in Australia. It also analysed the factors associated with those accidents.

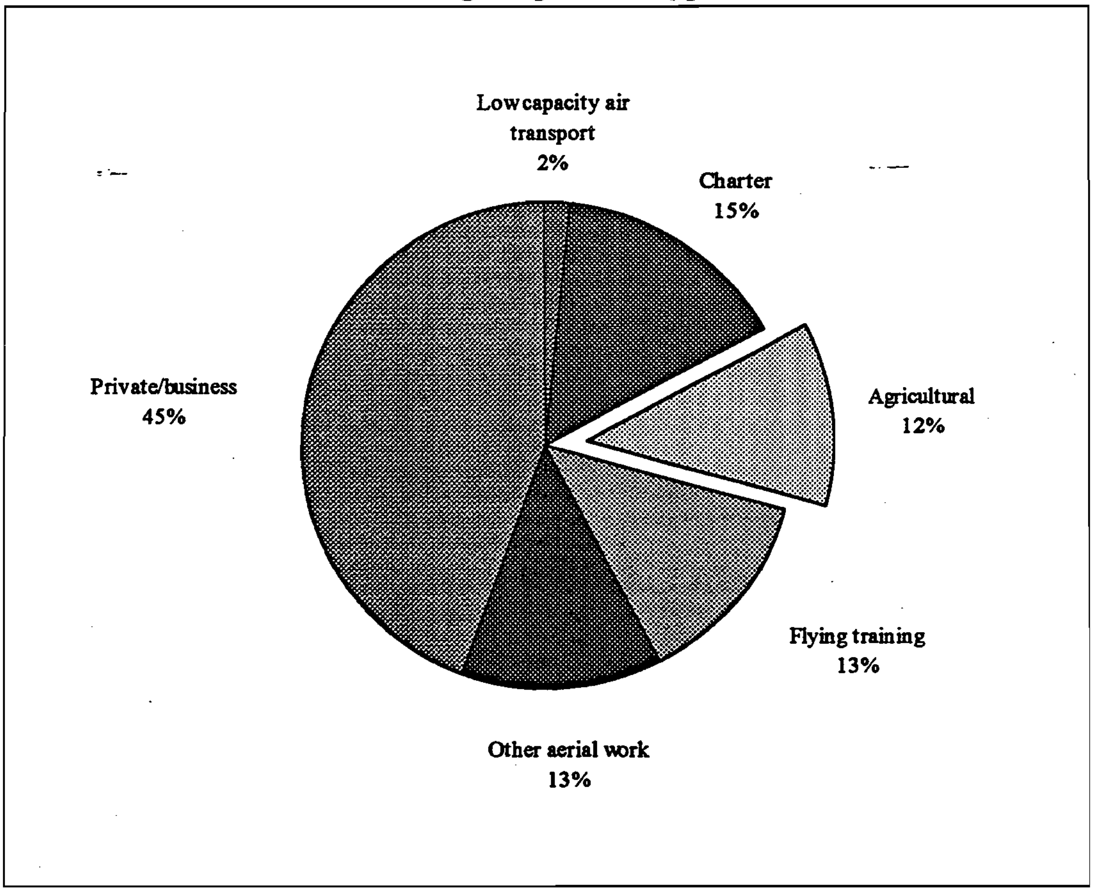
Accidents involving agricultural aircraft have continued to occur at a similar rate to that of the previous survey. The Bureau has therefore updated the previous survey by including the data for the three years 1993–1995, examining the accident trends for the 10-year period 1986–1995, and analysing the factors attributed to the latest accidents.

2. ACCIDENT NUMBERS AND RATES

2.1 Survey by type of operation

Between 1986 and 1995, there were 300 reported agricultural aviation accidents in Australia, involving 302 aircraft. This figure accounts for 12% of all Australian civil aircraft accidents over that period (see figure 1).

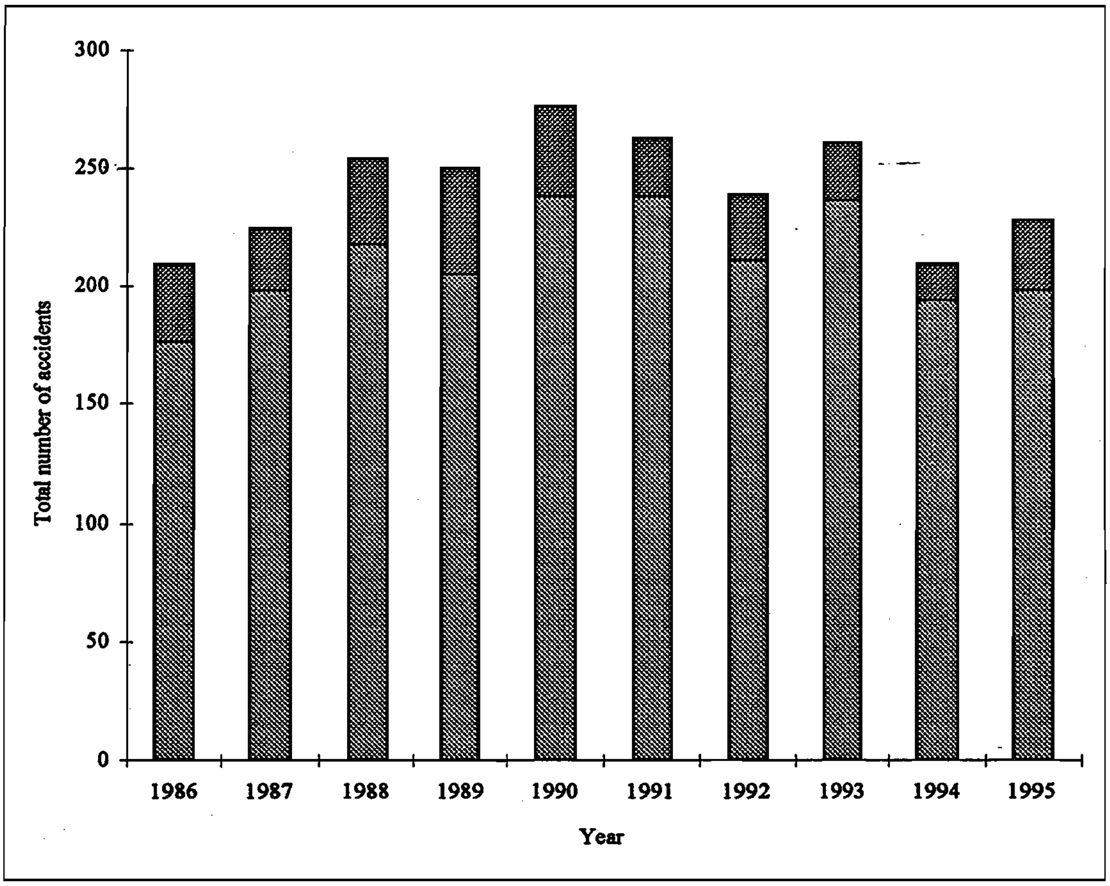
FIGURE 1 **Accidents according to operation type 1986–1995**



2.2 Comparison of total accidents involving non-agricultural and agricultural aircraft

Figure 2 compares the number of aircraft accidents in Australia on a year-by-year basis. Reported agricultural aviation accidents are indicated by a darker shading. The mean number of agricultural accidents per year was 30.0 (SD = 8.2). The standard deviation of 8.2 indicates that there was considerable variation in the number of agricultural accidents over the 10-year period 1986–1995, with a minimum of 16 in 1994 and a maximum of 45 in 1989.

FIGURE 2 **Accidents to civil aircraft 1986–1995**



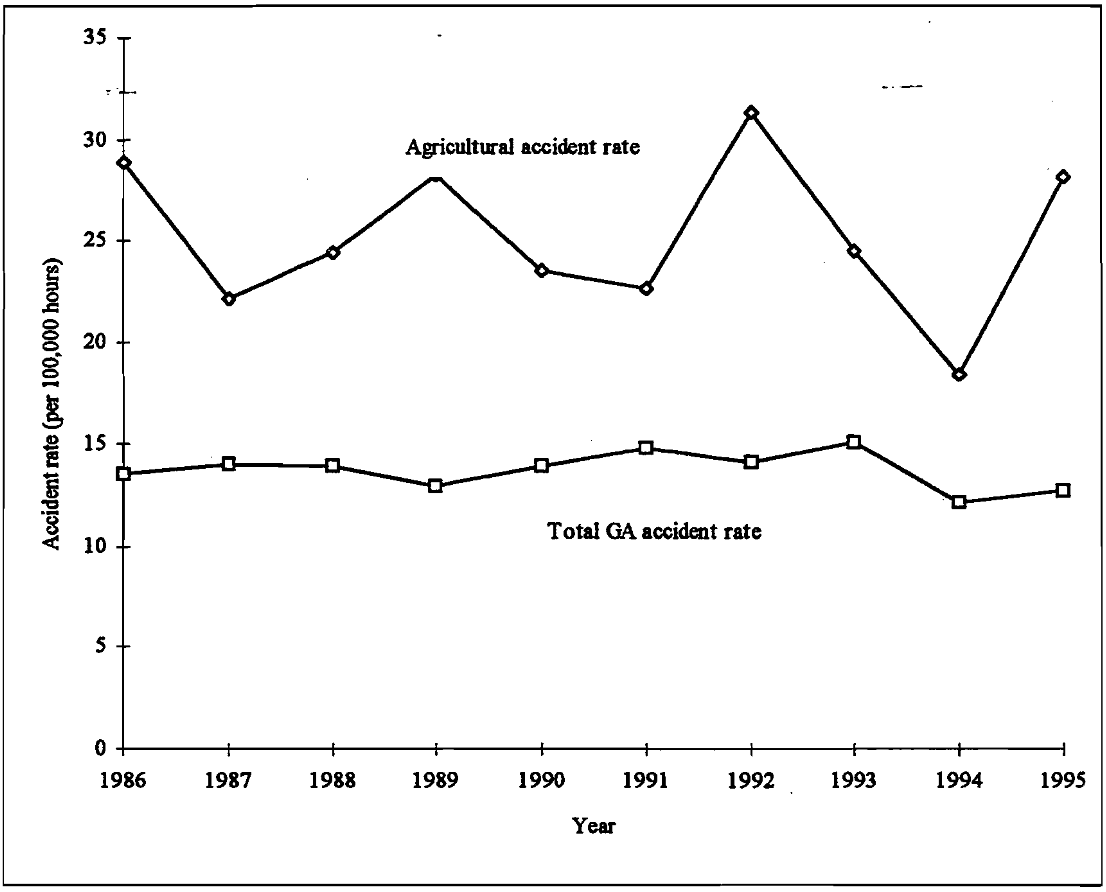
Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Agricultural accidents	33	26	36	45	38	25	28	24	16	29
Other accidents	177	199	218	205	238	238	211	237	194	199

The number of accidents in any year is often directly related to the amount of flying activity in that year. Agricultural aviation has been subjected to significant variations in activity during the 10-year period 1986–1995. Therefore it is more meaningful to examine the rate of accidents.

2.3 Accidents per 100,000 hours flown

When the number of accidents per 100,000 hours flown is considered (accident rate), agricultural aviation has a higher accident rate than that of the total Australian general aviation category (see figure 3). The accident rate for Australia air transport operations is not shown but is very small compared to that of agricultural aviation. The agricultural aviation accident rate has fluctuated between approximately 18 accidents per 100,000 hours and 30 accidents per 100,000 hours over the 10-year period 1986–1995. There has been no discernible sustained reduction in the accident rate, which has remained approximately double that of the total GA accident rate throughout the 10-year period.

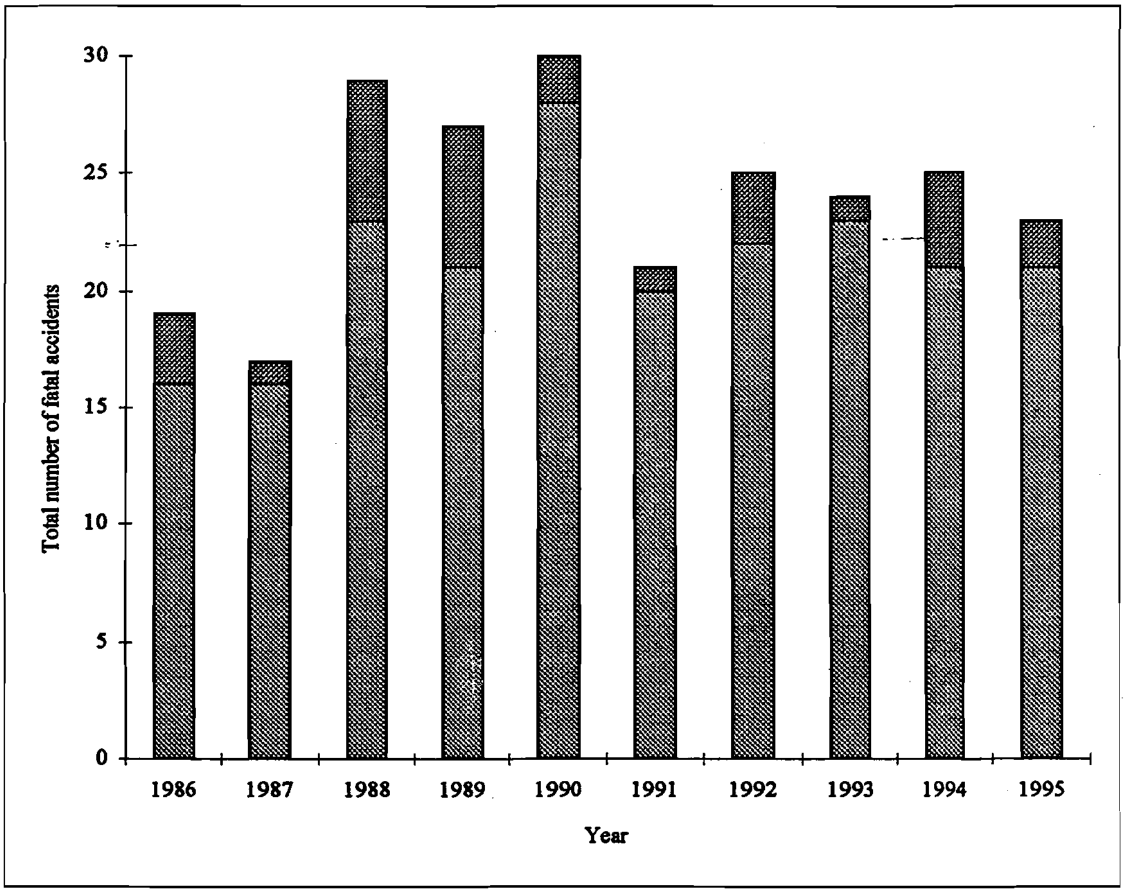
FIGURE 3 **Accidents per 100,000 hours flown 1986–1995**



2.4 Comparison of agricultural aviation fatal accidents and other GA fatal accidents

Figure 4 illustrates the number of fatal accidents for all GA categories, with those relating to agricultural aviation indicated by darker shading. The number of fatal accidents fluctuates from one in each of the years 1987, 1991 and 1993, to six in both 1988 and 1989.

FIGURE 4 **Fatal accidents 1986–1995**

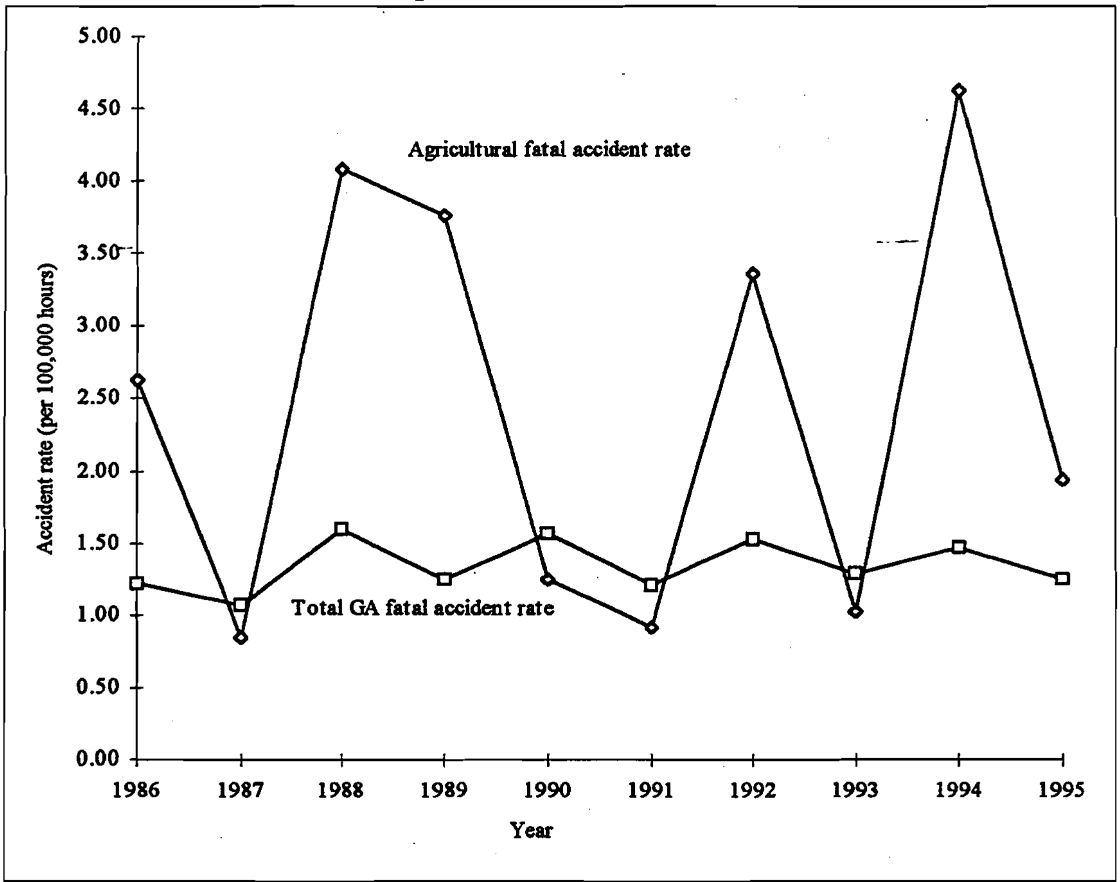


Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Fatal agricultural accidents	3	1	6	6	2	1	3	1	4	2
Other GA fatal accidents	16	16	23	21	28	20	22	23	21	21

2.5 Fatal accidents per 100,000 hours flown

When fatal accident rates are considered, the statistics indicate a marked variability in the agricultural aviation rate (see figure 5). The variability may reflect the variation in hours flown and the small number of accidents. The data presented suggests that in the 10-year period under consideration there has not been any significant decrease in the fatal accident rate.

FIGURE 5 **Fatal accidents per 100,000 hours flown 1986–1995**



Occurrence summaries for fatal agricultural accidents 1993–1995

- *Occurrence 9300533*. During a cotton spraying operation the aircraft collided with a marker as the aircraft was passing under powerlines.
- *Occurrence 9401443*. An agricultural aircraft struck a major powerline adjacent to the paddock the pilot was spraying. One wing was apparently caught by the powerline and the aircraft rolled into the ground.
- *Occurrence 9403653*. The aircraft was found crashed through trees about 100 metres short of the threshold and about 35 metres left of centreline of an agricultural strip.
- *Occurrence 9403799*. The helicopter was reported to have impacted a powerline and crashed while on spraying operations.

- *Occurrence 9403835*. About 10 minutes after the aircraft had taken off, the loader observed a fire on the side of a hill. Investigation revealed the burnt wreckage of the aircraft.

- *Occurrence 9500066*. The helicopter was conducting spraying operations of a potato crop when it hit powerlines while manoeuvring between spray runs. After the impact the main rotor severed the tail boom and the helicopter crashed and caught fire.

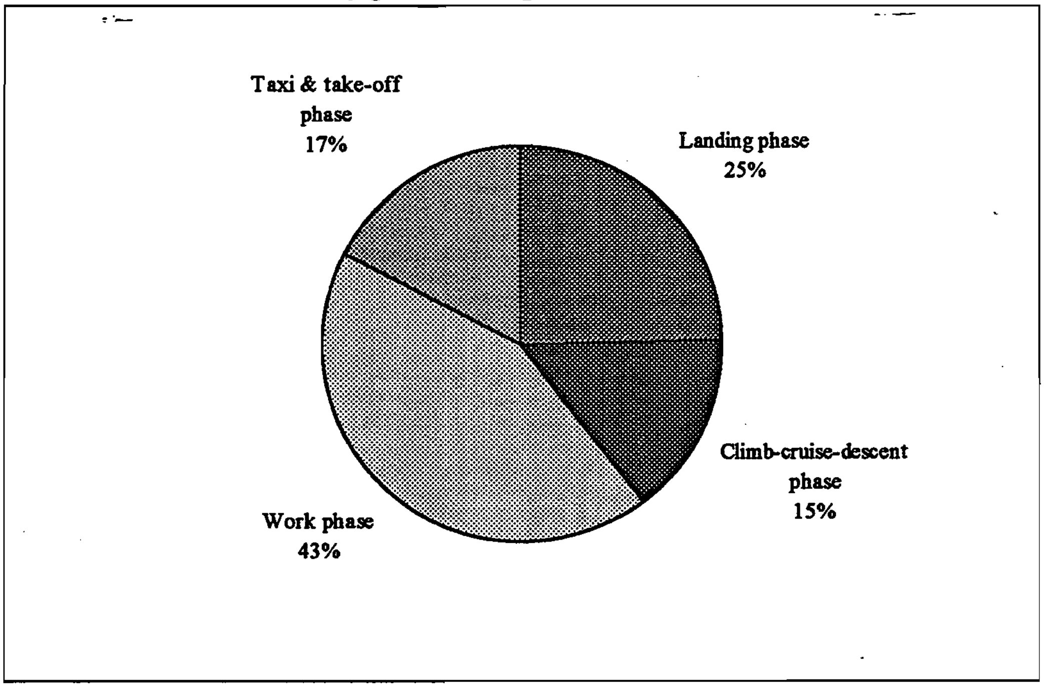
- *Occurrence 9503986*. The aircraft was involved in crop spraying activities when it struck powerlines and crashed into a canefield.

3. ACCIDENT CHARACTERISTICS

3.1 Accidents by phase of flight

In the period 1986–1995, 43% of agricultural aviation accidents occurred in the work phase of the flight (see figure 6), with a further 25% occurring in the landing phase. This distribution of agricultural accidents by phase of flight is interesting to compare with that for other operations. In other commercial operations the majority of accidents occur in the take-off and landing phases. However, due to the nature of agricultural operations, it is not surprising that a significant percentage occur in the work phase.

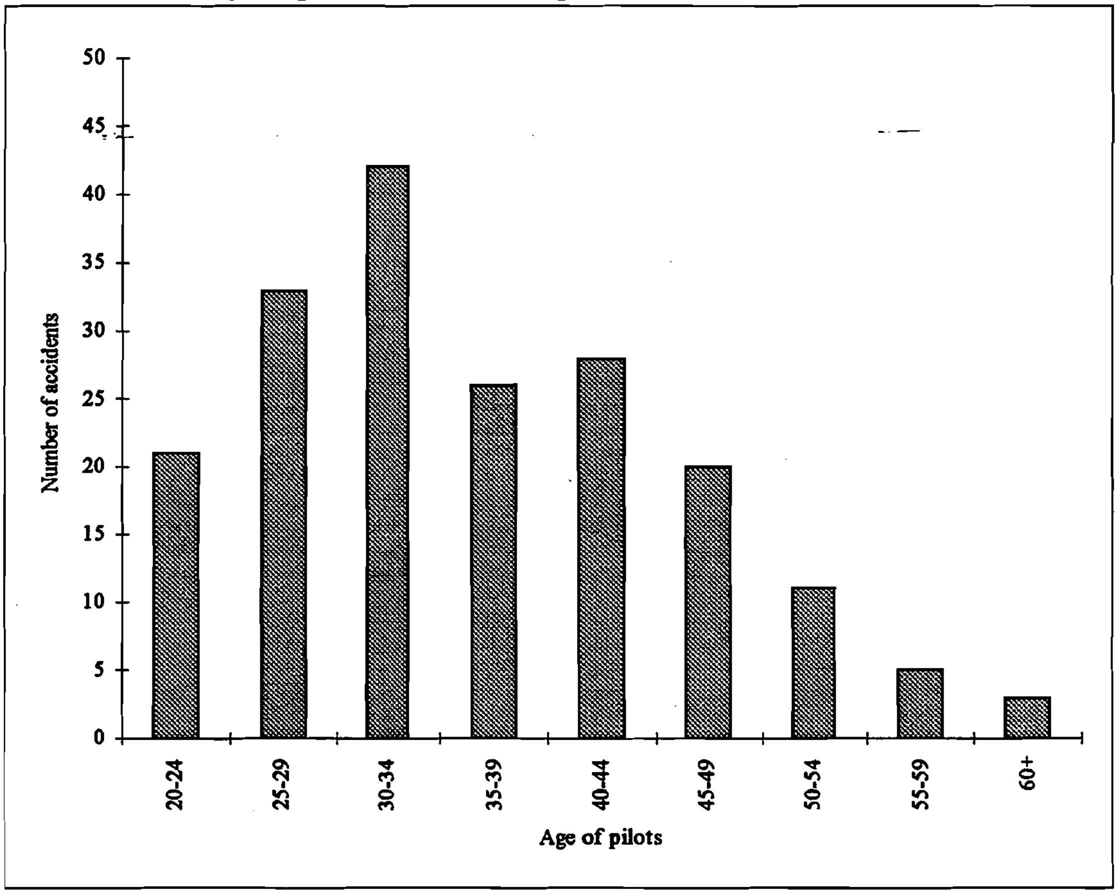
FIGURE 6 **Accident by phase of flight 1986–1995**



3.2 Age of pilots

An analysis of accident numbers according to the age of the pilots involved in agricultural accidents is shown in figure 7. Pilots in the age group of 30–34 were involved in 42 of the 188 accidents where the age of the pilot was recorded. However, the distribution reflects the overall pilot population age distribution, since most pilots are 30–34 years old. The distribution in figure 7 indicates that the age of the pilot was not a significant factor in the agricultural aviation accidents.

FIGURE 7 **Age of pilots involved in agricultural accidents 1986–1995**



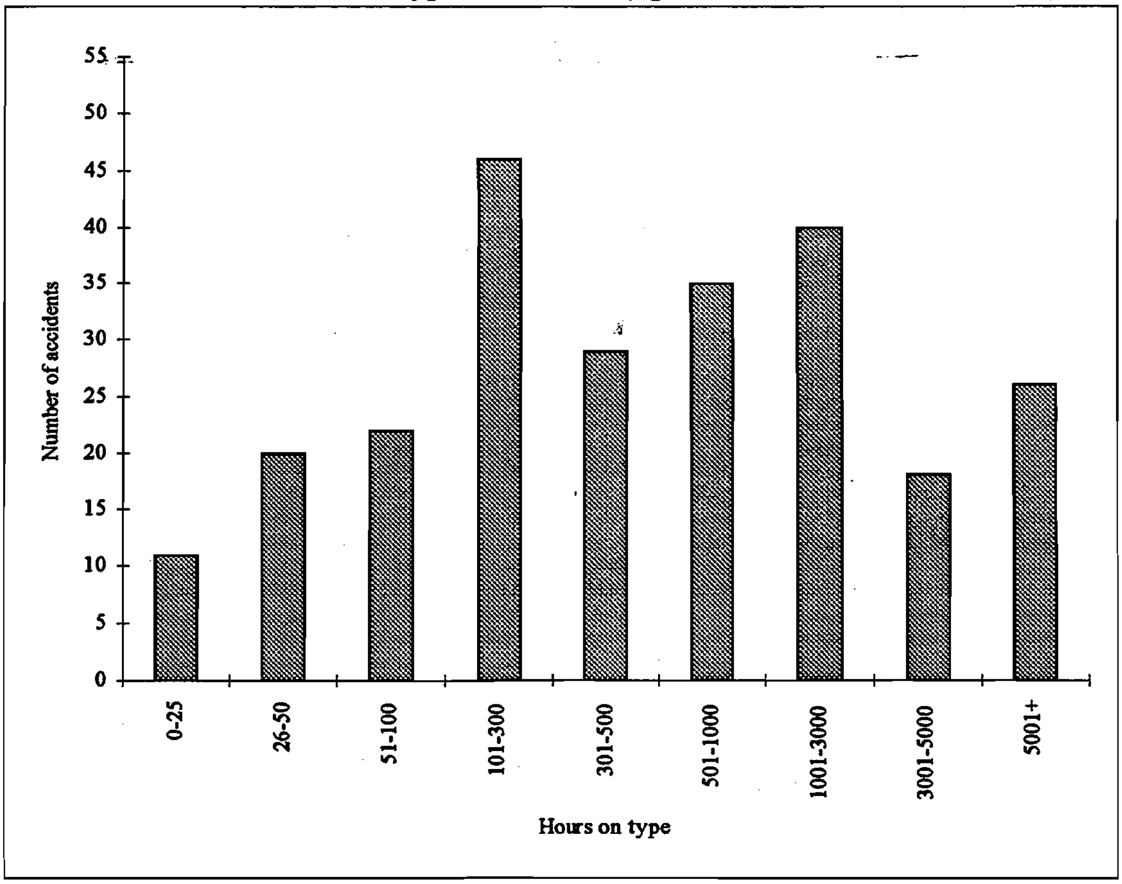
Note: In 112 cases the age of the pilot was not recorded.

3.3 Pilot hours on type

The agricultural accidents have been analysed to determine if the experience levels of the pilots were directly related to the frequency of accidents.

Figure 8 compares pilot hours on the aircraft type with accident numbers. Pilots with flying experience on the type of 101–300 hours and 1,001–3,000 hours were involved in the highest number of accidents. Information is not available in relation to the experience levels of all pilots employed on agricultural operations and it is therefore impossible to determine whether any one group is over-represented in the statistics.

FIGURE 8 **Pilot hours on type 1986–1995 (agricultural aviation accidents)**



Note: In 55 agricultural aviation occurrences the number of hours of the pilot on type was not established.

4. FACTORS ASSOCIATED WITH ACCIDENTS

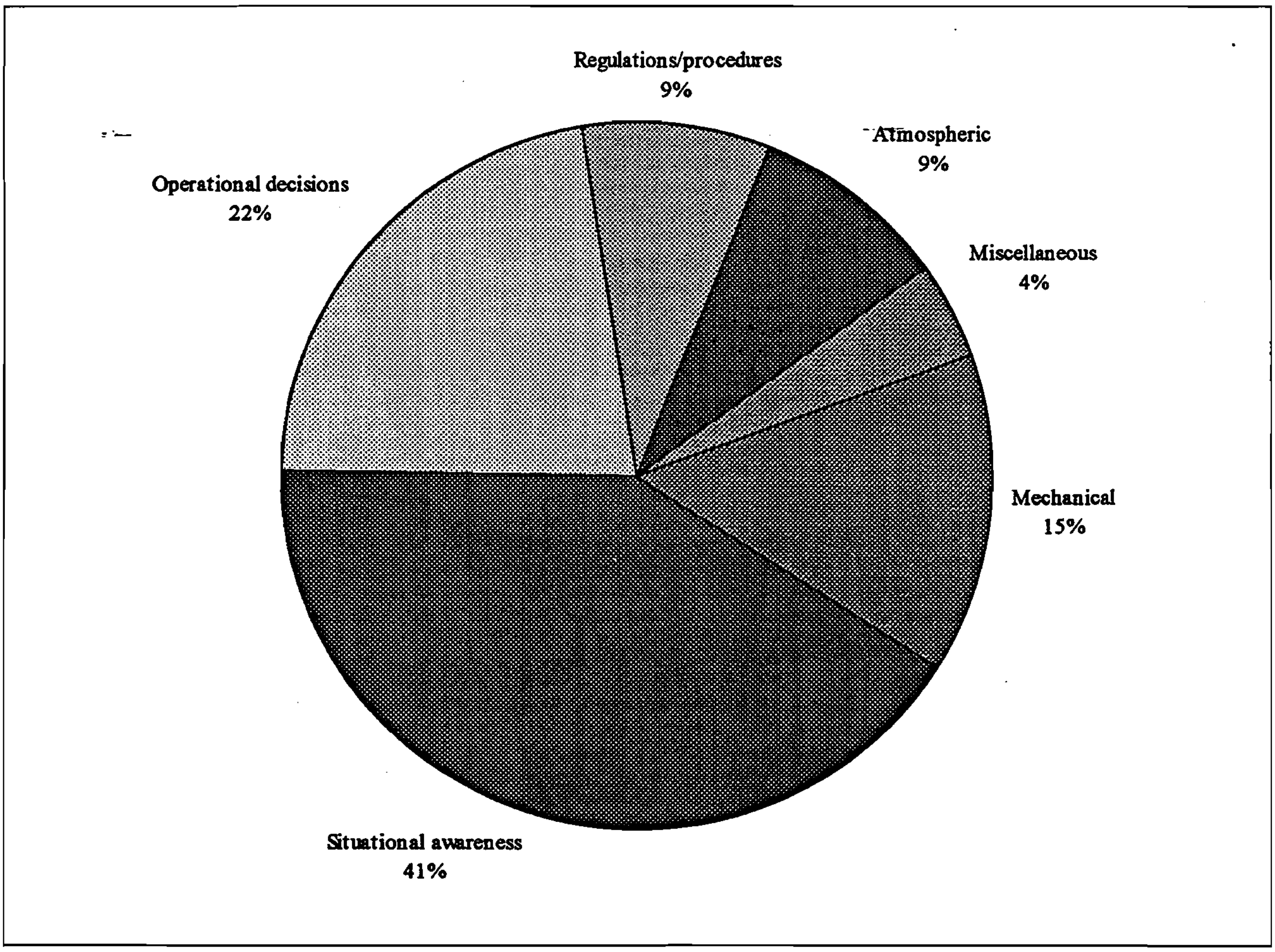
4.1 Introduction

The Bureau maintains a record of all the Australian registered aircraft accidents in the OASIS database. Each accident record has one or more factors assigned by the investigator. The factors allow similar accidents or groups of accidents to be analysed and systemic issues to be examined. The factors cover all the operational and mechanical aspects which might be associated with an accident, and can be classified under broad headings such as operational decisions, situational awareness, regulations or mechanical problems. The factors associated with agricultural aviation accidents for the period 1993–1995 have been examined. Only some of the factors can be compared directly with those of the previous survey because of a change in the way the Bureau assessed and recorded accidents after 1992.

4.2 Categorisation of factors

Forty-one per cent (n = 28) of the reported agricultural accidents in 1993–1995 were attributed to failure in the pilot's situational awareness (see figure 9), for example, failing to see an obstacle. A further 22% (n = 15) of the accidents were associated with incorrect operational decisions. Mechanical problems were involved in 15% of the accidents while atmospheric and regulations factors were each associated with 9% of the accidents. Subsections 4.3–4.6 address the factor categories presented in figure 9.

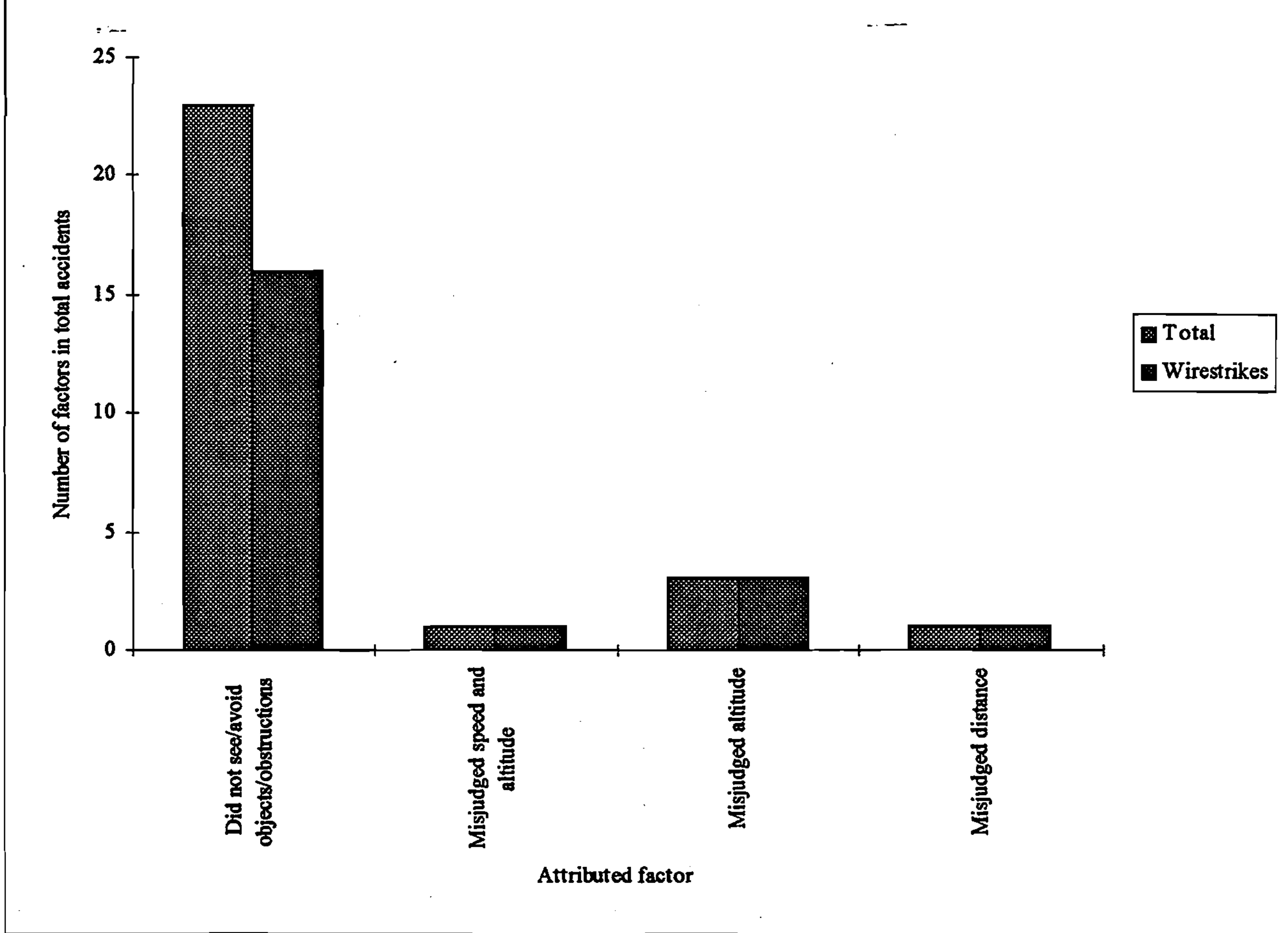
FIGURE 9 **Factors associated with accidents 1993–1995**



4.3 Situational awareness

There were 28 agricultural aviation accidents in the three years 1993–1995 where situational awareness was the primary factor. Twenty-three accidents were attributed to the pilot's failure to see and avoid objects or obstructions (see figure 10) which was the most frequently cited factor in agricultural aviation accidents in this period. Twenty-one accidents in the situational awareness group involved striking powerlines or other overhead cables.

FIGURE 10 **Situational awareness factors 1993–1995**

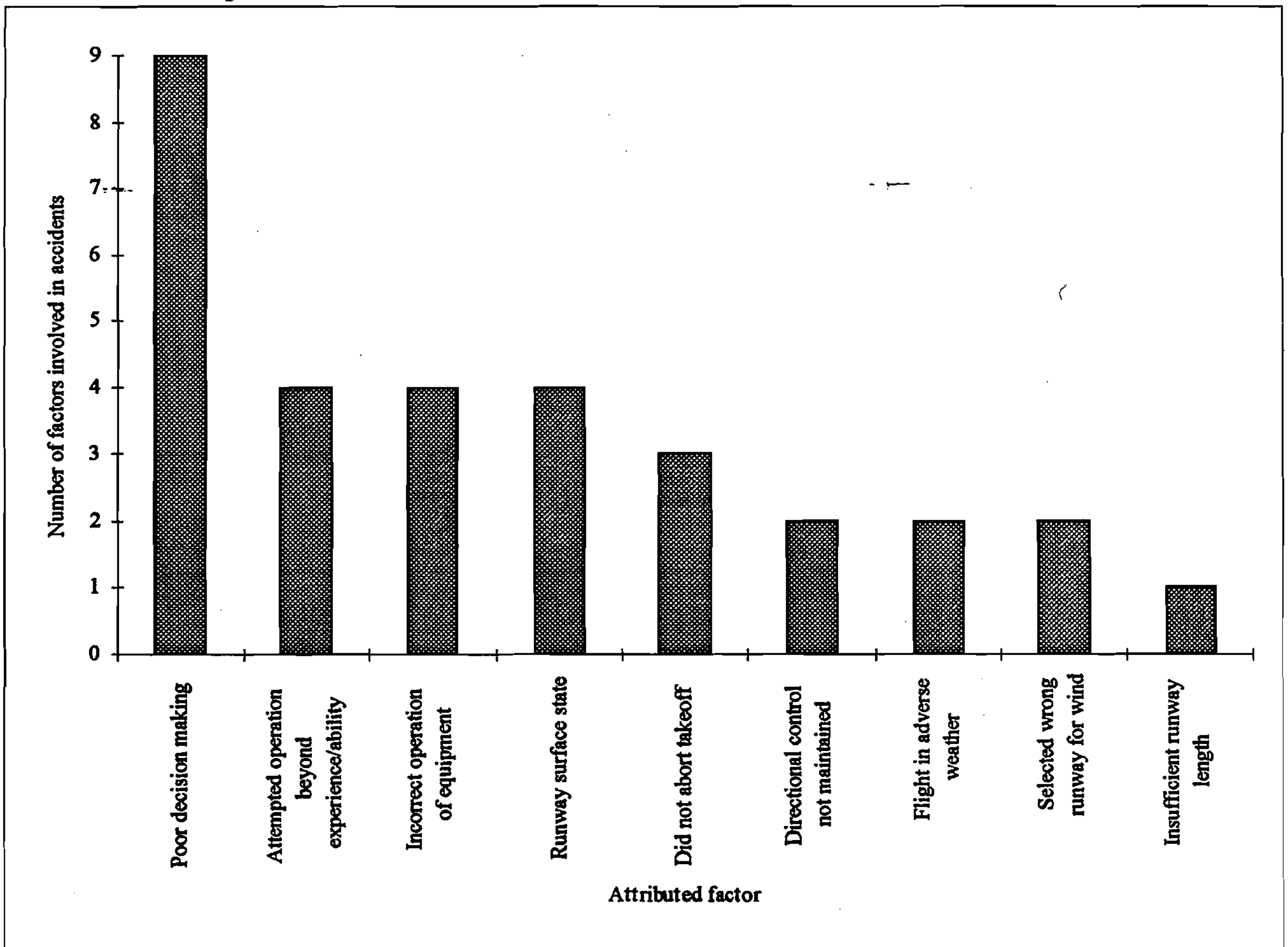


Example. The pilot had completed an inspection of the treatment area before commencing spraying operations. During the operation, the aircraft struck an undetected spurline and crashed.

4.4 Operational decisions

Figure 11 indicates the number of agricultural occurrences in which incorrect operational decisions were attributed to the accident. The most frequent accidents in this category were occasions when poor decisions were made by the pilot in command (n = 9).

FIGURE 11 **Operational decisions 1993–1995**

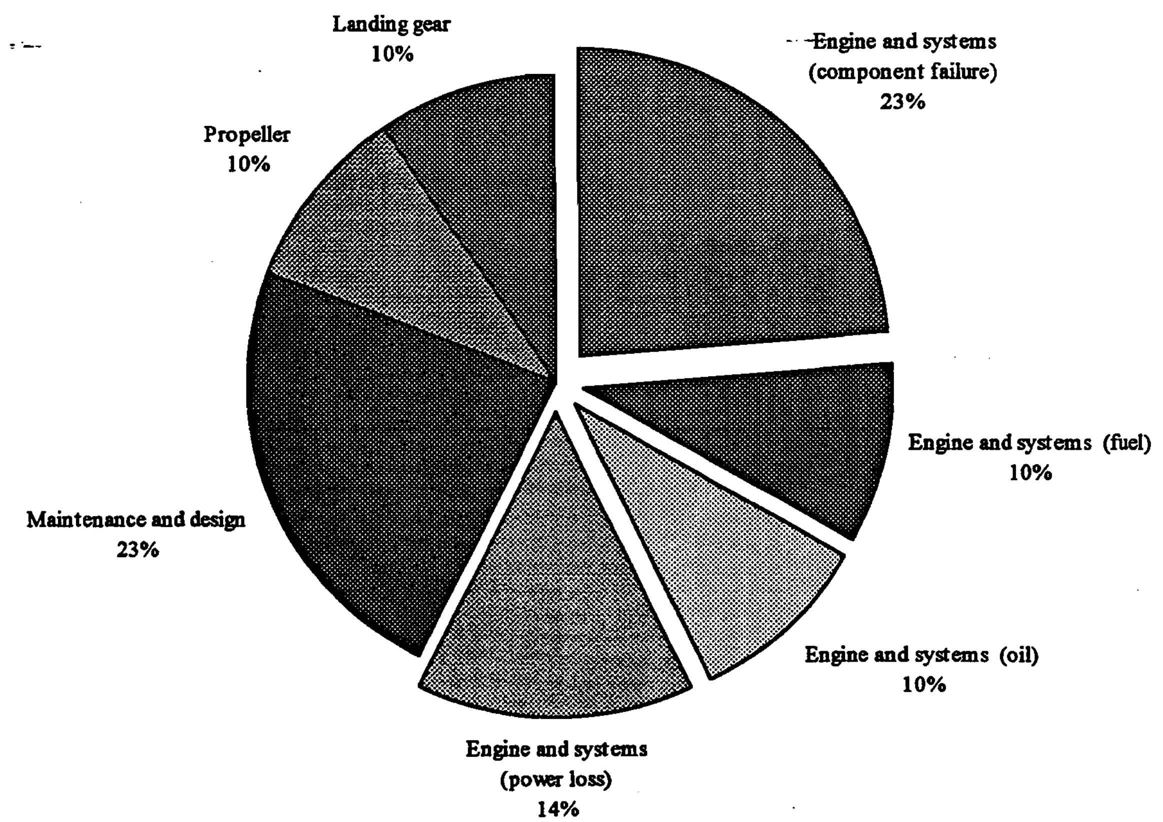


Example. The aircraft was conducting rice sowing operations from an agricultural strip. During the 26th takeoff, the pilot reported that the acceleration of the aircraft was reduced by a soft area on the strip. He said he began to dump the load and managed to get the aircraft off the ground. However, the right wing struck a fence post, causing damage to the undersurface. The aircraft was then flown to a safe landing.

4.5 Mechanical problems

Figure 12 shows the distribution in factors that were attributed to mechanical problems in agricultural accidents. Problems with the engine or the engine systems of the aircraft were associated with 12 accidents. This was 17% of the total accidents in the three-year period and suggests that although engine operating conditions are relatively harsh in agricultural aviation, the engine and systems are not the main area of concern.

FIGURE 12 **Mechanical problems 1993–1995**

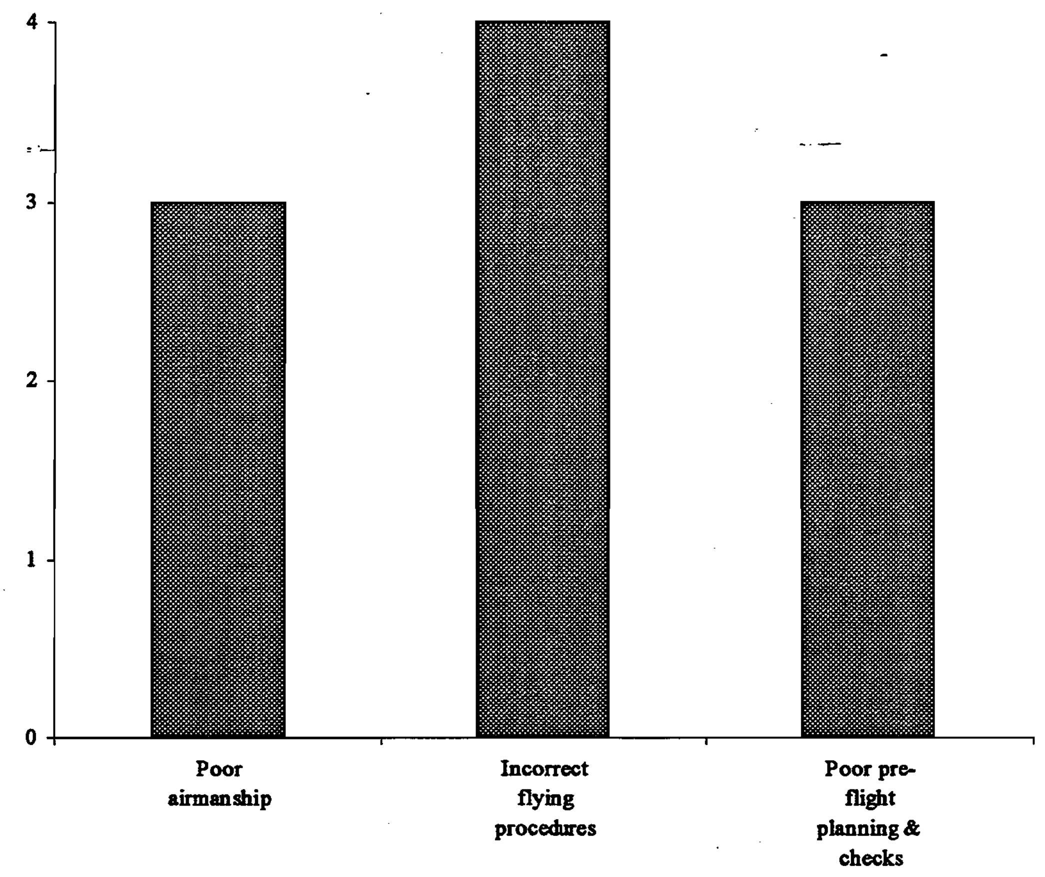


Example. At the completion of a crop spraying operation, the pilot noticed oil on the windscreen and smoke coming from under the cowling. He was crossing over a wheat field en route to a private airstrip when the propeller separated from the engine. As a result, the aircraft was landed on the wheat field but overturned due to the soft surface.

4.6 Regulations/procedures

Agricultural aviation accidents involving a breach of regulations or incorrect procedures were relatively infrequent in the three years 1993–1995. There were 10 accidents in this category and the factors in these accidents were divided into poor pre-flight planning, poor airmanship, or incorrect flying procedures. The distribution of these factors in shown in figure 13.

FIGURE 13 **Regulations/procedures 1993–1995**

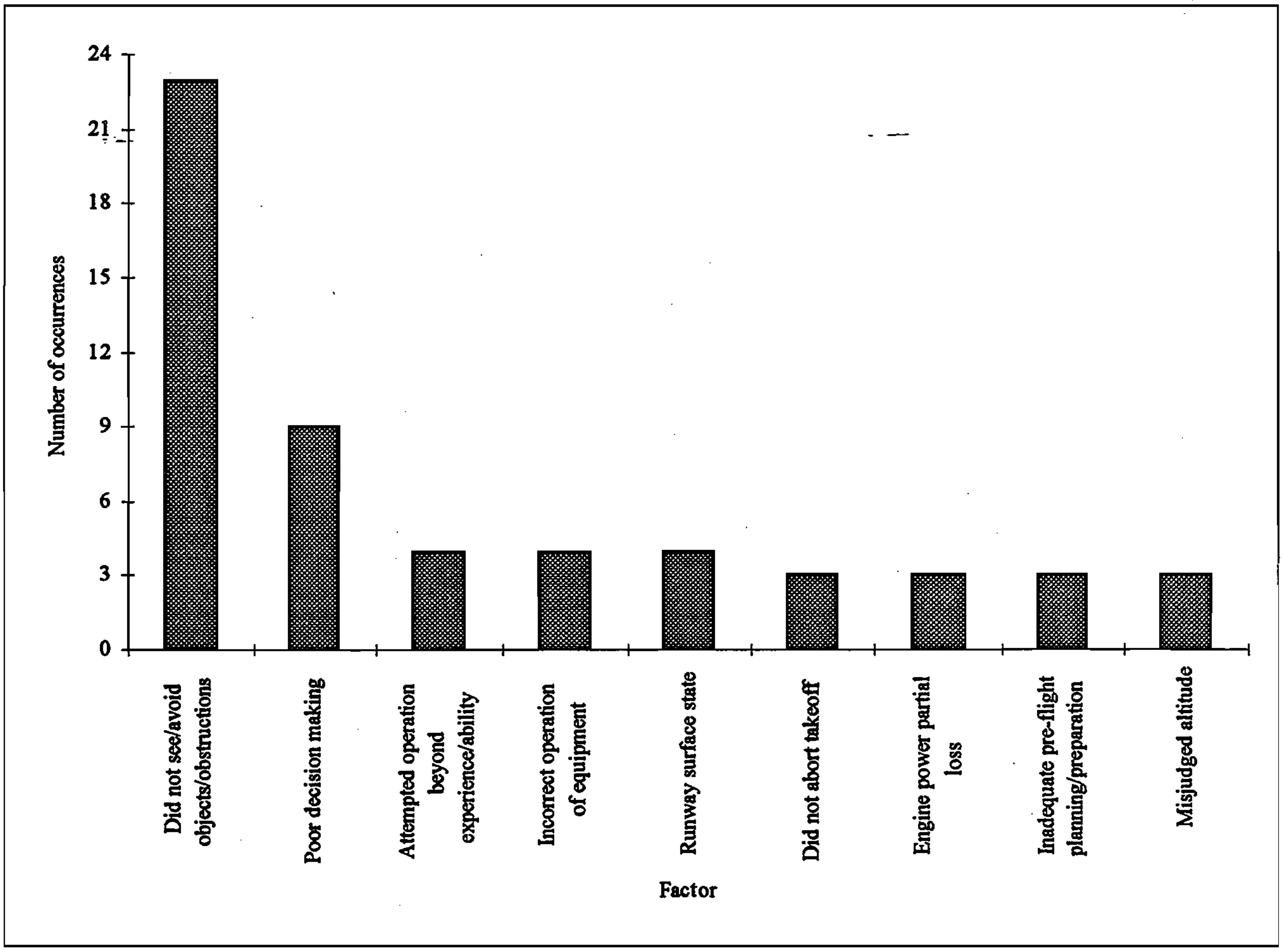


Example. Returning from a crop spraying operation, the pilot saw a lake and decided to fly low over it. Whilst flying at low altitude over the lake, the undercarriage struck the water. The aircraft came to rest inverted in the lake.

4.7 Factors associated with three or more accidents

Figure 14 presents the factors most commonly attributed to agricultural aviation accidents in the period 1993–1995. The trend from previous years has continued into this period, with the most frequently attributed factor being the failure to see and avoid objects or obstructions (n = 23). Accidents were also commonly attributed to poor decision making (n = 9). Three other areas of concern are pilots attempting operations beyond their ability, pilots using aircraft equipment incorrectly, and bad runway surfaces (all n = 4).

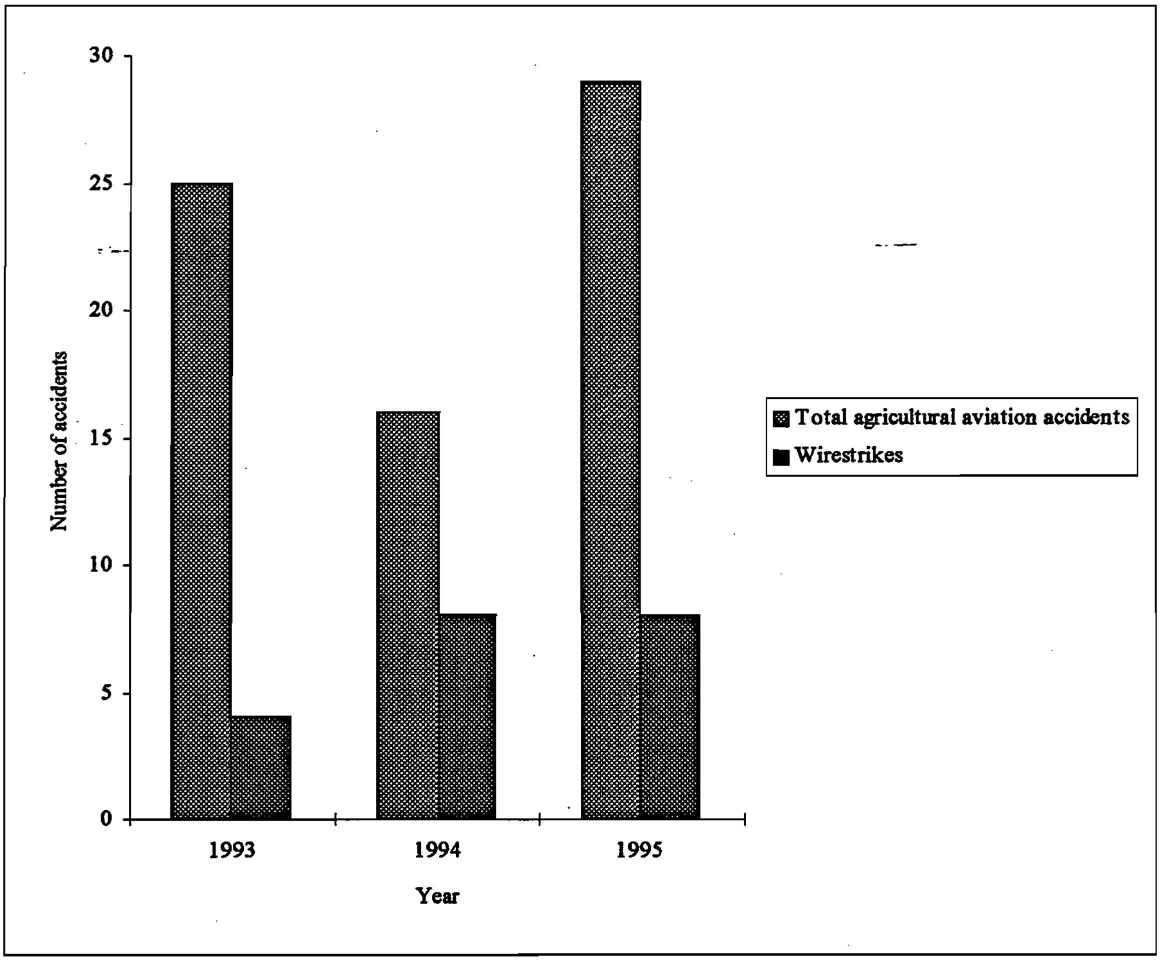
FIGURE 14 **Factors with three or more listings 1993–1995**



4.8 Wirestrikes

When the events associated with agricultural aviation accidents are analysed, accidents involving wirestrikes were predominant. In the three-year period 1993–1995, 29% (n = 20) of agricultural accidents involved contact with overhead powerlines or cables.

FIGURE 15 **Wirestrike accidents 1993–1995**



5. FACTORS ASSOCIATED WITH INCIDENTS

5.1 Introduction

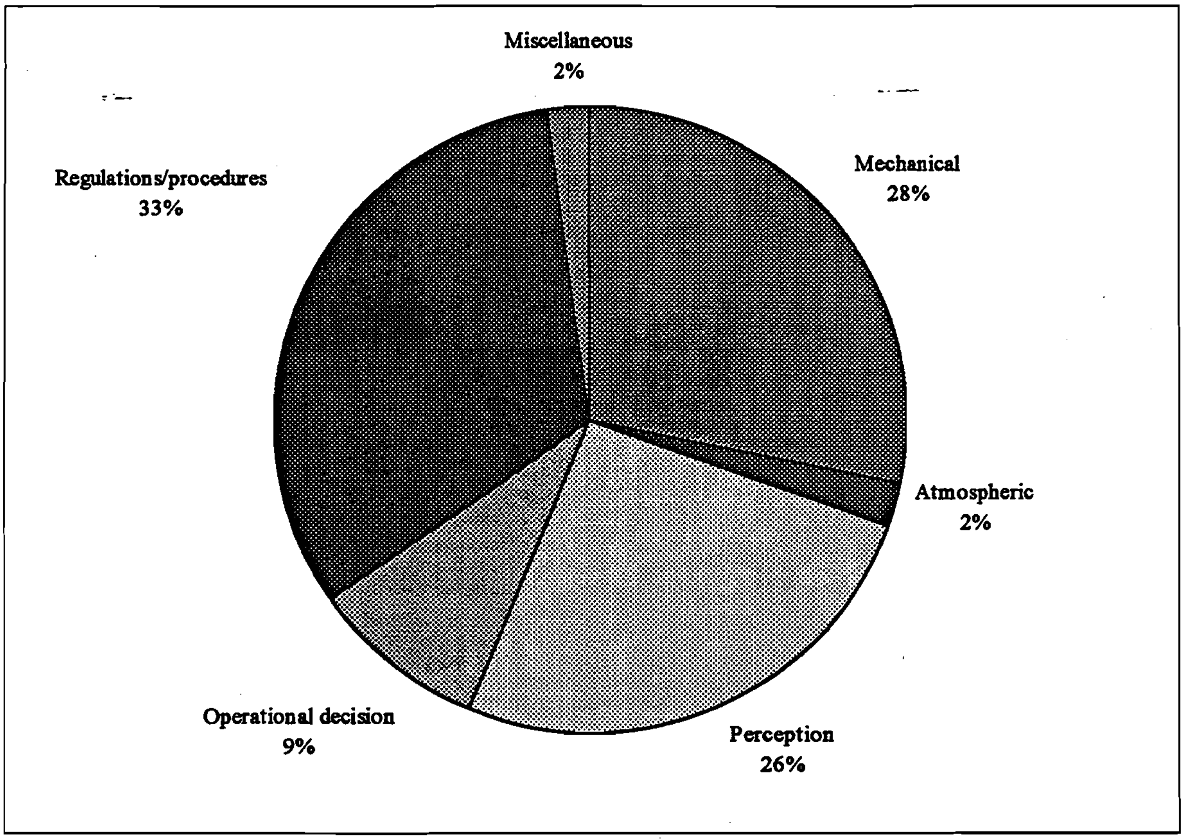
It is perhaps surprising that for the period 1993–1995 there were 70 agricultural aviation accidents, while there were only 47 reported agricultural aviation incidents. For that period a total of 6,775 general aviation incidents were reported to the Bureau, approximately 50% through the Airservices Australia electronic safety incident reporting system (ESIR). The agricultural aviation incidents reported were in general of a serious nature, such as engine failures or mechanical problems which did not result in aircraft damage.

Very few of the agricultural aviation incidents were reported through the ESIR system as the agricultural operations are predominantly outside controlled airspace and often in remote locations without Air Traffic Services involvement. Many incidents may go unreported to the Bureau because of the lack of a convenient reporting system and possibly due to the industry's understanding of what should be reported.

5.2 Categorisation of factors

For the period 1993–1995, a total of 47 incidents were reported with respect to agricultural aviation. When the factors attributed to the incidents are categorised, 33% (n = 15) of the reported agricultural incidents in 1993–1995 were attributed to breaches of regulations or operating procedures (see figure 16). A further 28% (n = 13) of the agricultural aviation incidents were associated with mechanical factors and 26% (n = 12) of the agricultural aviation incidents were associated with failure of pilot perception of the working environment, for example, failing to see an obstacle.

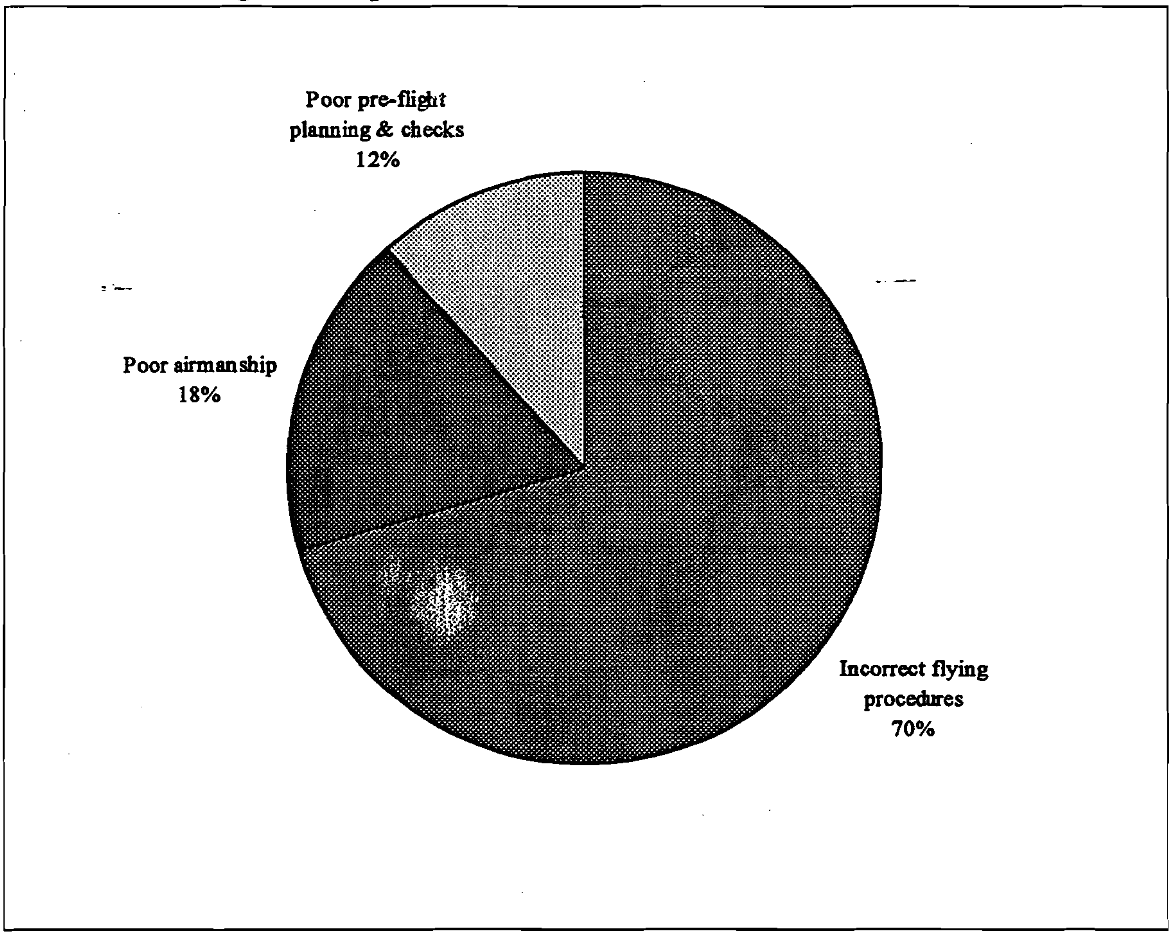
FIGURE 16 **Factors associated with incidents 1993–1995**



5.3 Regulations/procedures

Figure 17 shows the primary factors that were associated with reported agricultural incidents involving a breach or regulations and incorrect procedures.

FIGURE 17 **Regulations/procedures 1993–1995**

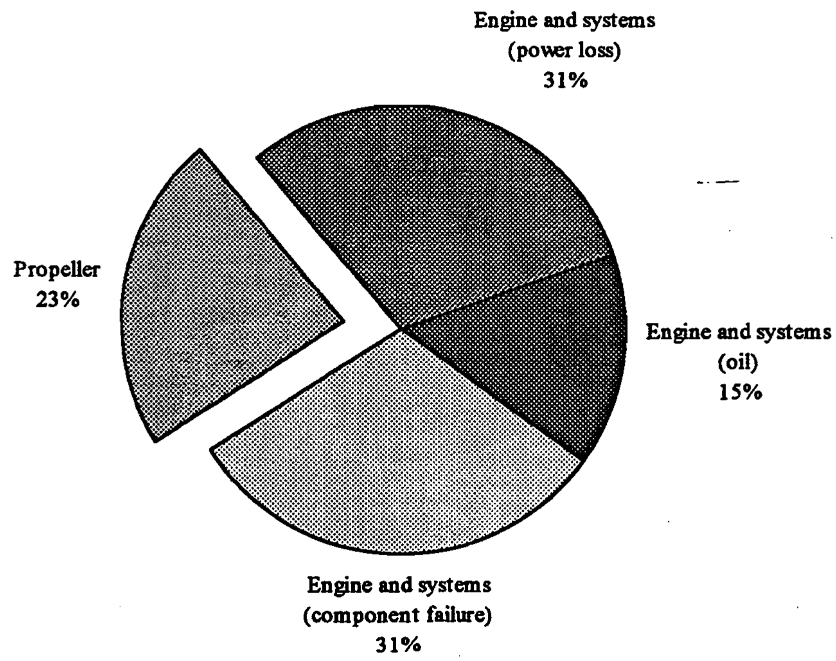


Example. The pilot advised of two near misses with an unidentified Thruster aircraft. The pilot was engaged in crop spraying. The near misses occurred during procedure turns when the aircraft was at a reported height of 120 feet. The Thruster, which appeared to be engaged in spraying, passed directly underneath the aircraft about 60 feet below. The events occurred on separate days.

5.4 Mechanical problems

Figure 18 shows the factors that were attributed to mechanical problems. Problems with the engine and systems accounted for 77% (n = 10) of the mechanical factors in reported agricultural aviation incidents.

FIGURE 18 **Regulations/procedures 1993–1995**

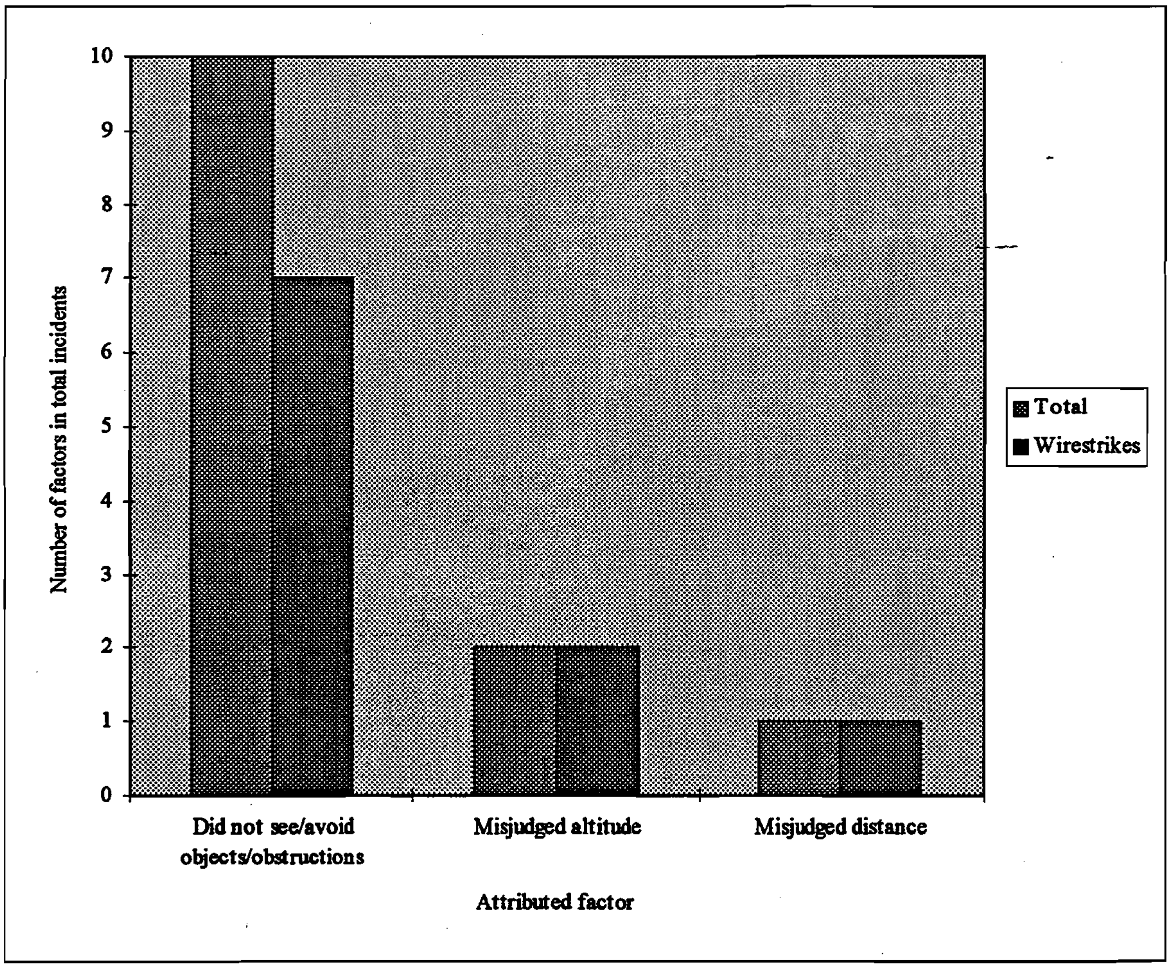


Example. During spraying operations the engine suddenly started to run rough. The pilot turned the aircraft toward the strip about a mile away and conducted trouble checks. The checks did not isolate any faults. Some 15 seconds after the rough running commenced, there was a loud bang and oil covered the windscreen. The pilot was able to jettison the load and turn back to a paddock which was suitable for a forced landing. The landing was accomplished without damage.

5.5 Situational awareness

Ten incidents were attributed to the pilot's failure to see and avoid objects or obstructions (see figure 19). Of the 13 incidents attributed to loss of situational awareness, 10 involved wirestrikes, with no resulting damage to the aircraft.

FIGURE 19 **Situational awareness factors 1993–1995**



Example. The pilot was spraying a paddock which had a powerline located across one end of it. At the completion of the fifth run the pilot forgot about the power line and pulled up into it. The landing gear legs contacted the powerline, severing it, without causing any damage to the aircraft.

6. SAFETY ACTIONS

In addition to conducting investigations into all agricultural accidents resulting in injury or substantial aircraft damage, the Bureau in 1993–1995 issued Air Safety Recommendation R950120 and Safety Advisory Notice SAN960052 (reproduced below), both of which relate to agricultural aviation aircraft and operations.

Air Safety Recommendation R950120

Occurrence Number: 9403799 **Occurrence Date**: 16 December 1994
Registration Number: VH-YEA **Manufacturer**: Hughes Helicopters
Model: 369HS **Type**: Helicopter

1. Helicopters are not specifically designed for agricultural work, unlike most modern agricultural aeroplanes which come with reinforced cabin and wire deflectors/cutters. Helicopters have been adapted for agricultural operations and have approved spray kits or spreaders attached. However, most helicopters used for agricultural operations do not have added crashworthiness built into their cockpits; nor do they have WSPS (Wire Strike Protection System) fitted.

2. WSPS have been developed and approved for several helicopter types, mostly as a result of low level military roles. However, rescue operators, fire bombers, medical retrieval helicopters and particularly agricultural helicopters are often in the low level environment where dangerous power lines exist.

3. Analysis of Bureau records indicates that wirestrikes account for about 9% of helicopter accidents in Australia. Since 1984 there have been 73 reported occurrences of wirestrikes by helicopters. Of these approximately 50% may have benefited by having an approved WSPS fitted, including 12 occurrences that resulted in fatalities. It is probable that had a WSPS been fitted to this helicopter, the accident would not have occurred.

Recommendation

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

(I) require the fitment of approved Wire Strike Protection System kits for all helicopters engaged in low flying activities for which a kit exists; and

(ii) [require] that only agricultural spray kits compatible with Wire Strike Protection Systems be approved for fitment to these helicopters.

Safety Advisory Notice SAN960052

Occurrence Number: 9401685 **Occurrence Date**: 27 June 1994
Registration Number: VH-ODR **Manufacturer**: Air Tractor Inc.
Model: AT-502 **Type**: Aeroplane

On 27 June 1994 an Air Tractor 502 (AT-502), VH-ODR, suffered a loss of engine power due to fuel starvation and subsequently conducted a forced landing. An inspection of the aircraft fuel system revealed that although there was fuel in one wing tank, the header tank feeding the engine was empty. As a result of the investigation into this occurrence, it was discovered that there had been two other unreported occurrences of this nature to AT-502 aircraft. In both these occurrences, the aircraft were on descent, and although there was sufficient fuel in the wing tanks for continued flight, a power loss occurred.

On 15 April 1996 another AT-502, VH-XST, suffered an engine power loss and subsequent forced landing. This aircraft was substantially damaged. It had over 200 litres of fuel total, mostly in one tank. The header tank was found to be half empty. Following this occurrence, there were other reported cases of power loss in this aircraft type.

The fuel system of the AT-502 aircraft consists of two wing tanks interconnected at the header tank. The two tanks are also connected by vent lines. There is no independent fuel selector for either tank and the system is described as 'self levelling'.

A review of the United States Federal Aviation Administration (FAA) Type Certificate TC A17SW, and the Approved Flight Manual (AFM) for the aircraft indicates that the fuel capacity of each fuel tank is 239.4 litres (63 US gallons) of which 228 litres (60 US gallons) is useable. Unusable fuel in each wing tank is of the order of 11.4 litres.

As a result of these occurrences, the Bureau of Air Safety Investigation notes the following:

1. A review of BASI occurrences reveals that there have been two reported cases of power loss due to fuel starvation in this aircraft type in Australia. However, from anecdotal evidence, there have been several unreported engine power losses.

2. A review of the US National Transportation Safety Board (NTSB) accident briefs on this aircraft type reveals several instances of engine power losses where the cause was undetermined.

3. Most of the engine power losses occurred during descent or a nose low attitude with a low fuel state in one tank. The total fuel had been sufficient for continued flight in each case.

4. Investigation revealed that the aircraft fuel system has a small cylindrical header tank (capacity approximately 4.5 litres) with the fuel outlet located midway up the rear face of the tank.

5. The header tank water drain is located on one end of the tank and may only be effective if the aircraft lateral attitude on the ground happens to favour that side.

6. Should either left or right fuel tank outlets become uncovered then air may be drawn into the header tank, and with the aircraft in a nose-low attitude, this may percolate to the fuel outlet, causing fuel starvation.

7. The aircraft fuel system design has not changed markedly from when the aircraft was fitted with a radial piston engine as an AT-401. The radial engine draws approximately 125–152 litres of fuel per hour. The AT-502 aircraft is fitted with a PWC PT6A-15AG turbine engine drawing approximately 185–225 litres of fuel per hour.

8. The AFM for the aircraft only discusses the possibility of engine flameouts in severe turbulence. There are also no cautions with regard to refuelling. Section 2.14 of the AFM titled 'Placards and markings' states that a placard located next to the fuel filler caps should say in part: 'Allow sufficient time for fuel level to equalise before top-off of tank'.

9. The fuel system self levelling feature appears inefficient in that it may allow significant asymmetric fuel states to remain between the two wing tanks.

Discussions were held with a Civil Aviation Safety Authority technical specialist on the concerns raised and copies of the appropriate documents were made available. These discussions indicate that further investigation into the AT-502 fuel system may be warranted.

As a result, The Bureau of Air Safety Investigation issues the following Safety Advisory Notice.

Safety action

The Bureau of Air Safety Investigation suggests that the Civil Aviation Safety Authority, in consultation with the US Federal Aviation Administration (FAA), review the fuel system design of aircraft conforming to Type Certificate A17SW to ensure the adequacy of the fuel system with all applicable airframe/engine combinations.

7. SUMMARY

This review of agricultural aviation accidents and incidents reported to BASI in the period 1986 to 1995 indicates that:

- there have been no significant reductions in the number or rate of accidents during the 10 years;
- 28.6% of accidents and 21.7% of incidents involved wirestrikes;
- the ratio of reported incidents to accidents is very much lower than the rest of the aviation sector;
- the accident and fatal accident rates were higher than for other GA operations;
- the majority of accidents occurred in the agricultural work phase of flight;
- factors related to pilot perception and operational decisions were most frequent; and
- accident prevention programs should address:
  - failure to see and avoid objects or obstacles;
  - pilots exercising poor judgement; and
  - pilots attempting operations beyond their experience or ability.

It is a widely held belief amongst safety organisations that the reporting of incidents can have significant safety benefits. It provides an insight into the factors affecting safe operation, as incidents are often the precursors to accidents.

The analysis of the reported agricultural incidents shows that the same factors are present in incidents as are associated with accidents. Increased reporting of agricultural incidents may have a beneficial effect in raising the safety awareness of pilots and personnel in the agricultural industry. In addition it would allow greater analysis of the factors before they are implicated in accidents.

BASI CONTACTS

basi@dot.gov.au

Australia-wide
24-hour toll-free number:
1800 011 034

Brisbane

PO Box 10024
Adelaide St Brisbane Qld 4000
Level 2, Samuel Griffith Place,
340 Adelaide Street
Brisbane Qld 4000
Facsimile: (07) 3832 1386

Canberra (Central Office)

PO Box 967
Civic Square ACT 2608
26 Mort Street
Braddon ACT 2612
Facsimile: (02) 6247 1290

Canberra Field Office

24 Mort Street
Braddon ACT 2612
Facsimile: (02) 6274 6604

Melbourne

Level 9
Casselden Place
2 Lonsdale Street
Melbourne Vic 3000
Facsimile: (03) 9285 6674

Perth

PO Box 327
Belmont WA 6104
Suite 2
Pastoral House
277–279 Great Eastern H'way
Belmont WA 6104
Facsimile: (08) 9479 1550

Sydney

PO Box Q78
Queen Victoria Bldg NSW 1230
Level 7 BT Tower
1 Market Street
Sydney NSW 2000
Facsimile: (02) 9283 1679

CAIR

Reply Paid 22
The Manager
CAIR
PO Box 600
Civic Square ACT 2608
24 Mort Street
Braddon ACT 2612
Facsimile: (02) 6247 4691

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