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ATSB TRANSPORT SAFETY REPORT

Aviation Research and Analysis Report – AR-2008-045

Final

Improving the odds: Trends in fatal and non-fatal accidents in private flying operations

Summary

Forty-four per cent of all accidents and over half of fatal accidents between 1999 and 2008 were attributed to private operations. These figures far surpassed the proportions for any other flying category, even though private operations contributed to less than 15 per cent of the hours flown in that decade.

This report aims to identify the factors contributing to fatal accidents in private operations and how these factors differed from non-fatal accidents. This was achieved through exploring common occurrence types (what happened), contributing factors (why the accident happened), contributing pilot errors, and aircraft and pilot characteristics.

Three occurrence types accounted for the majority of fatal accidents: collision with terrain (90%); loss of control (44%); and wirestrikes (12%). When all incidents and accidents are taken into account, the likelihood of being killed was about 36 per cent for a collision with terrain occurrence, 30 per cent for loss of control occurrences, and about 50 per cent for a wirestrike. For non-fatal accidents, there was greater variability in the common occurrence types - forced landings, hard landings, problems with the landing gear, and total power loss/ engine failure were also common.

Problems with pilots' assessing and planning were identified as contributing factors in about half of fatal accidents in private operations, and about a quarter involved problems with aircraft handling. Other contributing factors associated with fatal accidents to a smaller extent were visibility, turbulence, pilot motivation and attitude, spatial disorientation, and monitoring and checking. Non-fatal accidents were just as likely to involve aircraft handling problems, but had fewer contributing factors than fatal accidents.

Action errors and decision errors were both common to fatal accidents. Violations, while less frequently found, were mostly associated with fatal accidents.

In light of the contributing factors that were associated with fatal accidents in private operations, the report provides advice to pilots for improving the odds of a safe flight. Pilots are encouraged to make decisions before the flight, continually assess the flight conditions (particularly weather conditions), evaluate the effectiveness of their plans, set personal minimums, assess their fitness to fly, set passenger expectations by making safety the primary goal, and to seek local knowledge of the route and destination as part of their pre-flight planning. Also, becoming familiar with the aircraft's systems, controls and limitations may alleviate poor aircraft handling during non-normal flight conditions. Finally, pilots need to be vigilant about following rules and regulations that are in place – they are there to trap errors made before and during flight. Violating these regulations only removes these 'safety buffers'.

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- safety data recording, analysis and research
- fostering safety awareness, knowledge and action.

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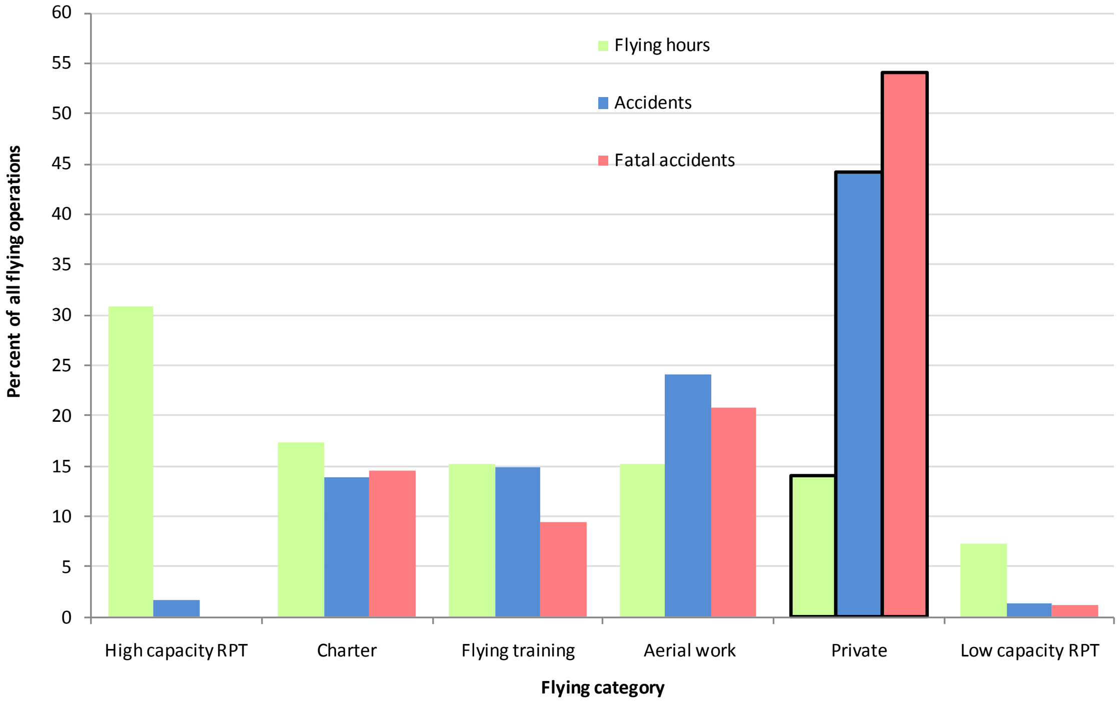
INTRODUCTION

In Australia, private operations[1] made up 14 per cent of hours flown by all VH-registered aircraft between 1999 and 2008 (Figure 1) (Bureau of Infrastructure, Transport and Regional Economics, 2010). However, private operations accounted for 44 per cent of all accidents. Moreover, fatal accidents in private operations accounted for over half of the total number of fatal accidents. Total accidents and fatal accidents in private operations far surpassed the proportion of accidents attributed to any other operation type.

In addition, the trend for non-fatal accidents peaked around 2002 and generally declined after 2004. Conversely, the number of fatal accidents steadily declined from 1999 to 2003, but increased after 2004.

Figure 1: Proportion of flying hours vs. proportion of accidents for all flying categories (1999–2008)



A large amount of research has looked into the factors that contribute to accidents and incidents, and to fatal and non-fatal accidents, in general aviation, military operations and commercial operations (e.g. Li, 1994; Li et al., 2003; O'Hare, 2006; O'Hare & Chalmers, 1999). However, although private operations make up a large percentage of accidents in Australia, there has been no research that has specifically examined the factors contributing to accidents in private operations.

The main aim of this report was to identify the common factors that contribute to accidents in private operations. Another aim was to identify any factors that may characterise fatal and non-fatal accidents in this flying category. To achieve these aims, Australian Transport Safety Bureau (ATSB) accident records were analysed in terms of occurrence types, contributing factors, contributing errors and other factors to determine which factors were more common in one type of injury outcome over another. These factors are explained below.

1 Private operations in this report refer to all not-for-reward flying activities on VH-registered aircraft, including business flying, but excluding sports aviation flying.

- Occurrence types refer to what happened in an accident (for example, faulty landing gear).
- Contributing factors refer to events and conditions that contributed to an increased risk of an accident.
- Contributing errors relate to the types of incorrect pilot actions related to contributing factors.
- Other factors included pilot and aircraft characteristics.

The interaction of common occurrence types, contributing factors, contributing errors and other factors was also analysed to establish whether their interplay affected the injury outcome of an accident.

The results from this report may be relevant and useful to all categories of general aviation. In particular, the common factors and trends found may highlight the factors, especially those related to fatal accidents, which all pilots need to be aware of each time they fly. The results may also offer insights for investigators when looking into the factors that contribute to accidents.

Only accidents in the ATSB occurrence database between 1999 and 2008 that involved privately operated aircraft were examined in this study. Specifically, this included all not-for-reward flying activities on VH-registered aircraft, including business flying, but excluding sports aviation flying. There were 624 accidents in this reporting period. Accidents were coded as having a fatal outcome, serious injury[2], minor injury, or nil injury outcome depending on the highest injury sustained in the accident. For example, an accident was coded as having a fatal injury outcome if there were serious and fatal injuries sustained. Accidents were grouped as either a fatal or a non-fatal accident for the analysis in this report. Serious, minor and nil injury accidents were grouped as non-fatal accidents.

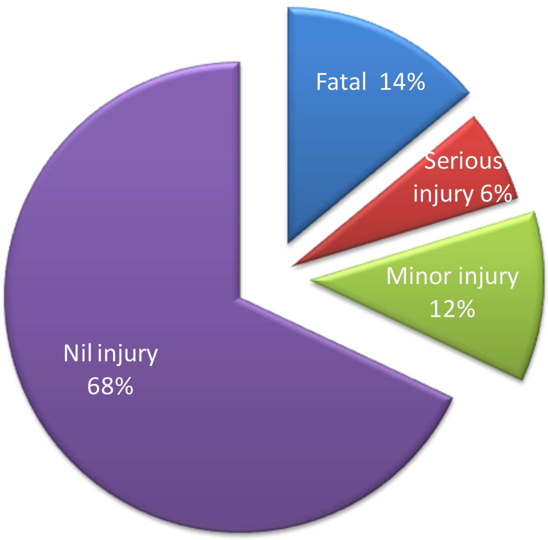
2 Serious injury is an injury that requires, or would usually require, admission to hospital within 7 days after the day when the injury is suffered. A minor injury is a non-fatal injury other than a serious injury.

ACCIDENT TRENDS IN PRIVATE OPERATIONS

Injury outcome

Figure 2 depicts the proportion of accidents in private operations according to the injury outcome. The majority of accidents did not result in any injuries, while fatal accidents were the next frequent. Accidents resulting in serious injury were the least common.

Figure 2: Breakdown of injury outcome for private operations accidents (1999–2008)



Occurrence types

The ATSB categorises aviation occurrences by coding w*hat* happened in an occurrence through an occurrence type taxonomy. Broadly speaking, occurrences can be operational, mechanical, airspace, aerodromes and airways facility, or environment related. Most of the accidents in private operations were associated with operational issues (i.e. the way the aircraft was operated - 84 per cent), followed by mechanical issues (12 per cent).

Each of the broad occurrence types is sub-divided into a number of related sub-categories. Every accident can be assigned more than one occurrence type. For example, an accident can involve both a forced landing (operational) and a bird strike (environment).

Common occurrence types

Three occurrence types accounted for the majority of fatal accidents (Table 1):

- collision with terrain (including controlled flight into terrain)
- loss of control
- wirestrikes.

While only three occurrence types were prevalent for fatal accidents, there was much more variation in the common occurrence types for non-fatal accidents. Nine occurrence types were identified as contributing to 10 per cent or more of all non-fatal accidents.

Collision with terrain was the most common occurrence type for both fatal and non-fatal accidents. However, 90 per cent of fatal accidents in private operations involved collision with terrain, while this was the case for only 20 per cent of non-fatal accidents.

Table 1: Common occurrence types for fatal and non-fatal accidents in private operations (1999–2008)

Injury outcome	Occurrence type	Description	Per cent of injury outcome with occurrence type
Fatal accidents (n = 87)	Collision with terrain (n=79)	Accidents involving a collision between an airborne aircraft and the ground or water, where the flight crew were aware of the terrain prior to the collision. Can be either controlled or uncontrolled collision with terrain.	89.7
	Loss of control (n= 39)	Accidents where a pilot is unable to maintain positive control of an aircraft, either during flight or on the ground.	43.7
	Wirestrike (n=10)	Accidents where an aircraft strikes a wire, such as a powerline, telephone wire, or guy wire, during normal operations.	11.5
Non-fatal accidents (n = 537)	Collision with terrain (n= 104)	Accidents involving a collision between an airborne aircraft and the ground or water, where the flight crew were aware of the terrain prior to the collision. Can be either controlled or uncontrolled collision with terrain.	19.4
	Forced landing (n=99)	Accidents where an aircraft attempts a landing in situations where continued flight is not possible.	18.6
	Excursion (n=90)	Accidents where an aircraft on the ground departs from a runway or taxiway.	16.8
	Hard landing (n=69)	Accidents where a landing is reported as heavy or hard, where aircraft damage is indicative of a hard landing.	13
	Landing gear (n=66)	Accidents where aircraft landing gear, brakes (or their component parts) or tyres have exhibited damage or have failed.	12.3
	Total power loss / engine failure (n=62)	Accidents involving the failure of an engine in flight or on the ground.	11.5
	Collision on ground (n=58)	Accidents where an aircraft has a collision with another object whilst it is operating on the ground or water.	10.8
	Loss of control (n=56)	Accidents where a pilot is unable to maintain positive control of an aircraft, either during flight or on the ground.	10.4
	Wheels up landing (n=55)	Accidents where an aircraft with retractable landing gear lands without the landing gear fully extended and locked before contact with the ground or runway.	10.2

Common and deadly

When all incidents[3] and accidents involving for private operations are taken into account, the likelihood of being killed in an occurrence that involved collision with terrain is about 36 per cent. Similarly, the chances of being killed in an occurrence where the pilot lost control of the aircraft is 30 per cent. However, although there were fewer wirestrike fatal accidents in private operations compared to the above, the likelihood of a wirestrike resulting in fatalities was higher (about 50 per cent).

Uncommon but deadly

There are other types of occurrences, while less prevalent, that were more likely to result in fatalities. In 2010, the ATSB published a bulletin on avoidable accidents[4] that looked at the dangers of unauthorised low-level flying. The cases in the bulletin reflect what was found in this study – there are not many instances of unauthorised low-level flying related accidents reported to the ATSB, however, 80 per cent of those reported between 1999 and 2008 ended up being fatal accidents. Likewise, the data show that although the event is quite rare in private operations, in-flight breakups were always fatal. On the other hand, flying with only a visual flight rules (VFR) qualification in instrument meteorological conditions (IMC) resulted in a fatal accident in a quarter of the instances reported to the ATSB. Crew incapacitation resulted in a fatal accident 38 per cent of the time. It should be noted, however, that there is likely to be underreporting for incidents involving unauthorised low flying, VFR into IMC and crew incapacitation, which will inflate the proportion of fatal accidents.

Contributing factors

The ATSB defines a contributing factor as an event or condition (for example, of the individual, of the environment, or of the task) that increases safety risk. Contributing factors can be related to pilot actions, local conditions, technical failures, risk controls, or organisational influences. Each of these are broken down into sub-categories. The common contributing factors in all private operations accidents were either pilot actions or local conditions (Figure 3). See Appendix A for descriptions of specific contributing factors identified in Figure 3.

Pilot actions are observable behaviours performed by the flight crew. Other factors may be influenced to reduce the likelihood of those actions reoccurring. For example, pilots can be encouraged to conduct more frequent monitoring and checking of fuel consumption during flight through targeted training or use of personal checklists. Ideas on managing or reducing these pilot actions are discussed later in the report (see *Improving the Odds*). Local conditions (for instance, the prevailing weather conditions) are those conditions which exist in the immediate task context or environment in which pilot actions or technical events occur, and usually impact upon a pilot's ability to control his or her actions.

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3 An incident refers to an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation (ICAO, 2001).

4 Available on the ATSB website (http://www.atsb.gov.au/publications/2010/avoidable-accidents-low-level-flying.aspx).

A factor is considered a contributing factor if it is probable that if it was not present at the time of the occurrence, then either the occurrence would not have occurred, or the consequences associated with the occurrence would not have been as serious, or another contributing factor would not have occurred.[5]

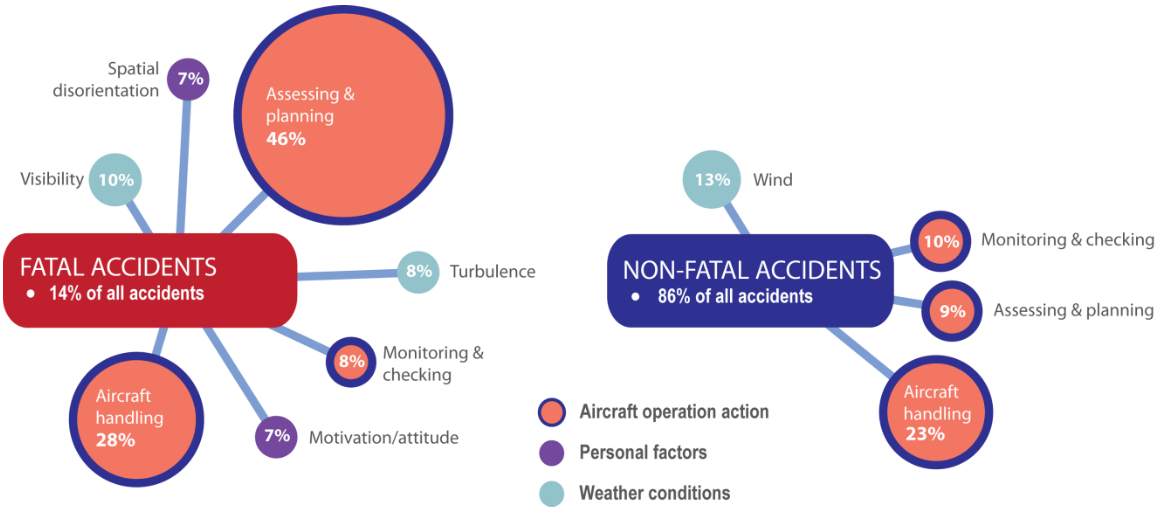
Pattern of contributing factors

Figure 3 describes the common contributing factors that were associated with fatal and non-fatal accidents (present in more than five per cent of accidents of the injury outcome). For fatal accidents:

- Problems with pilots' assessing and planning were the most common contributing factor and were present in nearly half of the fatal accidents.
- Aircraft handling problems were also common (28 per cent of fatal accidents).
- Other factors associated with fatal accidents to a smaller extent were visibility, turbulence, pilot motivation and attitude, spatial disorientation, and monitoring and checking.

For non-fatal accidents, there was limited range of contributing factors found.[6] Aircraft handling problems were the most common contributing factor, but only represented 23 per cent of non-fatal accidents. This was followed by wind, monitoring and checking issues and assessing and planning problems.

Figure 3: Common contributing factors by injury outcome for private operations (1999–2008)



Aircraft operation action refers to a pilot action. All other factors in this figure refer to local conditions. Note that the percentages do not total to 100 per cent as each accident can be assigned with more than one contributing factor.

5 Refer to Walker and Bills (2008) for more information about contributing factors and its use in transport investigations.

6 However, it should be noted that this result may be partially contributed to the limited information available about non-fatal accidents as they are investigated less often by the ATSB. For example, the presence of cognitive-based safety factors, such as assessing and planning, will be more difficult to establish in the absence of further investigation than skill based safety factors, such as aircraft handling.

Pilot actions as contributing factors

In Figure 3, contributing factors that are classified as pilot actions are highlighted with a dark blue border. Problems with assessing and planning, aircraft handling, and monitoring and checking are all pilot actions that were common to all accidents, with assessing and planning particularly prevalent in fatal accidents. Pilots need to be aware of the pilot actions that are commonly associated with fatal accidents and to prepare countermeasures for them. For example, revising your knowledge of the aircraft systems and controls may reduce the risk of mishandling aircraft controls in non-normal flight conditions. Additionally, assessing threats and errors, and planning countermeasures for them as part of the pre-flight planning process may alleviate some assessing and planning problems during flight if and when threats and errors occur.

While assessing and planning problems were the most common contributing factor for fatal accidents, they were only associated with 9 per cent of non-fatal accidents. Some examples of assessing and planning problems for fatal accidents included:

- the pilot failed to reject the takeoff due to poor engine performance
- the pilot failed to check the weather forecast before the flight
- the pilot did not conduct proper reconnaissance of the area for wires and other hazards
- beat up and stall turn at low level

Example – low level manoeuvre

On 15 May 2005, an American Champion Corporation Citabria 7GCAA aircraft took off on a local flight from a private airstrip at Stonefield, SA. On board were the pilot and a passenger.

The aircraft engine was heard powering up on the strip and shortly after became airborne. After becoming airborne, the aircraft was observed to remain approximately 10 feet above the strip, and remained at that height until the end of the strip. At about this point, the aircraft was observed to enter a near vertical climb. At an estimated height of 500 feet above ground level, the aircraft stalled in the vertical position, before entering a right hand spin. The aircraft completed one and a half turns in the spin before it appeared to recover. At the point where the aircraft appeared to have recovered from the spin, it impacted the ground. Both occupants were fatally injured and the aircraft was destroyed.

Although the aircraft appeared to have stopped spinning to the right just before impact, the pilot had insufficient height to avoid a collision with the ground.

Why did it happen?

The pilot was reported to have conducted a similar low-level manoeuvre to that which preceded the accident on several previous occasions. The manoeuvre left little or no margin for error and required sound judgement and skill. No evidence was found of his ever having undertaken the appropriate check to assess those skills and obtain approval to conduct low-level aerobatic manoeuvres. Disregard for the rules governing the conduct of flight and the operation of the aircraft removed safety defences that were established to prevent this type of accident.

(ATSB investigation report 200502116)

In contrast, assessing and planning problems associated with non-fatal accidents included:

- weight and balance issues which made the aircraft unstable
- the pilot did not correctly assess how much fuel was required for the flight or did not accurately monitor fuel consumption.
- the pilot conducted a late go-around
- the pilot failed to assess the wind direction and magnitude.

Aircraft handling problems, on the other hand, were involved in fatal and non-fatal accidents to a similar extent (28 cf. 23 per cent respectively). Aircraft handling problems was also the most common contributing factor for non-fatal accidents. However, it should be noted that this result may be partially contributed to the limited information available about non-fatal accidents as they are investigated less often by the ATSB.

Aircraft handling issues associated with fatal accidents mostly involved stalls, and included:

- stalled the aircraft in a steep turn, nose too high, or immediately after takeoff
- mishandled the aircraft during response to an emergency
- stalled or became spatially disorientated in IMC.

Some common aircraft handling problems associated with non-fatal accidents included:

- heavy or mishandled landings (usually associated with wind gusts)
- directional control was not maintained
- the aircraft landed short of runway.

Problems with monitoring and checking also featured in a similar number of fatal and non-fatal accidents (8 and 10 per cent respectively). The most common problem with monitoring and checking was the failure to lower the landing gear, followed by inadequate monitoring of fuel.

Local conditions

Local conditions include characteristics of the individuals and equipment, as well as the nature of the task and the physical environment. Local conditions can increase the likelihood of inappropriate pilot actions, which can then increase safety risk. For example, a poor motivation towards flight safety (local condition) may increase the likelihood that the pilot will not conduct a proper pre-flight assessment (pilot action). Similarly, adverse weather (local condition) may limit a pilot's ability to control the aircraft (pilot action).

There were more local conditions that commonly contributed to fatal accidents than there were for non-fatal accidents.[6] Wind was the only local condition that was frequently cited (more than 5 per cent) in non-fatal accidents. The pilot's motivation and/or attitude and spatial disorientation, as well as visibility and turbulence accounted for between 7 and 10 per cent of fatal accidents.

Contributing factor and occurrence type interactions

Some contributing factors were specific to particular occurrence types. For example, for accidents that involved collision with terrain and/ or a loss of aircraft control, aircraft handling issues were most likely to be a factor. Table 2 shows the contributing factors most frequently associated with the common occurrence types for fatal and non-fatal accidents.

For fatal accidents, assessing and planning issues were linked to all three common occurrence types (collision with terrain, loss of control, and wirestrikes). Assessing and planning issues associated with collision with terrain and/or loss of control accidents mostly involved pilots failing to plan for the weather conditions, not properly assessing the weather during flight, or deciding to continue to fly in marginal weather. Some pilots flew at night without a night visual flight rules rating and most pilots who conducted low-level flying which resulted in collision with terrain did not conduct a reconnaissance of the area beforehand. The failure to assess the area before flying at low levels was also a common issue with respect to wirestrike accidents.

Example – weather planning

On 14 September 2008, a Cessna U206 Stationair aircraft, with a pilot and two passengers on board, was on a private flight under VFR from Bankstown, NSW to Archerfield, Qld with a planned stop at Scone, NSW. The aircraft was reported missing when it did not arrive at Archerfield as expected later that day.

The wreckage of the aircraft was found the following day on top of a 3,800 ft ridge in rugged terrain, approximately 56 km (30 NM) north-north-east of Scone Airport. All three occupants were fatally injured and the aircraft was destroyed.

The weather in the area at the time of the occurrence was not suitable for VFR flight and included low cloud, rain showers and high winds. Inspection of the accident site indicated that the aircraft was tracking towards Scone prior to impact with terrain. The circumstances of this occurrence were consistent with controlled flight into terrain, probably as a result of the pilot encountering IMC as he attempted to return to Scone.

Why did it happen?

There was no evidence that the pilot had accessed any pre-flight weather forecast or subsequent forecast updates from the National Aeronautical Information Processing System (NAIPS). Nevertheless, the pilot would have been aware of the weather situation from observations during the flight from Bankstown and at Scone.

What the pilot might not have appreciated, however, was that the route he had chosen from Scone to Archerfield via Casino was likely to involve more extreme conditions and expose the aircraft to high and rugged terrain, strong winds, and reduced visibility. It is possible that he took some level of assurance following completion of the flight from Bankstown to Scone, that he could safely complete the Scone to Archerfield leg.

(ATSB Investigation report AO-2008-063)

Aircraft handling was a significant contribution to both loss of control and collision with terrain fatal accidents. These mostly involved stalling, usually precipitated by steep turns.

Two of the 10 accidents involving wirestrikes were found to have survival issues: one pilot did not wear his seatbelt, which may have increased the severity of his injuries; and in another accident, bottles were stowed under the seat of a Robinson R22 aircraft. Obstruction of this crumple zone greatly reduced the survivability of the accident. Another two accidents were related to equipment - the seatbelt anchor was not upgraded for one accident and another found that the powerline was not fitted with high visibility markers.

Table 2 also shows that most of the common occurrence types for non-fatal accidents, such as loss of control and hard landing, had aircraft handling issues as the most frequently identified contributing factor.

Because contributing factors are occurrence type specific, the large variance in the occurrence types for non-fatal accidents means that the types of contributing factors also vary significantly. This explains in part why the common contributing factors for non-fatal accidents in Figure 3 make up a smaller proportion of non-fatal accidents and why there are fewer common contributing factors in non-fatal accidents compared with fatal accidents.

There are ways for pilots to reduce or manage the pilot actions and local conditions that are more likely to result in a fatal accident in private operations, and they are presented later in this report (*Improving the Odds*).

Table 2: Common contributing factors by occurrence type in private operations

Injury outcome	Occurrence type	Common contributing factor	Per cent of injury outcome and occurrence type with contributing factor[7]
Fatal	Collision with terrain	Assessing and planning	41.8
		Aircraft handling	29.1
	Loss of control	Aircraft handling	56.4
		Assessing and planning	51.3
	Wirestrike	Assessing and planning	50.0
		Other equipment factors	20.0
		Survival factors	20.0
Non-fatal	Collision with terrain	Aircraft handling	31.7
		Wind	19.2
	Forced landing	*No contributing factors contributed to more than 20 per cent*	
	Excursion	Aircraft handling	38.9
		Wind	20.0
	Hard landing	Aircraft handling	52.2
		Wind and windshear	27.5
	Landing gear	*No contributing factors contributed to more than 20 per cent*	
	Total power loss / engine failure	*No contributing factors contributed to more than 20 per cent*	
	Collision on ground	Monitoring and checking	29.3
	Loss of control	Aircraft handling	50.0
		Wind	32.1
	Wheels up landing	Monitoring and checking	38.2

7 Percentages in Table 2 do not total 100 as there can be more than one safety factor assigned to an occurrence type.

Contributing errors

When a contributing factor involves a pilot action, the ATSB assigns contributing errors to classify what sort of error influenced the pilot action (or inaction). Out of the 624 accidents involving private operations between 1999 and 2008, there were 204 non-fatal accidents and 53 fatal accidents that had at least contributing one pilot action. The contributing errors assigned to these pilot actions were as follows.

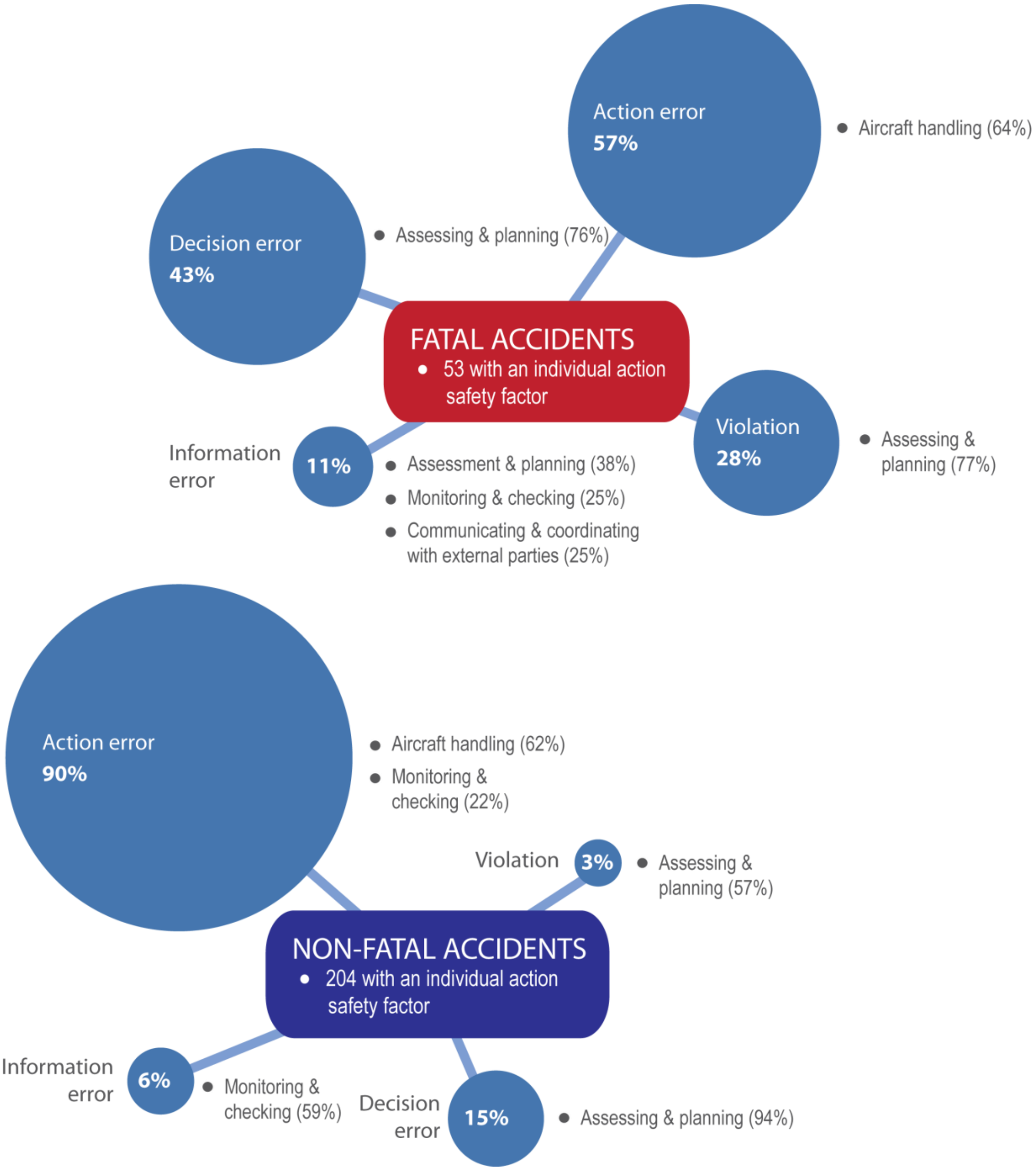
- Action errors: actions which deviate from the individual's plans (skill-based slips and lapses).
- Decision errors: when the individual's plans are not adequate for the situation.
- Information error: failure to perceive something, perceiving something incorrectly, or not correctly understanding the current situation.
- Violations: deliberate intention to deviate from procedures or standards.

Common contributing pilot errors

Action errors were the most common contributing error for both types of accidents (Figure 4). Most non-fatal accidents were associated with action errors (90 per cent), while fatal accidents were associated with a mixture of errors types - action errors (57 per cent), decision errors (43 per cent), and violations (28 per cent).

Decision errors were three times more frequent in fatal accidents than they were in non-fatal accidents, and violation of rules and regulations occurred nine times more often in fatal accidents than in non-fatal accidents. While violations were only identified in 24 accidents, 70 per cent of these violations were associated with a fatal outcome. Although the latter result may be influenced by the fact that fatal accidents are more likely to be investigated, it also supports what past research into contributing errors had found - that violations tended to be more common in fatal accidents than in non-fatal accidents (Wiegmann et al., 2005).

Figure 4: Contributing errors by injury outcome and common contributing factors[8]



Contributing error, contributing factor and occurrence type interactions

Figure 4 also shows the proportion of contributing factors associated with each contributing error. Assessing and planning problems were identified in a large proportion of decision errors and violations associated with both fatal and non-fatal accidents. Not surprisingly, aircraft handling issues made up the majority of contributing factors for action errors for both accident outcomes. Monitoring and checking problems were also associated with information errors for both fatal and non-fatal accidents, as well as action errors made in non-fatal accidents.

For fatal accidents, there was no difference in the occurrence types across the different errors made. This is because the common occurrence types were limited to collision with terrain, loss of control and wirestrikes (Table 1).

8 Note that each accident can be assigned with more than one contributing error, so the percentages of contributing errors do not total 100.

However, there was a variation of occurrence types for non-fatal accidents. All types of error were associated with collision with terrain non-fatal accidents. Collisions on the ground were commonly associated with information errors (30 per cent), and excursions accidents were commonly associated with action errors and decision errors (12.5 and 15 per cent respectively).

Other factors

Past research has found other factors that may play a role in contributing to accidents. These factors have included pilot characteristics (such as age, experience, licence type) and aircraft characteristics (such as the type of aircraft and the number of engines) (O'Hare, 1999; O'Hare et al., 2003). In addition to occurrence types, contributing factors and contributing errors, this study also investigated whether these other factors had a role in determining the injury outcome of an accident in private operations.

Aircraft factors

Some studies have found a relationship between aircraft factors and the injury outcome of the accident. For example, O'Hare et al. (2003) found that pilots of twin-engine aircraft were three times more likely to have a fatal accident compared with pilots of single-engine aircraft, and that amateur built aircraft were three times more likely to be involved in a fatal accident than factory-built aircraft. In 2010, the ATSB reported that between 1999 and 2009, pilots of helicopters were five times more likely to be in a fatal accident than pilots of fixed-wing aircraft in general aviation.

Aircraft factors, such as whether it was an amateur built aircraft or the number of engines, did not affect injury outcome for private operations in this ATSB study. The aircraft type (fixed or rotary wing) also did not affect the injury outcome for accidents in private operations.

Pilot characteristics

Studies looking into pilot age as a risk factor in accidents have produced mixed results (Broach, Joesph & Schroeder, 2003; Li, 1994). O'Hare et al. (2003) reported no difference between the age distribution of pilots who were fatally injured and those who were not, nor did they find any significant association between flight experience and the fatality of an accident. Li et al. (2003) found that accident risk increased with age for professional pilots, while other studies (Guide & Gibson, 1991; Lubner, Markowtiz & Isherwood, 1991) found that in the general pilot population, younger pilots had a higher accident rate than older pilots. However, these studies did not look at whether the accident was likely to be fatal or non-fatal.

This ATSB study found that personal factors such as the pilot's age, total hours on type and total hours flying experience did not affect the injury outcome of the accident in private operations.

People on board

O'Hare (1999) and O'Hare et al. (2003) found that the presence of other people on board the aircraft contributed to the likelihood of an accident being fatal. O'Hare (1999) discovered that the pilot-in-command was almost twice as likely to suffer fatal injuries when there were others in the aircraft. The presence of others on board (whether they were other crew members or passengers) did not affect injury outcome in this study.

Other factors by contributing errors and occurrence types

Are some factors associated with a particular contributing error more likely to contribute to a fatal accident? For example, are accidents more likely to be fatal if they involved a violation (such as overloading the aircraft) and there were others on board? Unfortunately, the data available for these other factors when restricted to particular contributing errors mostly proved too limited for analysis. The exceptions were accidents associated with action or decision errors and those where other people were on board. Having other people on board did not affect the injury outcome of the accident, regardless of the contributing errors associated with it. Similarly, the problem of limited data also occurred when analysis was restricted to particular occurrence types. However, analyses was able to be conducted for collision with terrain accidents, and it was found that age and hours on all types of aircraft and hours on type did not affect whether these accidents were fatal or not.

IMPROVING THE ODDS

The comparison between fatal and non-fatal accidents in private operations has highlighted some factors that were connected with fatal accidents more so than with non-fatal accidents. This section of the report aims to encourage some thought and discussion about these factors – why they occur, and most importantly, how they can be avoided or managed.

Assessing and planning

Assessing and planning problems were cited in 46 per cent of fatal accidents in private operations between 1999 and 2008. Those cases investigated by the ATSB included accidents where the pilot did not assess the weather conditions correctly, where the pilot overloaded the aircraft, or where the pilot failed to adequately plan for the flight (for example, fuel management).

Pilots are encouraged to take the time to do as much assessing and planning before the flight as possible. Assessing the possible threats and errors that may be encountered during flight and planning countermeasures for them may reduce the need to decide on a plan of action when these threats and errors arise once you are airborne. Keep in mind that flight conditions are constantly changing, so do not lock yourself into your plan. Instead, keep your plan dynamic and have other options to give yourself an out when conditions change.

ATSB (2009)[9] found the three most commonly perceived threats to general aviation pilots were adverse weather, traffic (air or ground congestion), and issues with air traffic control commands and communications. The three most common errors reported by pilots were procedural checklists errors, radio errors, and communication errors with air traffic control or other aircraft. The report also suggests some ways to mitigate the common errors reported. These reported threats and errors can be used as a starting point for your pre-flight assessment and planning.

It is also important to have a post-flight debriefing with yourself (and your copilot, if any).

Some ideas to consider when assessing and planning your flight include:

Make decisions pre-flight

- Once you have identified the likely threats and errors you may encounter during your flight, decide how you will deal with them as part of your pre-flight planning (and don't forget to discuss these with your copilot if you have one).
- Making decisions beforehand will also reduce your workload in-flight if and when these threats and errors occur, and may reduce your chances of making a poor decision in-flight under stress and time pressure.
- Be mindful of the pressures you may face while making your decisions, whether you are making them pre-flight or in-flight. These pressures may be to arrive on-time, pressure from passengers to continue with the flight, or monetary pressures.

Seek local knowledge

- Before the flight, seek out local knowledge (of the weather and terrain for example) on the routes and destination. Local knowledge can be sought from the flying instructors at the local aero club or flying schools.

9 *Perceived threats, errors and safety in aerial work and low capacity air transport operations*, available from the ATSB website (http://www.atsb.gov.au/publications/2006/ar2006156.aspx).

Set personal minimums

- Know your personal minimums. These are your set of rules and criteria for deciding if and under what conditions to fly or to continue flying based on your knowledge, skills and experience (adapted from Parson, 2006). They act as a 'safety buffer' between the demands of the situation and the extent of your skill.
- Take into account the terrain, weather, external pressures, the aircraft's performance limitations and any limitations you may bring to the flight (for example, stress and inexperience).
- Discuss your personal minimums with an instructor or a more experienced pilot. Have the discipline to stick to your personal minimums in spite of external pressures. Treat your personal minimums as a line in the sand over which you would not cross.
- A checklist for establishing your personal minimums can be found on the Civil Aviation Safety Authority's (CASA's) website (http://www.casa.gov.au/wcmswr/_assets/main/pilots/download/checklist.pdf).

PILOT

Experience/recency

Take-offs/landings .... ______in the last ______days

Hours in make/model .... ______in the last ______days

Instrument approaches .... ______in the last
(simulated or actual) ______days

Instrument flight hours .... ______in the last
(simulated or actual) ______days

Terrain and airspace ....familiar

Physical condition

Sleep.. ______in the last 24 hours

Food and water ....in the last ______hours

Alcohol....................................none in the last ______hours

Drugs or medication ....none in the last ______hours

Stressful events ....none in the last ______days

Illness ....none in the last ______days

Fit and rested ....Yes

▶ ______

AIRCRAFT

Fuel reserves (cross-country)

VFR Day .... ______hours

VFR Night .... ______hours

IFR Day .... ______hours

IFR Night .... ______hours

Experience in type

Take-offs/landings .... ______in the last
in aircraft type ______days

Aircraft performance

Establish that you have additional performance available over that required. Consider the following:

- gross weight
- load distribution
- density altitude
- performance charts

Aircraft equipment

Avionics................familiar with equipment (including autopilot and GPS systems)

COM/NAV ....equipment appropriate to flight

Charts...................current

Clothing ....suitable for pre-flight and flight

Survival gear........appropriate for flight/terrain

▶ ______

ENVIRONMENT

Airport conditions

Crosswind................ ______% of max POH

Runway length......... ______% more than POH

Weather

Reports and forecasts...........not more than ______hours old

Icing conditions....................... ______ft below freezing level

Weather for VFR

Ceiling Day .... ______feet

Night......................... ______feet

Visibility Day .... ______Km

Night......................... ______Km

Weather for IFR

Precision approaches

Ceiling................................ ______feet above min.

Visibility.............................. ______metres above min.

Non precision approaches

Ceiling................................ ______feet above min.

Visibility.............................. ______metres above min.

Missed approaches

No more than.................. ______before diverting

Take-off minimums

Ceiling................................ ______feet

Visibility.............................. ______metres

▶ ______

Assess your fitness to fly

The *Instrument Flying Handbook (2001)* published by the US Federal Aviation Administration (FAA) recommends that pilots use its Illness Medication Stress Alcohol Fatigue Eating (IMSAFE) checklist pre-flight to evaluate their own physiological and psychological fitness to fly. The FAA recommends that if a pilot answers 'yes' to any of the questions below, then they should consider not flying as their status may compromise flight safety.

IMSAFE Checklist

- Illness—Do I have any symptoms?
- Medication—Have I been taking prescription or over-the counter drugs?
- Stress—Am I under psychological pressure from the job? Do I have money, health, or family problems?
- Alcohol—Have I been drinking within 8 hours? Within 24 hours?
- Fatigue—Am I tired and not adequately rested?
- Eating—Have I eaten enough of the proper foods to keep adequately nourished during the entire flight?

Set expectations

- Brief any passengers on the possibility of changes to the flight, including cancelling the flight, diversions and turning back, or late departure or arrival times due to changes in weather or aircraft performance. Also point out to passengers that safety, not reaching the destination regardless of conditions, is the primary goal.
- Brief others that you may be meeting with at your destination of the possibility of late arrival times.
- Setting expectations beforehand will take the pressure off continuing with the flight if the conditions exceed your personal minimums.
- Nominate a SARTIME[10]. It makes good sense to let someone know where you're going and what time you expect to get there. Also, ensure you cancel it when you reach your destination.

Continuous assessment

- Don't forget that decision making is an evolving process. If you find that the decisions made are inappropriate to the current conditions, adapt them using the information and the resources available to you.
- Keep assessing the situation – continually obtain weather information en route, assess air traffic (for instance, is it congested, are you comfortable with the amount of traffic?), and keep an eye on the fuel you have remaining.
- CASA offers a reusable plastic card, called Time in Your Tanks[11], which shows pilots how to calculate the amount of fuel left in their tanks.

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10 The time nominated by a pilot for the initiation of search and rescue action if a report has not been received by the nominated unit. Call CENSAR on 1800 814 931 to submit or cancel a SARTIME.

11 Available from the CASA online store (http://casa.cart.net.au/details/2258601.html).

Aircraft handling

Problems with aircraft handling were associated with about 30 per cent of fatal accidents. Many of the fatal accidents were attributed to the aircraft stalling, in many cases, when the turn was too steep at low level during the circuit.

- It is important for you to understand the aircraft controls and systems, and limitations of the aircraft (for example, stall speeds, weight and balance) before you fly. Be familiar with your aircraft operating manual, which will have this information. This is especially important if you do not fly regularly on the aircraft type or are flying a new aircraft type.
- Being familiar with the aircraft controls, systems and limitations may alleviate confusion and aircraft handling issues during non-normal or emergency situations.

Weather

Poor weather conditions were associated with about 18 per cent of all fatal accidents in private operations between 1999 and 2008. Adverse weather was also found to be one of the most common threats reported by pilots (ATSB, 2009; Thomas, 2004).

- Pilots should always obtain up-to-date weather information before and during flight. The more doubtful the weather, the more information you will need to get and the more planning is required. Cancel the flight if the flight conditions exceed your personal minimums.
- Even though you may have decided on a course of action in case of marginal weather, decision making is a dynamic process, particularly when it comes to weather, and requires continuous assessment of conditions en route.
- CASA has produced some material on weather related assessment and decision making. One such product is the 'Weather to Fly' DVD[12] which provides tips on flying in and around bad weather and has advice from chief flying instructors from local aero clubs on some of the critical areas.

12 Available from the CASA online store (http://casa.cart.net.au/cat/2030075.html).

Personal factors

Together, motivation and attitude and spatial disorientation contributing factors were linked to about 14 per cent of fatal accidents in private operations.

Motivation and attitude

- A pilot's motivation and attitude strongly influences his or her approach to conducting a safe flight. There is no 'one way' to develop a 'safe' motivation and attitude. However, a starting point would be to establish your personal minimums, have the discipline to stick to them, and to follow civil aviation rules and regulations.
- The FAA has produced guidance material that describes five hazardous attitudes that may affect flight safety and how to deal with them (FAA, 1991). These hazardous attitudes are
  - anti-authority (*don't' tell me what to do!)*
  - macho (*I can do it!)*
  - invulnerability (*it won't happen to me)*
  - impulsivity (*do something now!)*
  - resignation (*what's the use?)*.

The FAA suggests that pilots become familiar with these hazardous thoughts and attitudes so as to recognise these in themselves and in other pilots, question why these hazardous thoughts exist, and to counteract them with what they call *antidote thought*. For example, when you notice that you are being impulsive, tell yourself 'Not so fast. Think first'.

Spatial disorientation

Fatal accidents were more commonly associated with spatial disorientation than were non-fatal accidents in private operations. Spatial disorientation commonly occurs when VFR pilots enter into IMC, but it can also occur under other conditions. For example, the ATSB investigated a fatal accident where the pilot became disorientated when flying over dark water after flying in a brightly lit area.

- Studies have found that spatial disorientation can happen to any pilot. Flying experience does not protect a pilot from spatial disorientation (Holmes et al. 2003).
- Newman (2007) describes some measures to prevent spatial disorientation:
  - Do not fly when you are not physically or psychologically fit to do so. Assess your fitness to fly using the IMSAFE checklist described above.
  - Be aware of the potential for spatial disorientation to occur at various stages of a flight and prepare for it as part of the pre-flight routine. For example, pilots should familiarise themselves with the characteristics of the destination runway and approach path as this will help prepare for any visual illusions that may arise (for instance, height illusions associated with approaching a narrow or sloping runway).
  - Exposure to instrument flight with an experienced flight instructor as well as some in-flight disorientation demonstrations and unusual attitude recovery practice would be beneficial.
- In-flight measures for managing spatial disorientation include (Newman, 2007):
  - handing control over to your copilot if you have one
  - contacting air traffic control, asking them for help and giving them your last known position
  - if you are IFR rated, trust in your instruments. This is the best way to minimise the effects of spatial disorientation, even in the face of contradictory visual and vestibular sensations.

Violations

Compared with non-fatal accidents, fatal accidents were more likely to be associated with violations of rules and regulations. Some fatal accidents were attributed to unauthorised low-level flying, overloading the aircraft, and flying at night when the pilot did not have a current night-VFR rating.

- Errors are inevitable and even the most trained pilots in the industry make errors during flight. For instance, line operation safety audits have found that airline pilots made an average of 1.57 errors every flight (Thomas, 2004). Rules and regulations are put in place to trap errors when they occur. Violations of rules and regulations remove these defences and when coupled with an error, increase the likelihood of an accident.

- Pilots need to be aware of and be vigilant about following rules and regulations that are in place. If you find that you are violating regulations, ask yourself why. Is it because of commercial or social pressures or a hazardous attitude for instance? Are these reasons worth violating regulations and risking flight safety?

REFERENCES

Australian Transport Safety Bureau. (2009). Perceived threats, errors and safety in aerial work and low capacity air transport operations. Aviation Research and Analysis Report (AR-2006-156(2)). Canberra: Author.

Australian Transport Safety Bureau. (2010). Avoidable accidents No.1: Low-level flying. Aviation Research and Analysis Report (AR-2009-041). Canberra: Author.

Australian Transport Safety Bureau. (2010). Aviation occurrence statistics: 1999 to 2009. Aviation Research and Analysis Report (AR-2009-016(3). Canberra: Author.

Batt, R., & O'Hare, D. (2005). General aviation pilot behaviours in the face of adverse weather. Aviation Research Investigation Report (B2005/0127). Canberra: Australian Transport Safety Bureau

Broach,D., Joseph, K.M., Schroeder, D.J. (2003). Pilot age and accident rates report 3: An analysis of professional air transport pilot accident rates by age. Retrieved 30 March, 2010 from http://www.faa.gov/library/reports/medical/age60/media/age60_3.pdf

Bureau of Infrastructure, Transport and Regional Economics. (2010). General Aviation Activity 2008 [Data file]. Canberra: Author.

Federal Aviation Administration. (1991). Aeronautical decision making (Advisory Circular 60-22). Washington DC: Author.

Federal Aviation Administration. (2001). *Instrument Flying Handbook* (FAA-H-8083-15). Washington DC: Author.

Guide, P.C., & Gibson, R.S. (1991). An analytical study of the effects of age and experience on flight safety. *Proceedings of the Human Factors Society 35th Annual Meeting* (pp. 180-184). Santa Monica, CA: Human Factors Society.

Holmes, S., Bunting, A., Brown, D., Hiatt, K., Braithwaite, M., & Harrigan, M. (2003). Survey of spatial disorientation in military pilots and navigators. *Aviation, Space, and Environmental Medicine, 74*, 957-965.

International Civil Aviation Organisation. (2001). Annex 13: Aircraft accident and incident investigation (9th ed.). Montreal, QC: Author.

Li, G. (1994). Pilot-related factors in aircraft crashes: A review of epidemiologic studies. *Aviation, Space, and Environmental Medicine, 65*, 944-952.

Li, G., Baker, S.P., Grabowski, J.G., Qiang, Y., McCarthy, M., & Rebok, G. (2003). Age, flight experience, and risk of crash involvement in a cohort of a professional pilots. *American Journal of Epidemiology, 157*, 874-880.

Lubner, M.E., Markowitz, J.S., & Isherwood, D.A. (1991). Rates and risk factors for accidents and incidents versus violations for U.S. airmen. *The International Journal of Aviation Psychology, 1,* 231-243.

Newman, D.G. (2007). An overview of spatial disorientation as a factor in aviation accidents and incidents. Aviation Research and Analysis Report (B2007/0063). Canberra: Australian Transport Safety Bureau.

O'Hare, D. (1999). Safety is more than accident prevention: Risk factors for crashes and injuries in general aviation. In D. O'Hare (Ed.) Human Performance in General Aviation.

O'Hare, D. (2006). Cognitive functions and performance shaping factors in aviation accidents and incidents. *The International Journal of Aviation Psychology, 16*(2), 145-156.

O'Hare, D., & Chalmers, D. (1999). The incidence of incidents: A nationwide study of flight experience and exposure to accidents and incidents. *The International Journal of Aviation Psychology, 9*(1), 1-18.

O'Hare, D., Chalmers, D., & Scuffman, P. (2003). Case-control study of risk factors for fatal and non-fatal injury in crashes of civil aircraft. *Aviation, Space, and Environmental Medicine*, *74*(10), 1061-1066.

Parson, S. (2006, May/ June). Getting the Maximum from Personal Minimums. *FAA Aviation News*, 1-8.

Thomas, M.J. W. (2004). Predictors of threat and error management: Identification of core nontechnical skills and implications for training systems design. *The International Journal of Aviation Psychology, 14*(2), 20 -231.

Walker, M.B., & Bills, K.M. (2008). Analysis, causality and proof in safety investigations. Aviation Research and Analysis Report (AR-2007-053). Canberra: Australian Transport Safety Bureau

Wiegmann, D., Faaborg, T. Boquet, A., Detwiler, C., Holcomb, K., & Shappell, S. (2005). Human error and general aviation accidents: A comprehensive, fine-grained analysis using HFACS. (Report No. DOT/FAA/AM-05/24). Washington, D.C.: Federal Aviation Administration, Office of Aerospace Medicine.

APPENDIX A: CONTRIBUTING FACTOR DESCRIPTIONS

	Contributing factor	Description
Pilot actions	Aircraft handling	Direct manipulation of aircraft flight path and configuration, either through the use of normal flight controls or through FCU, FMS or similar systems. Direct manipulation refers to actions having a relatively immediate change of flight parameters or configuration.
	Assessing and planning	Problems associated with assessment and planning activities, including briefings conducted as part of planning for a particular task (e.g. pre-takeoff briefing or not rejecting take off with an under-performing engine).
	Monitoring and checking	Flight crew actions associated with maintaining awareness of system states (e.g. fuel, engine temperature), environmental states (e.g. weather), traffic disposition and other relevant variables.
Local conditions	Motivation / attitude	Situations in which an individual's motivation or attitude contributes to an pilot action. Includes wide range of concepts such as low levels of motivation, complacency, poor morale, low levels of job satisfaction, learned helplessness, lack of pride in work, overconfidence, lack of confidence, misplacing primary task goals with personal goals, risk-taking, 'macho', aggression, lack of assertiveness, anti-authoritarian, 'get-home-it is', or 'perceived licence to bend rules'.
	Spatial disorientation	Situation where a pilot develops a false sense of his/her orientation relative to the earth or other significant objects. Results from a false (or inadequate) perception of vestibular and somatosensory cues combined with the momentary loss of adequate visual cues.
	Turbulence	Situations where turbulence has influenced aircraft performance, the ability of the pilot to control the aircraft, or the ability of cabin crew or passengers to safely conduct activities in the cabin. Includes clear air turbulence, convective turbulence, terrain-induced turbulence, wake turbulence.
	Visibility	Situations where the ability to detect or process visual information about external environment is impaired due to a reduction in visibility caused by weather or similar phenomena. Includes visibility reduced by rain, cloud, mist, fog, smog, smoke.
	Wind	Situations where the direction or magnitude of wind has influenced aircraft performance, or the ability of the pilot to control the aircraft.