Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Occurrence Report –200605133

Final

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1 September 2006
VH-RIL
Cessna 172L

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Abstract

On 1 September 2006, at approximately 1100 Western Standard Time, the pilot of a Cessna C172L aircraft, registered VH-RIL, was conducting a private, visual flight rules (VFR) flight, and together with four passengers (two adults, one child and an infant), departed from 'Bronco', a cattle mustering area on Mt Vernon station, WA. The pilot was to fly to the homestead on the property, a flight of approximately 10 minutes duration.

At the same time, members of the pilot's family and station staff left Bronco in motor vehicles to drive the approximately 30 km journey back to the homestead. Upon their arrival, it was noted that the aircraft had failed to arrive at the homestead. After attempts to contact the pilot by radio failed, a search was conducted, during which the pilot and child passenger were found walking towards the homestead. The pilot, who was disorientated and injured, reported that the aircraft had crashed in bushland adjacent to the homestead airstrip. The child had minor injuries.

After obtaining general directions to the aircraft, the search party were able to locate the aircraft wreckage. On arrival, searchers found a female adult passenger semiconscious with extensive injuries. The male adult passenger and the infant had been fatally injured.

The pilot and female passenger reported that the aircraft had entered severe turbulence during the descent to land, which resulted in a near-vertical nose down attitude of the aircraft approximately 300 to 350 feet above the terrain.

The investigation determined that the pilot had most likely flown through a strong willy-willy and was unable to recover from the in-flight upset. The investigation also found that it was likely that inadequate restraint of some occupants increased the severity of injuries sustained.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the Transport Safety Investigation Act 2003 and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

FACTUAL INFORMATION

Sequence of events

On 1 September 2006, at approximately 1100 WST[1], the pilot of a Cessna C172L aircraft, registered VH-RIL, was conducting a private, visual flight rules flight, and together with four passengers (two adults, one child and an infant), departed from 'Bronco', a cattle mustering area on Mt Vernon station, WA. The pilot was to fly to the homestead on the property, a flight of approximately 10 minutes duration.

At the same time, members of the pilot's family and station staff left Bronco in motor vehicles to drive the approximately 30 km journey back to the homestead. Upon their arrival, it was noted that the aircraft had failed to arrive at the homestead. After attempts to contact the pilot by radio failed, a search was conducted, during which the pilot and child passenger were found walking towards the homestead. The pilot, who was disorientated and injured, reported that the aircraft had crashed in bushland adjacent to the homestead airstrip. The child had minor injuries.

After obtaining general directions to the aircraft, the search party were able to locate the aircraft wreckage. On arrival, searchers found a female adult passenger semiconscious with extensive injuries. The male adult passenger and the infant had been fatally injured.

The pilot later reported that, on departing Bronco, the weather had been calm and clear, with a temperature of 35 degrees Celsius. During the flight, light turbulence was experienced, with the pilot observing willy-willies[2] approximately 3 to 5 km in the distance. On commencing descent, and after selecting flaps in preparation to land, the aircraft entered severe turbulence that resulted in it moving rapidly around all three axes before adopting a near-vertical nose down attitude, 300 to 350 ft above the ground.

The pilot recalled that, during the early stages of the in-flight upset, he glanced over to the male passenger and observed his hands on the control column. The pilot shouted to the passenger to release the column, while he fought to stabilise the aircraft. The pilot could not recall at what point during the turbulence that had occurred or if it had any affect on the handling of the aircraft. He did recall that, in responding to the in-flight upset, the controls felt heavy and he needed to apply more power, but could not remember whether more power was applied.

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1 The 24-hour clock is used in this report to describe the local time of day, Western Standard Time (WST), as particular events occurred. Western Standard Time was Coordinated Universal Time (UTC) +8 hours.

2 Willy willies (also known a dust devils) – A revolving mass of air resulting from local atmospheric instability, such as that caused by intense heating of the ground by the sun on a hot summer day. Examples are … … small whirls of dust or leaves, and the sand whirls of the desert, called dust devils [Willy willies] or dust whirls. http://columbia.thefreedictionary.com/Willy+willies

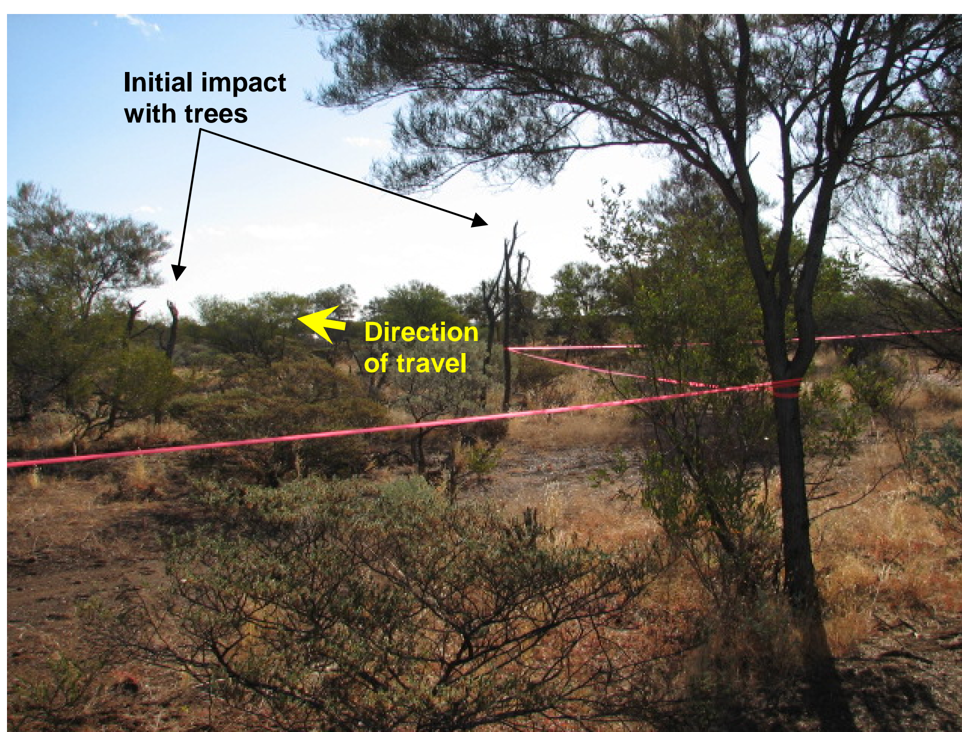
Soon after, the aircraft entered foliage, impacted the ground and came to rest in an almost inverted position.

Wreckage site

The Australian Transport Safety Bureau (ATSB) conducted an on-site examination of the wreckage.

The wreckage trail extended for 70 metres, with the initial impact being contact with Mulga trees. From the dissimilar heights of the damaged tree trunks (Figure 1) and given the length of the wreckage trail, it was determined that the aircraft had entering the foliage in a left wing-low, near-horizontal attitude with a descent angle of approximately 4 degrees.

Figure 1. View looking at initial impact with trees



An examination of the accident site indicated that, during the impact sequence, the aircraft contacted several trees, tearing the right wing and right horizontal stabiliser from the fuselage, which resulted in the aircraft rolling to the right. The right main landing gear also separated from the fuselage, coming to rest on the left side of the wreckage trail approximately 50 metres from the initial impact. Because of its rotated attitude, the right side of the aircraft sustained the most damage, with the right door and door pillar being torn from the aircraft structure. The aircraft came to rest in a near inverted position with the fuselage breached behind the cabin (Figure 2).

Figure 2. Fuselage breached at the rear of cabin with right wing, horizontal stabiliser and main landing gear torn away

Aircraft information

Manufacturer	Cessna Aircraft Corporation
Model	C172L
Serial Number	17259230
Registration	VH-RIL
Country of manufacture	USA
Date of Manufacture	1970
Date of import to Australia	1972
Total time in Service (TTIS)	11,051.6 hours (at time of accident)
Last Maintenance	9 Feb 2006
Type of maintenance	100 hourly

The aircraft was acquired by the Mt Vernon Station property owner on 15 March 2005. The pilot was the registered operator of the aircraft.

The aircraft had undergone a periodic 100-hourly inspection on 9 February 2006 at 10,961.4 hours TTIS or 1080.18 hours Engine Tachometer Time (ETT), when the aircraft's maintenance release had been issued.

That maintenance release was due to expire on 9 Feb 2007 or 11,061.4 hours TTIS or 1180.2 hours ETT.

Engine

Engine Manufacturer	Textron Lycoming
Model	O-320-D2J
Engine Serial Number	L-11535-39A
Overhaul Life	2,000 hours time between overhauls (TBO)
Next Overhaul Due	11,348.6 Airframe hours TTIS
Hours to run to overhaul	296 remaining

Propeller

Propeller Manufacturer	McCauley
Model	1C160/DTM7557
Propeller Serial Number	JB007
Overhaul Life	2,200 hours TBO
Next Overhaul Due	12,208.3 Airframe hours TTIS
Hours to run to overhaul	1,156.7 remaining

Wreckage examination determined that, prior to the accident the aircraft had been configured for landing with the flaps extended to approximately 20 degrees. The on-site examination of the aircraft did not find any system anomalies that would have prevented controlled flight. All structural damage observed was as a result of impact with foliage and terrain. Evidence indicated that the engine had been producing power at the time of impact. After the on-site assessment, the engine and propeller were removed for disassembly and further examination with no anomalies found.

Aircraft weight and balance

The aircraft departed from Bronco, with three adults, one child, one infant and approximately 60 litres of fuel on board. No additional baggage or cargo was carried in the aircraft, aside from the aircraft tie down kit and some small personal effects. Calculations indicated that the aircraft was within its weight and balance limitations.

Pilot Qualifications

The pilot held a private pilot's (aeroplane) licence and had completed an aeroplane flight review on 8 January 2006. He also held a valid Civil Aviation Safety Authority (CASA) class 2 medical certificate. The pilot had accumulated a total of 1,897 flying hours, with approximately 1,800 hours on the Cessna C172L aircraft. In the 30-day period preceding the accident, the pilot had flown 10.7 hours. He had not flown in the three days prior to the accident.

Occupant injuries

The pilot sustained serious injuries to his head and upper body.

The male passenger received fatal injuries. His injuries were contained primarily to the right side of the head and upper body.

The female passenger sustained multiple fractures to her arms, and bruising to the body primarily on the right side.

The infant was located outside the aircraft and had sustained fatal injuries.

The child passenger received minor injuries in the form of bruising across the abdomen and hips.

Occupant seating and restraint

The aircraft was configured with two front seats and a bench rear seat. There were safety restraints for four occupants; the front two seats had lap and shoulder strap restraints with the rear bench seat having two lap-strap restraints. The pilot and the male passenger, who had previous passenger experience in light aircraft, occupied the front seats. The pilot advised that he and the male passenger were wearing the lap straps only, neither had the shoulder straps fastened. The female and the child were seated on the rear seat, with the infant seated on the female's lap. Both the female and child wore the lap strap seatbelts. The infant was not wearing a restraint belt and was being restrained by the arms of the female passenger.

Meteorological conditions

The pilot assessed the weather condition for the vicinity of the intended landing as approximately 35 degrees Celsius with an 8 to 10 knot westerly wind. During the flight, both the pilot and female passenger observed numerous willy-willies within 3 to 5 km of the airstrip.

A local meteorological observer confirmed the weather conditions at the time were conducive to the formation of strong willy-willies with high ground temperature and light wind. He added that vertical development could readily be between 500 ft and 1,000 ft above ground level.

The accident site was attended by the Royal Flying Doctor Service. The pilot of that flight was amongst the first to approach the area by air. He confirmed seeing strong willy-willy activity in the area.

Willy-willies

Willy-willies occur as a result of hot air at ground level expanding, becoming less dense, and rising rapidly. Sideways movement (such as a light wind) in the initial upward surge of the air, establishes a vortex and a twisting, rising column is formed. Willy-willies are only seen by the naked eye when dust or debris is picked up within the vortex (Figure 3). As a result, not all Willy-willies are visible.

Figure 3. A Willy-willy

Willy-willies are capable of vertical development in excess of 1,000 feet above ground level, with reports of grass lifted in Willy-willies being observed at 8,000 feet in Western Queensland. The air within Willy-willies is very unstable with rapid rising thermals and downdrafts created.

A 1988 research paper into the effect of meteorological phenomena such as willy-willies (also known as dust devils), on light aircraft was published in the US publication, Journal of Aircraft.[3] The research focussed on the structure, behaviour and effects of the updrafts and downdrafts that occur within them.

The significance of their findings to aviation was seen in the occurrence of downdrafts of greater than 2 m/s (approximately 394 ft/min) at a height of 140 m (459 ft) for 2% of the time. That equated to affecting one landing in every 50 where a willy-willy had been encountered.

The downdraft and outflow model developed suggested that, aircraft affected would experience a variation in lift of ±30% during landing. By way of example, the report considered a light aircraft making an approach to land at an indicated airspeed of 70 kts, which encountered a willy-willy with a core downdraft of 1.05 m/s. The pilot would need to correct for lift variations of ±30% and downdraft sink of 206 ft/min, in addition to the existing normal descent rate of 350 ft/min associated with the approach.

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3 Spillane, K.T. and Hess, G.D., Fair Weather Convection and Light Aircraft, Helicopter and Glider Accidents in *Journal of Aircraft* Vol 25, No 1, Washington, Jan 1988, p. 55-61.

A 1990 Bureau of Meteorology Research Report[4] confirmed the findings of the previous research paper and added further data highlighting the following:

- the major hazard willy-willies pose to aviation is during times of takeoff and landing for light aircraft
- not all willy-willies are visible
- willy-willies of convective origin mainly occur between 1000 and 1500 local time
- there is a tendency for willy-willies to form near the edge or over runways.

Aircraft handling and configuration

The pilot had elected to join on the final leg and make a straight-in approach for the secondary airstrip, runway 27 (Figure 4). That was intended to place the aircraft into wind for the landing. The pilot reported being on a normal approach profile with flap extended to about 20 degrees, although he was not sure how much flap he had selected.

Figure 4. Aerial view of airstrip

Image courtesy of Google Earth™

The pilot recalled a power setting in the vicinity of 1,800 to 2,000 revolutions per minute and airspeed of 75 to 80 kts. Both the pilot and female passenger confirmed that conditions were rough due to turbulence.

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4 Spillane, K.T. and Hess, G.D., A Survey of Australian Dust Devils in *BMRC Research Report No. 20* Bureau of Meteorology Research Centre, Melbourne, June 1990.

At approximately 1 km from the runway 27 threshold, slightly right of the extended centreline, and at a height of approximately 500 ft above aerodrome elevation (which due to the down slope of the terrain towards the airstrip, placed the aircraft approximately 300 to 350 ft above the ground), the pilot reported encountering severe turbulence. The female passenger (who had travelled as a passenger in the aircraft for a number of years) similarly recalled encountering turbulence more severe than she had ever experienced causing her to scream in alarm.

As a result of the turbulence, the aircraft initially became uncontrollable and moved rapidly around all three axis, before rapidly assuming a near-vertical, nose down attitude.

During the attempt to recover the aircraft, the pilot observed the male passenger in the right seat braced with his hands on the control column. The pilot shouted to the passenger for him to release the controls, while attempting to pull the aircraft up. The pilot recalled the control column was able to be moved but felt heavy and ineffective. The aircraft then entered the foliage in a near-horizontal, left wing low attitude before impacting trees and rolling approximately 90 degree to the right.

Aircraft flight characteristics

Various C172 model owner's manuals contained a statement that slips should be avoided with flaps extended due to the downward pitch encountered under certain combinations of airspeed, side-slip angle and centre of gravity loading.

Some C172 models contained a placard located in the cockpit near the flap indicator stating the following:

> AVOID SLIPS WITH FLAPS EXTENDED.

Child and Infant restraint requirements

CASA defined a child as being a passenger who had reached its third but not thirteenth birthday and an infant as a passenger who had not reached its third birthday.

The requirements for child and infant restraint on aircraft were contained in *Civil Aviation Regulation (CAR) (1988), Part 14 –* Air Service Operators, *Division 4 General Provisions relating to the Operation of Aircraft*, which stated that:

> 251 Seat belts and safety harness
>
> (1) Subject to this regulation, seat belts shall be worn by all crew members and passengers:
>
> (a) during take-off and landing;
>
> (b) during an instrument approach;
>
> (c) when the aircraft is flying at a height of less than 1,000 feet above the terrain; and
>
> (d) at all times in turbulent conditions.

Further detailed requirements were contained in *CAO*[5] *20.16.3. subsection 4 - Seatbelts and safety harnesses*, which stated:

> 4.1 Except as provided in subsections 14 and 16 safety harnesses, or Seat belts where safety harnesses are not fitted, shall be worn by all persons at the times listed in paragraph 3.1. Seat belts should be adjusted to fit the wearer without slack.

Subsection 13.2 - Carriage of infants and children, stated:

> 13.2.(1) An infant may be carried in the arms or on the lap of an adult passenger, in a bassinet or in an infant seat in accordance with paragraphs 13.3, 13.4, 13.5 and 13.6 providing the bassinet or infant seat is restrained so as to prevent it from moving under the maximum accelerations to be expected in flight and in an emergency alighting, and precautions are taken to ensure that, at the times seat belts are required to be worn, the infant will not be thrown from the bassinet or infant seat under these accelerations.
>
> (2) When an infant is carried in the arms or lap of a passenger in accordance with subparagraph 13.2 (1) the seat belt, when required to be worn, shall be fastened around the passenger carrying or nursing the infant, but not around the infant.
>
> (3) When an infant is carried in the arms or on the lap of a passenger in accordance with subparagraph 13.2 (1) on an aircraft engaged in charter or regular public transport operations, the name of the infant shall be bracketed on the passenger list with the name of the person carrying or nursing the infant.
>
> (4) An infant must not be carried in an exit seat during take-off or landing unless the pilot in command is satisfied that the infant's presence in the seat will not obstruct or hinder the escape of other persons from the aircraft.
>
> (5) In subparagraph (4), exit seat means a seat that is in a row of seats adjoining an exit.

The remainder of CAO 20.16.3 stated:

> 13.3 An infant seat, being a seat designed for the seating and restraint of infants, must not be used on an aircraft unless CASA or a recognised authority has approved the seat in writing as being of a type that is suitable for use by infants in an aircraft.
>
> 13.4 In paragraph 13.3, recognised authority means the Civil Aviation Authority of the United Kingdom, the Federal Aviation Administration of the United States of America or the authority of another country that is responsible for the safety of air navigation and that CASA declares in writing to be a recognised authority for the purposes of paragraph 13.3.
>
> 13.5 An infant seat must not be used on an aircraft:
>
> (a) if it is secured to a side-facing seat; or
>
> (b) unless it is secured at all times during the flight, by means of a seat belt or as otherwise approved, to a seat ordinarily used by an adult passenger.

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5 CAO – Civil Aviation Order.

13.6 The use of an infant seat on an aircraft is subject to such conditions (if any) of which CASA notifies the operator of the aircraft in writing.

In 2002, CASA issued a letter to industry regarding the use of infant restraints to help clarify the confusion over the legal requirements for the restraint of infants and children on aircraft. That letter was distributed to all air operator certificate holders, all aeroplane flight crew license holders and all helicopter flight crew license holders.

The letter noted that CAO 20.16.3 may be construed as allowing an infant to travel unrestrained in an aircraft. However, CAR (1988) 251 stated that all passengers must wear a seat belt at stipulated times throughout the flight and that the adult seat belt must not be used for lap held infants.

The letter strongly advised that individual car type infant seats, that complied with Civil Aviation Advisory Publication (CAAP) 235-2 (0) were permitted for use or where not available, the use of an infant 'belly' belt or other suitable alternatives were permitted for infant restraint.

Later that same year (2002) a revised CAAP 235-2 (amendment 1) was issued, detailing acceptable means of restraint for a lap held infant and the acceptable types and fitment of 'car type' infant seats (Appendix A).

Approved child and infant restraint systems

CASA had approved the use of a supplementary loop belt known as a 'belly' belt, for restraint of lap carried infants. These belly belts consisted of a single lap strap with a loop sewn into it. When an adult was seated with an infant on their lap, they fed the seat lap strap, through the belly belt loop, fastening the lap strap normally. The belly belt was then fastened around the infant, effectively securing the infant to the seat's lap strap. These types of restraints were common on airlines within Australia as they are light, unobtrusive and did not take up additional seating space.

CASA had also approved the use of rearward and forward facing automotive child restraint seats and capsules that were internationally approved for aircraft use or met Australian Design Standard (Automotive) AS/NZS 1754.

Research into child and infant restraint

Over the past five decades, a number of research studies have been conducted into aircraft child restraint systems (CRS). In 1962 the US, Civil Aeromedical Research Institute (CARI) conducted an assessment of child harness and bassinet systems in full-scale crash tests. In 1972, tests of infant seats were conducted in the US with a recommendation that they be allowed for use on aircraft. By the 1980s, a great deal of research into dynamic testing of automotive type CRS had been carried out.

In 1994, a US Civil Aerospace Medical Institute (CAMI) study found that lap held restraint systems allowed excessive forward body excursion of the infant, resulting in severe head impact with the seatback directly in front. The study also found that a lap held infant could be crushed between the back of the forward seat and the

accompanying adult during impact[6]. As a result of that study, in 1996, the US Federal Aviation Administration (FAA) imposed a ban on the use of all lap held restraint devises (belly belts) and booster seats in aircraft during takeoff, landing and taxiing, preferring the infant to be hand held or restrained by another method.

In 2006, the ATSB released the findings of a study into CRS titled 'Child Restraint in Australian Commercial Aircraft[7]'. The aim of that study was to review the development in safe transport of children in aircraft, and to conduct a test program of current Australian CRS, which included forward and rearward facing automotive infant/child restraints, child booster seats and aircraft lap straps. The study also carried out an assessment of infant carrier systems (commonly known as baby slings) to determine their suitability for use as restraints in aircraft.

The study found that the use of automotive CRS in aircraft was far safer for infants and children than if they were simply lap held (with or without restraint). However, under high deceleration rates, the motion of the CRS was not as well controlled as when tested for motor vehicles, with all types exhibiting significant forward motion, rotation and rebound motion. The lack of an upper tether on the CRS was the most significant cause of their excessive forward motion, and had a direct effect on the amount of head excursion that occurred.

As a result, the study proposed a number of suggested actions which included:

1. The use of CRS by infants and young children on flights in Australia is to be encouraged. The CRS used could be either designed specifically for use in aircraft, or, Australian automotive CRS approved for use in aircraft as per suggestion number 3.
2. Testing should be conducted of the system of an upper tether strap for Australian automotive CRS with a non-breakover aircraft seat back, as currently used by Qantas.
3. An approval system should be established to ensure that any Australian automotive CRS to be used in aircraft fits in the aircraft seat and is compatible with the aircraft lap belt. The approval could be in the form of an extra test added to the existing motor vehicle requirements similar to the FAA approval system.
4. Improvements in the crash performance of Australian automotive CRS in aircraft could be achieved by making changes to the seating systems in the aircraft to minimise forward excursion of the CRS in the seat. In order of priority, these suggested improvements are:
    a. Supply a properly mounted upper tether, either as used by Qantas should testing show that this is effective or, by supplying attachment points in the aircraft for CRS use. This could be achieved by restricting CRS use to the seats forward of a bulkhead and by requiring a modified bulkhead design with appropriate attachment points built in for the tether.

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6 CAMI study – *Gowdy & De Weese, 1994.*

7 Australian Transport Safety Bureau, Aviation Safety Research Grant Report B2004/0241- Child restraint in Australian Commercial Aircraft, *T Gibson, K Thai (Human Impact Engineering) & M Lumley (Britax Childcare Pty Ltd, Australia).*

b. Change lap belt geometry (angled at 45 to 60 degrees instead of vertical) for use with a CRS to reduce the initial forward excursion of the base. However, such seat belt geometry may not be appropriate for other users of the belt.

c. Make changes to the seat base cushion to ensure its retention under CRS dynamic loads.

5. Improvements in the crash protection offered in aircraft to an infant seated on the lap of an adult could be achieved if some seats were fitted with lap sash or harness type seat belts for use by parents holding infants. These seats, possibly adjacent to a bulkhead could be forward or rearward facing. Controlling the upper torso motion of the adult has the potential to reduce crash loading to an infant seated on the lap of an adult.

6. If suggestion 5 was implemented, then an approval system for infant carriers (slings) for use in aircraft should be put in place. A sling system could be designed and developed as a replacement for the belly belt. This type of infant carrier could offer improved retention and comfort in turbulent conditions; in conjunction with appropriate seating fitted with a lap/sash or harness for the parent, it could offer improved safety for the infant in a crash.

7. The changes resulting from the incorporation of the ISO [International Standards Organisation] rigid anchorage systems (ISO-fix or latch systems), which are becoming mandatory worldwide, need to be studied and accommodated for use in aircraft.

The primary focus of the majority of research into CRS to date has been on high and low capacity regular passenger transport category aircraft. A small amount of work in 1983 was carried out by the US, General Aviation Safety Panel (GASP) on crashworthy adult seat and CRS for small private aircraft.

In 2006, CASA conducted research into alternative attachment methods of CRS in aircraft. The result of that research is yet to be published.

ANALYSIS

Aircraft loss of control

The aircraft damage observed was consistent with ground impact, due to aircraft loss of control, resulting from inadvertent flight into a willy-willy at low altitude. Examination of the wreckage did not find any aircraft or engine system anomalies that would have prevented normal controlled flight. The aircraft had been operated within its performance parameters and had sufficient fuel on board for the flight.

The pilot was appropriately licensed and experienced on the aircraft type, having obtained in excess of 1,800 flying hours. He was familiar with the area in which he was flying.

The pilot, female passenger and other witness recollections, confirmed the high probability of willy-willy activity in the area at the time of the accident. The ground foliage in that area may have prevented dust being lifted within the willy-willy, reducing its visibility to the pilot. The turbulence and movement of the aircraft while approaching to land was likely to have produced a violent side-slip condition that, with flaps extended, resulted in an uncontrolled near-vertical, downward pitch of the aircraft.

Research had shown that a rapid downdraft sink rate can be experienced during flight through willy-willies. Considering the aircraft's height above local terrain and that the aircraft was in descent, recovery of the aircraft from the rapid sink rate and the near-vertical nose-down attitude encountered would have been extremely unlikely.

Although the pilot reported momentarily observing the male passenger's hands on the control column during the initial stages of the in-flight upset, the duration and effect that action had on the control of the aircraft cannot be determined. The severity of the turbulence and violent pitching of the aircraft, may have led to an instinctive reaction of the male passenger to reach out and brace himself, grabbing the control column. However, the pilot was able to continue to operate the controls and obtain a near-horizontal attitude before impacting the foliage, indicating that no attempt to override the pilot's inputs or control of the aircraft was made by the passenger and that release of the controls had occurred quickly.

Willy-willies

Research has shown that willy-willies present a high risk to light aircraft (both fixed wing and helicopters) during takeoff and landing, because of the dramatic downdrafts that can occur. That risk was increased due to the inability to see willy-willy formations in some instances. Key factors effecting willy-willy formation were high surface temperatures and light winds, with formations occurring most commonly along the edge or over runways and between the hours of 1000 and 1500 local time.

Survivability

The severity of the injuries sustained by the passengers seated on the right of the aircraft were consistent with the high impact loads observed in the structural damage found on the aircraft's right side. Both front seat occupants sustained injuries to their heads and upper bodies consistent with impacting the instrument panel and control columns. These injuries would likely have been reduced had the shoulder straps been worn, restricting upper body movement.

The high impact forces, prevented unaided physical restraint of the infant within the aircraft. Research has indicated that had a Civil Aviation Safety Authority (CASA) approved child restraint systems (CRS) been used, there was a greater likelihood of retention of the infant within the aircraft, and the potential for the severity of injuries to have been reduced.

Child and infant restraint requirements

Although CASA approved the carriage of infants less than 3 years of age in the arms or on the lap of an adult, some confusion over the additional restraining requirements for those infants existed. CASA's awareness of that confusion led to the issue of a letter to industry and the publication of Civil Aviation Advisory Publication (CAAP) 235-2 in 2002. However, the focus of research into child and infant restraint had been primarily on high capacity regular public transport aircraft and not smaller private or charter aircraft.

FINDINGS

Contributing safety factors

- The aircraft entered a region of severe turbulence, the likely result of an unseen willy-willy formation.
- With the wing flaps extended during the encounter with severe turbulence, the pilot was unable to maintain control of the aircraft and it adopted a sudden near-vertical nose-down attitude.
- A lack of adequate restraint devices for the infant passenger resulted in unrestrained movement of the infant during the accident sequence.
- The front seat occupants did not fasten their shoulder straps, leading to a higher degree of upper body and head injuries.

SAFETY ACTION

The Civil Aviation Safety Authority

In 2002, CASA provided advice to industry regarding the requirement to restrain lap held infants at certain stages of flight by issue of a letter to industry and publication of CAAP 235-2(0) and CAAP 235-2 (2). Since that time, CASA has conducted further research into child restraint systems (CRS) and presented its findings to the international community at the 5th Triennial International Fire & Cabin Safety Research Conference, in 2007.

At the time of the issue of this report, CASA advised the following had been planned:

- revision of CAAP 235-2 (2)
- issue an Airworthiness Bulletin on the installation of automotive child restraints in transport category and general aviation aircraft
- start a public education campaign on CRS, including general aviation applications
- start a public education campaign on the hazards and risks associated with flying in the vicinity of willy-willies.

APPENDIX A

CAAP 235-2(1)

Civil Aviation Advisory Publication December 2002

Carriage and restraint of small children in aircraft

This publication is only advisory but it gives the CASA preferred method for complying with the Civil Aviation Regulations 1988 *(CAR 1988).*

It is not the only method, but experience has shown that if you follow this method you will comply with CAR 1988.

Always read this advice in conjunction with the appropriate regulations.

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References

- Subregulation 235 (7), regulation 251 and Civil Aviation Orders Section 20.16.3.
- Regulations referred to in this CAAP are regulations under CAR 1988

Who this CAAP applies to

- Operators and owners of passenger aircraft
- Passengers

Why this CAAP was written

This CAAP has been prepared by the Civil Aviation Safety Authority (CASA) to provide advice relevant to regulations 235 and 251 and more particularly to subsection 13 of Civil Aviation Order 20.16.3, Air Service Operations – Carriage of Persons. This publication details acceptable means of restraint for a lap held infant and the acceptable types and fitment of 'car type' infant seats as an option to the existing methods of carriage and restraining small children in Australian passenger aircraft.

Status of this CAAP

This is the second issue of this CAAP and cancels CAAP 235-2(0).

For further information

Contact the CASA Area Office closest to you.

1. Directions under regulation 251

1.1 Subregulation 251 (1) requires that, during take-off and landing and other specified times during flight, all occupants shall be restrained by at least a seat belt. Subregulation 251 (3) provides for alternate restraint for occupants in lieu of a seat belt.

1.2 Paragraph 13.2 of Civil Aviation Orders Section 20.16.3 (CAO 20.16.3) permits an infant to be carried in the arms or on the lap of an adult passenger, in a bassinet or in an infant seat in accordance with the conditions specified in paragraphs 13.2, 13.3, 13.4, 13.5 and 13.6. However, in all these situations the requirement of subregulation 251 (1) for all occupants to be restrained remains applicable.

2. Restraint for a lap held infant

2.1 An infant carried in the arms of an adult passenger (lap held) must be restrained, but the adult seat belt must not be fastened around both adult and infant. During an emergency landing sequence, the restraining loads on the adult would be transferred from the lap belt <u>through the infant</u> causing serious or potentially fatal injuries.

2.2 A device known as a "supplementary loop belt" provides an additional seat belt with stitched loops through which the adult seat belt is passed. The adult belt is fastened around the adult, and the additional belt is then separately fastened around the infant. This is the only known device which provides an acceptable restraint for a lap held infant during the times specified in CAO 20.16.3 subsection 3.

2.3 The supplementary loop belt was developed from the extension belt used for the larger adult passenger. Without the stitched loops, the webbing would be twisted out of plane when passed through the adult belt and around the infant and would tend to pull the adult belt's release buckle out of alignment. An extension belt without stitched loops is not acceptable as an infant restraint.

2.4 The supplementary loop belt will provide some restraint to an infant during turbulence or mild longitudinal emergency loading such as a rejected take off. However, the supplementary loop belt <u>does not</u> provide an equivalent level of protection to a lap belt restraint for a separately seated adult during a severe but potentially survivable crash. The supplementary belt is even less effective for a new-born infant as their skeletal structure would be unable to cope with any significant load from the 5 cm wide webbing. For an equivalent level of protection, all infants should be seated in an individual infant restraint device in a separate passenger seat.

3. The use of bassinets

3.1 An infant under approximately 6 months old is unsuitable for a forward facing car type child seat. A rear facing reclined seat or other means to allow the infant to lie down is required.

3.2 Rear facing or convertible car type infant seats are addressed in paragraph 4 below.

3.3 Bassinets have often been used in aircraft to permit a lap held infant to rest during flight. However, most installations have not been approved for use during take-off or landing. A common installation for the bassinet has been to mount it to a bulkhead immediately ahead of the passenger seat. The bassinet is stowed for take-off and landing as it would otherwise interfere with an emergency evacuation.

3.4 A bassinet or other device mounted separately to a passenger seat would only be acceptable if the installation has been shown to provide protection for the infant and does not interfere with any other safety aspect of the aircraft and has been approved to this effect.

4. The use of a car type infant seat in an aircraft

4.1 Subsection 13 of CAO 20.16.3 permits an infant to be carried in an acceptable separate child restraint system (CRS) fastened to a passenger seat. This could be forward or rearward facing and is the preferred method of restraint for an infant. A child up to age 4 would also be more effectively protected if seated in a CRS provided the weight or size of the child does not exceed the placarded limits of the device. Any child seat must be secured to the aircraft seat in accordance with the child seat manufacturer's instructions or an approved alternate method.

4.2 A rear facing CRS could be a capsule type or seat type and is suitable for the younger infant who is unable to sit upright. There are also "convertible" seats which can be rear facing and then forward facing when the infant develops. Due to their design, these CRS are usually larger, and may not physically fit into some aircraft seats, particularly in the smaller regional aircraft. As for all CRS, the installation must be in accordance with the manufacturers' instructions or an approved alternate method.

4.3 A child booster cushion in a motor vehicle allows an older child to be adequately restrained in the lap/sash restraint and for the child to see out the window. Booster cushions normally do not provide any back or side protection and do not have integral belts to restrain the child. For aircraft use, a booster cushion is not recommended and would not be acceptable unless an upper torso harness (either symmetric or single shoulder strap) is fitted to the aircraft seat which is used to restrain both the child and the

booster cushion and where the aircraft seat back does not fold forward under design crash loads. When not in use the cushion should be stowed or otherwise appropriately restrained

4.4 Those seats currently acceptable in Australia are:

(a) seats complying with Australian design standard AS/NZS 1754 for infant car seats which are secured in the aircraft in a manner consistent with the seats' design criteria. As this standard requires a 3-point attachment, a top tether, in addition to the fastened lap belt, must be fitted. See paragraph 4.5 below;

(b) seats accepted by the Federal Aviation Administration of the United States of America as meeting the Technical Standard Order TSO-C100b or seats which have two markings: "This Restraint is Certified for Use in Motor Vehicles and Aircraft" in red lettering and "This seat conforms to all applicable Federal motor vehicle safety standards";

(c) seats approved to Canadian Motor Vehicle Safety Standard (CMVSS) No. 213 entitled "Child Restraint Systems" or CMVSS No. 213.1 entitled "Infant Seating and Restraint Systems";

(d) seats accepted by the Civil Aviation Authority of the United Kingdom for which general guidance can be found in the CAA Official Record Series 4 General Exemption – Child Restraint (Public Transport);

(The Type 2040-1 Carechair, manufactured by Aviation Furnishings International Limited has been accepted by the CAA(UK) as a child safety seat specifically designed for aircraft applications)

(e) seats meeting European Safety Standard requirements of ECE Regulation 44.

4.5 If the securing of a child seat in an aircraft involves more than using the aircraft lap belt, the design of the installation must be approved as a modification to the aircraft under regulation 35.

5. Fitment and use

5.1 Child and Infant seats should:

(a) be installed in accordance with the child/infant seat manufacturer's instructions;

(b) not be located in the row adjacent to an emergency exit or immediately forward or aft of such a row. This does not apply where the low seating capacity of the aircraft is such that this limitation is impractical; and

(c) not obstruct access and passageways to any emergency exit.

5.2 A window seat or the middle row of seats in a two-aisle aircraft are the preferred locations although aisle seats are acceptable when the seats in the same row are occupied by persons responsible for the infant.

5.3 Only one infant seat should be located in any one row unless the infants are in the same family or traveling group.

5.4 The condition and continued maintenance of these seats is the responsibility of the owner of the seat. The seat should be serviced in accordance with the manufacturer's instructions.

5.5 Operators or passengers may supply these infant seats. The option of using infant seats on certain flights is a matter purely between operators and passengers.

6. Restraint in special circumstances

6.1 In special operations, such as aeromedical, the condition of the child may prevent, without being detrimental to their health, the use of restraints described above or any restraint on the child. In these circumstances, alternate means, such as humidicribs need to be considered which provide as much crash protection to the child and other occupants as is possible within the restrictions due to the child's condition. Any such alternative or non compliance with the regulation must obtain, from CASA, either specific approval or approval of procedures to address the situation. (Refer exemption CASA EX40/2002).

7. Further advice from regulatory bodies

7.1 Further advice on the specific standards applied in the United States can be obtained from:

The Director, Flight Standards Service
Federal Aviation Administration
800 Independence Ave, S.W.
Washington, DC USA
or

National Highway Traffic Safety Administration
Docket Section, Room 5108
400 7th Street, SW
Washington, DC USA

7.2 Further advice on the specific standards applied in the United Kingdom can be obtained from:

Civil Aviation Authority
Safety Regulation Group
Aviation House
Gatwick Airport South
West Sussex RH6 0YR
United Kingdom

7.3 Further advice in the Australian context can be obtained from:

The Executive Manager, Aviation Safety Standards
Civil Aviation Safety Authority
GPO Box 2005
Canberra ACT 2601
Australia

Bill McIntyre
Executive Manager
Aviation Safety Standards