Australian Government
Australian Transport Safety Bureau

Amateur-built aircraft

Analysis of accidents involving VH-registered non-factory-built aeroplanes 1988–2010

Part 2

Research

ATSB Transport Safety Report
Aviation Research Investigation
AR-2007-043(2)
Final – 26 March 2013

Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Research Report

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FINAL

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Part 2:
Analysis of accidents involving VH-registered non-factory-built aeroplanes 1988-2010

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SAFETY SUMMARY

Why have we done this report

In the last three decades, Australia has seen a significant growth in the number of amateur-built aeroplanes (aircraft built for personal use from an original design, established plans or kit, which are not entirely built and assembled in a factory). However, the safety record of amateur-built aircraft in Australia had not been robustly established.

What did this report do

The ATSB investigated the safety history of amateur-built aircraft in Australia through analysis of accident data held in the ATSB's occurrence database from 1988 to 2010. Comparisons were made between accidents involving amateur-built aircraft and those involving similar factory-built aircraft to help identify whether the rate and types of accidents differed between these two groups of aircraft.

What the ATSB found

Amateur-built aircraft had an accident rate three times higher than comparable factory-built certified aircraft conducting similar flight operations between 1988 and 2010. The fatal and serious injury accident rate was over five times higher in amateur-built aircraft, in particular due to relatively more serious injury accidents.

The pilots of amateur-built aircraft involved in accidents were significantly more experienced overall than factory-built aircraft accident pilots. However, they were significantly less experienced on the aircraft type that they were flying at the time of the accident.

Over half of the accidents were precipitated by mechanical events, which were mainly complete or partial engine failures. Following the amateur-built phase one test period, mechanical failures were still significantly more common when compared with factory-built aircraft. A quarter of accidents were from loss of aircraft control. Structural failures were not common precursors in amateur-built aircraft.

Collision with terrain and forced landing accidents were more frequent in amateur-built aircraft. Collisions with terrain, hard landings, and runway excursions were more likely to result in a serious injury from an amateur-built aircraft accident than for factory-built accidents.

Safety Message

Builders of amateur-built aircraft should select, install and maintain aircraft engines carefully as engine issues are the most likely reason why an accident will occur. Careful consideration to occupant protection at the time of building is also encouraged as serious injuries have been disproportionally more common.

Owners of amateur-built aircraft should ensure they have adequate training in the same type of aircraft before operating the aircraft they have built, or purchased second-hand.

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Addendum

Page	Change	Date
103	For the accident dated 23/02/2007 the aircraft model was incorrectly recorded as a Lancair 320. It has been changed to Van's RV-4.	31 May 2013

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

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 identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, 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 initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes appropriate, or to raise general awareness of important safety information in the industry. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Accident: an investigable matter involving a transport vehicle where:

(a) a person dies or suffers serious injury as a result of an occurrence associated with the operation of the vehicle; or

(b) the vehicle is destroyed or seriously damaged as a result of an occurrence associated with the operation of the vehicle; or

(c) any property is destroyed or seriously damaged as a result of an occurrence associated with the operation of the vehicle.

Incident: An occurrence, other than an accident, associated with the operation of a transport vehicle which affects or could affect the safety of operation.

Occurrence: accident or incident.

Private operations: Flight operations not for hire or reward, including flights for pleasure and business travel.

Safety factor: An event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Serious damage: Serious damage means the destruction of the aircraft; or damage that significantly affects the structural integrity, performance or operational characteristics of the aircraft; and requires major repair or replacement of the affected component or components.

Serious incident: An incident involving circumstances indicating that an accident nearly occurred.

Serious injury: Serious injury means an injury that requires, or would usually require, admission to hospital within 7 days after the day when the injury is suffered.

1 INTRODUCTION

In the last three decades, Australia has seen a significant growth in the number of amateur-built aircraft as they cement their role as an integral part of the general aviation scene. In general, amateur-built aircraft refer to aircraft that are built for personal use from an original design, established plans or kit, and which are not entirely built and assembled in a factory. There are a wide variety of amateur-built aircraft designs of varying sizes, performance, and complexity - from single to twin-engine, piston to jet-powered, and single-place up to four-seat aircraft.

This report is the second part of the Australian Transport Safety Bureau's (ATSB) research investigation into Australian amateur-built aircraft. The first part, *Amateur-built and experimental aircraft Part 1: A survey of owners and builders of VH-registered non-factory aircraft* (AR-2007-043(1)), was published in June 2009. That report (part 1) focused on defining the amateur-built aircraft community, including pilots and their aircraft. Context was given through a review of the different regulatory schemes that amateur-built and experimental aircraft have been constructed under in Australia, and the growth and development of amateur-built aircraft associations to support builders, owners and flyers. It explored issues that affect amateur-built aircraft owners when selecting, building, purchasing, testing, designing, operating, and maintaining these aircraft, based on the results of a survey to owners and builders of VH- registered amateur-built aircraft.

This report (part 2) investigates the safety history of amateur-built aircraft in Australia. This was done through analysis of accident data held in the ATSB's occurrence database from 1988 to 2010. Comparisons were made between accidents involving VH- registered amateur-built aircraft and those involving similar factory-built aircraft to help identify whether the rate and types of accidents differed between these two groups of aircraft.

To allow an appropriate comparison of the types of accidents involving amateur-built aircraft and those involving certified factory-built aircraft, this comparison only considers VH- registered amateur-built aircraft that have been involved in accidents reported to the ATSB. There are a large number of amateur-built aircraft operating under the auspices of Recreational Aviation Australia about three times as many as are on the Australian civil (VH-) register at the time of writing. These aircraft can be distinguished by the casual observer by their numeric registration[1]. While many aircraft of similar (or the same) model and performance level are registered under either system, the differences in licensing, operational, and maintenance rules between the two systems means that considering only VH-registered aircraft accidents ensures a fairer representation of amateur-built and factory-built aircraft safety.

Due to the vast majority of VH-registered amateur-built aircraft being single-engine, propeller-driven aeroplanes (both those in operation, and those involved in accidents), this report considers only these aircraft when examining amateur-built

[1] Recreational Aviation Australia aircraft registrations have different prefixes, depending on whether the aircraft is amateur-built or factory built. Amateur-built aircraft registrations begin with a 10-, 19-, or 28-. Factory-built aircraft registrations begin with a 24-, 25-, 32-, or 55-. Recreational aircraft, up to a maximum of about 600 kg can be registered with Recreational Aviation Australia.

aircraft accidents and comparisons with factory-built aircraft. Helicopters and gliders have been excluded.

Specifically, the objectives of Part 2 were to determine:

- whether the rate of accidents was the same or different between amateur-built aircraft and similar types of factory-built aircraft
- what types of accidents were common for amateur-built aircraft, and whether these were the same or different from common accidents involving similar factory-built aircraft
- what the main contributing factors were to accidents involving amateur-built aircraft.

1.1 What are amateur-built aircraft?

Amateur-built aircraft can be referred to in many different ways: home-built, kit planes, amateur, experimental, plans-built, and non-factory-built aircraft. In general, amateur-built aircraft are:

- built from an original design, established plans or kit
- for personal use
- built solely for the builder's own education or recreation.

Collectively, these aircraft are called amateur-built aircraft in this report. Australia has two systems for building amateur-built aircraft. The term amateur-built is associated with aircraft built under the Amateur-built Aircraft Acceptance (ABAA) legislation, while the term 'amateur-built experimental' refers to aircraft-built under the current Experimental Certificate legislation modelled on the US Federal Aviation Regulations that was introduced in 1998. Part 1 of this report series covers the legislation governing construction and sale of amateur-built and amateur-built experimental aircraft in greater depth.[2]

Presently, the Civil Aviation Safety Authority (CASA) defines an amateur-built and experimental aircraft as:

> ... an aircraft of which the major portion[3] has been fabricated and assembled by a person who undertook the construction project solely for the person's education or recreation.[4]

Today, amateur-built aircraft embody a wide range of aircraft sizes, designs, construction methods and performance capabilities. They range from single-engine single-seat through to large, high-performance four-seat touring aircraft. Some amateur-built aircraft are designed as 'one-offs', however, the vast majority of designs are built from plans, or assembled from pre-fabricated kits. They are constructed from wood, metal, tube and fabric, composite materials, or sometimes a

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2 Amateur-built experimental aircraft are not to be confused with factory-built experimental aircraft. Factory-built experimental aircraft are either not type-certificated, or have certain unapproved modifications, however, have been built in a factory. The focus of this report is on amateur-built and amateur-built experimental aircraft, which are non-factory-built.

3 The major portion means more than 50 per cent of the aircraft.

4 Civil Aviation Safety Regulation (CASR) 21.191(g) 1998.

mixture of all. They often use a certified or non-certified aircraft engine, although motor vehicle engines are also sometimes used instead of aircraft engines.

Amateur-built and factory-built aircraft differ in a number of important ways:

- the rules governing the certification of amateur-built aircraft are designed to protect third-parties, compared with the established US Federal Airworthiness Regulation Part 23 type standards of factory-built general aviation aircraft.
- the types of operations the aircraft are able to conduct
- who is allowed to perform maintenance on the aircraft
- the level of modification that is allowed to be made to the aircraft, engine, and aircraft systems
- the level of support for operators that exists from clubs and organisations.

1.2 United States safety study of experimental amateur-built aircraft

The National Transportation Safety Board (NTSB) has recently published a research report relating to amateur-built aircraft accidents within the United States. That study included a retrospective review of 10 years of accident data and a prospective analysis of detailed investigations of all 224 experimental amateur-built aircraft accidents that occurred in the year 2011.[5]

The NTSB study found the following.

- Amateur-built aircraft account for a disproportionate number of total accidents and an even more disproportionate share of fatal accidents when compared with similar factory-built aircraft conducting similar flight operations.
- Accident analyses indicate that power plant failures and loss of control in flight are the most common amateur-built aircraft accident occurrences by a large margin and that accident occurrences are similar for both new and used aircraft.
- Structural failures have not been a common occurrence among amateur-built aircraft.
- In comparison with similar factory-built aircraft, a much higher proportion of accidents involving amateur-built aircraft occur early in the operational life of the aircraft.
- A similarly large proportion of amateur-built aircraft accidents occur shortly after being purchased by a subsequent owner.

The findings of the NTSB report about US accidents are consistent with the conclusions of the ATSB report about Australian accidents. However, both reports also bring unique factors which may provide mutual benefit to all participants in the amateur-built aircraft industry.

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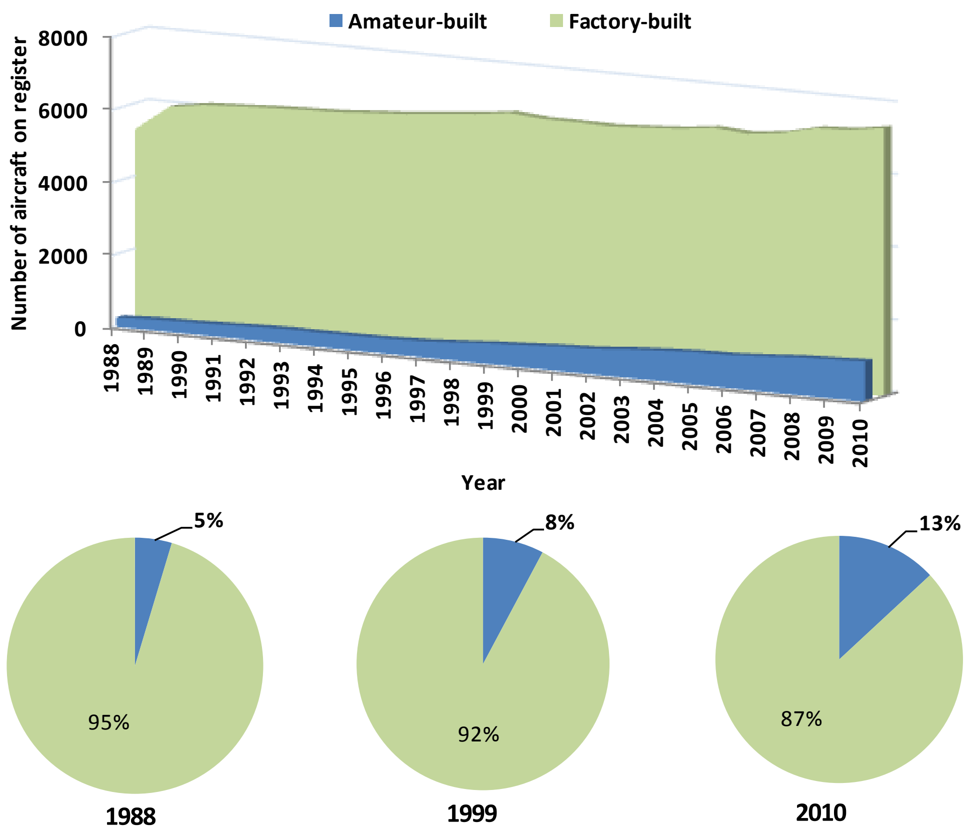
[5] NTSB (2012). *The Safety of Experimental Amateur-Built Aircraft.* (Safety study NTSB/SS-12/01). Washington, DC. Available from http://www.ntsb.gov/doclib/reports/2012/SS1201.pdf.

2 FLEET, FLYING ACTIVITY, AND OPERATIONS

The number of amateur-built aircraft on the Civil Aviation Safety Authority civil (VH-) register has increased from 256 in 1988 to 1,111 registered aircraft in 2010, as shown in the figure below. The relative number of amateur-built aircraft, when compared with the total population of single-engine aeroplanes, has increased by more than two-and-a-half times during the 23-year period as shown by the pie charts in Figure 1 below.

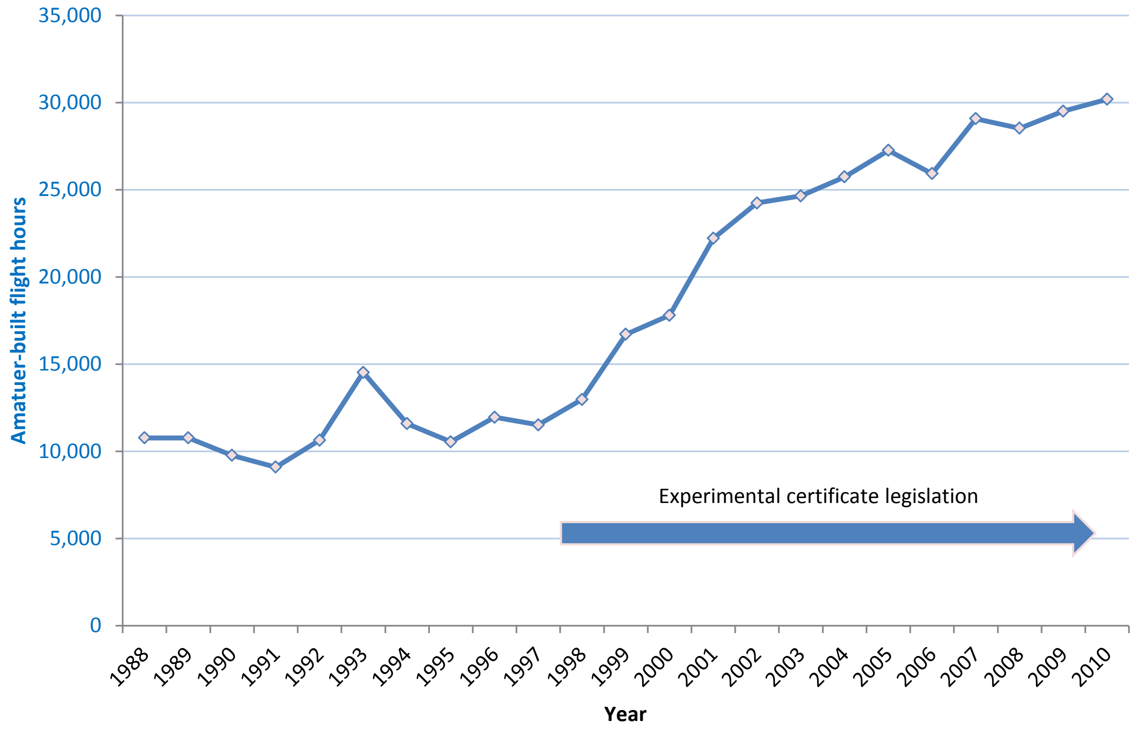
Figure 1: Number of single-engine aeroplanes on the Australian register from 1988 to 2010



The number of factory-built aircraft on the register has increased by more than 2,000 aircraft during this time.

Figure 2 shows that amateur-built aircraft flight hours almost tripled from 1988 to 2010, with the most significant increase being from 11,500 hours flown in 1997 to 30,000 hours flown in 2010. This was associated with an increase in aircraft registrations. The early period of study between 1988 and 1997 shows a very slight increase in the number of amateur-built aircraft hours flown, which is due in part to the smaller number of registered aircraft at that time. In particular, flying activity involving amateur-built aircraft grew significantly after the introduction of the current Experiment Certificate operating regime introduced by CASA in 1998. Factory-built aircraft flight hours decreased by 30 per cent from 1988 to 2010.

Figure 2: Amateur-built single-engine aeroplane flight hours 1988 to 2010



The increase in amateur-built aircraft in Australia since the 1980s (both VH- and non-VH- registered) coincides with the decline of certified GA aircraft production in the United States, when many of the major manufacturers (Cessna, Piper, Beechcraft) slowed or ceased production. While lower-rate production of GA aircraft resumed in the late-1990s, purchase and operating costs for new aircraft are high in comparison to amateur-built aircraft.

Shifts in general aviation, and the growth in popularity of amateur-built aircraft in the last twenty years is discussed further in the ATSB publication *Amateur-built and experimental aircraft Part 1: A survey of owners and builders of VH-registered non-factory aircraft* (AR-2007-043(1)).

2.1 Fleet mix of amateur and factory-built single-engine propeller-driven aeroplanes

At the time of writing, there is a wide range of amateur-built aircraft on the Australian civil (VH-) register. While there are a number of one-off designs, the most popular aircraft are those which are made from factory-fabricated kits.

Figure 3 (below) shows that the 15 most popular amateur-built aircraft models on the VH- register make up almost half (44%) of the amateur-built aircraft on the register in 2012. A majority of these aircraft are metal-fabricated kits.

Figure 3: Most common amateur-built aircraft models on the VH- register (at May 2012)

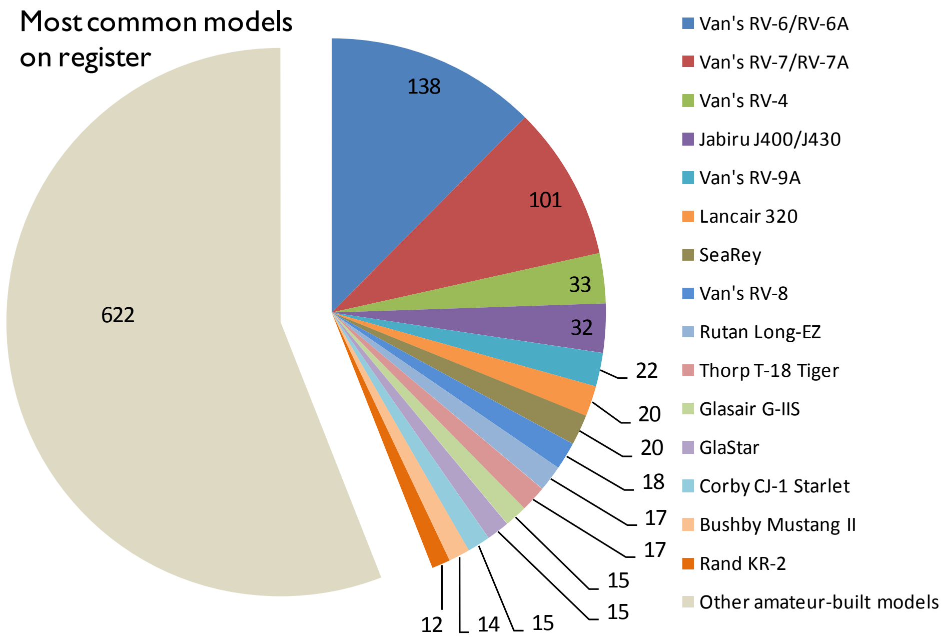
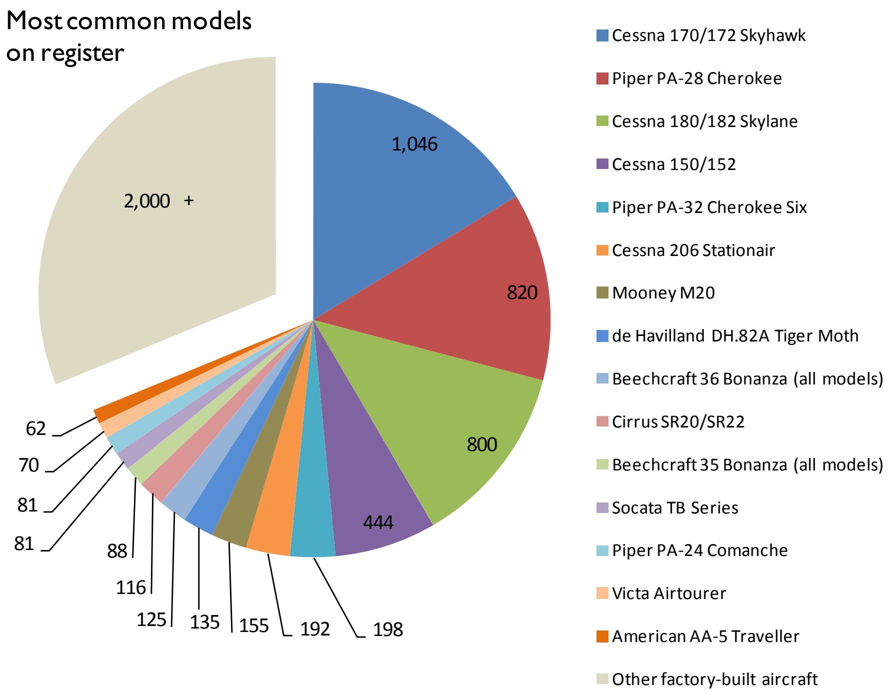


Figure 4 shows a similar story for comparable factory-built aircraft – single-engine piston aircraft that were used for pleasure/private flying among other operations. More than two-thirds of the estimated 6,500 aircraft on the CASA register that fall into this category were spread across 15 aircraft models, and more than half were manufactured by Cessna or Piper. Most of these aircraft were manufactured in the 1960s, 1970s, and early 1980s, and are significantly older than most amateur-built aircraft in service today.

Figure 4: Most common single-engine factory-built aeroplane models on the VH- register (at May 2012)



2.2 Types of operations for amateur and factory-built single-engine propeller-driven aeroplane hours and accidents

Amateur-built aircraft are used for a smaller number of operations when compared with factory-built aircraft. This is due in part to restrictions placed on amateur-built experimental aircraft that they are not to operate for profit and reward[6], such as in commercial flight training schools and charter work, but also due to the types of home-built kit aircraft available, which are generally not suitable for operations such as agricultural work. Restrictions on amateur-built experimental aircraft, in particular during the initial testing and assessment phase are imposed to limit the risk to third parties.

Private operations make up more than 91 per cent of amateur-built aircraft operations, with test and ferry[7] flying and training making up the significant remainder of flight operations (Figure 5). As amateur-built aircraft (under current regulations) cannot be used for commercial flight training operations, the training conducted in amateur-built aircraft is expected to be transition type training for pilots unfamiliar with operating the aircraft, mainly by flying with type experienced

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6 As per Civil Aviation Regulation (CAR) 262AP(7) for Experimental Certificate-operated amateur-built aircraft. Amateur-built Aircraft Acceptance (ABAA) operated amateur-built aircraft are not subject to the CAR 262AP restrictions, however are subject to restrictions under CASR 21.190.

7 Test and ferry flying is defined in the *General Aviation Activity Survey* conducted by the Bureau of Infrastructure, Transport, and Regional Economics as: 'Flying associated with the testing of an aircraft or associated with its delivery or movement to a location for maintenance, hire or other planned use.'

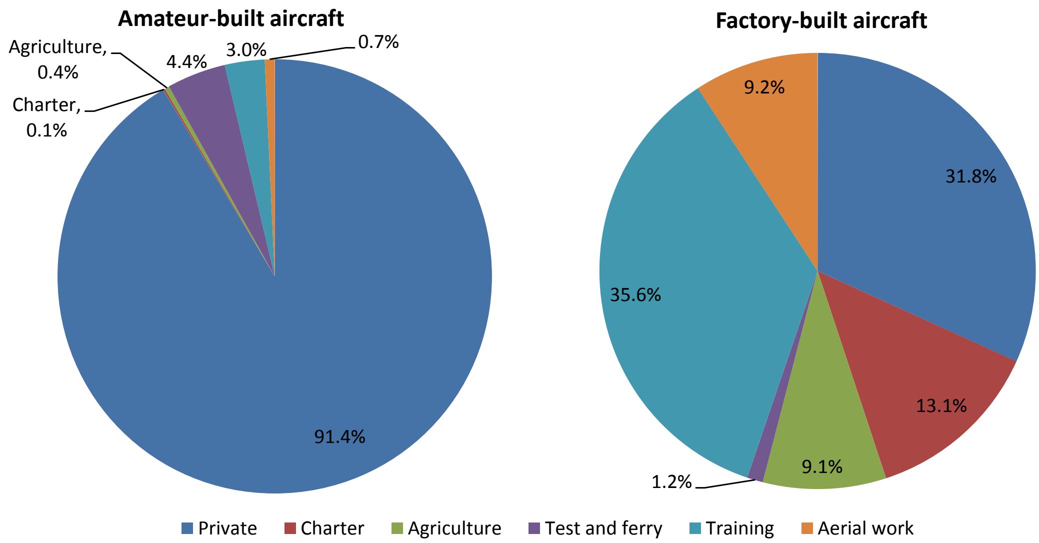
pilots, or self-training. This includes second-hand owners, owner-builders or other pilots who are unfamiliar with operating their amateur-built aircraft type.

In comparison, factory-built single-engine aeroplane operations can be used for flying that is private, flight training, and flying for hire or reward (aerial work, agriculture and charter). Each of these types of flying accounted for about one third of all hours flown by factory-built aircraft over the 1988 to 2010 period.

Although not specifically shown, amateur and factory-built aircraft were used for a similar proportion of business operations[8].

Test and ferry flying hours were higher in amateur-built aircraft operations. This is due to the 25 to 40 hours of testing and evaluation required for every amateur-built aircraft constructed in Australia. As there is very little testing of new factory-built airframes in Australia, it is expected that most factory-built test and ferry hours flown are in the ferry sub-category, and are accumulated when an aircraft is delivered after maintenance, or from a factory or a previous owner either within Australia or from an international location.

Figure 5: Single-engine amateur and factory-built aeroplane hours by type of operation, 1988 to 2010[9]



To make all comparisons between activities and accident rates valid, all comparisons below between amateur and factory-built aircraft will be based on the subset of private flying only.

The distribution and total number of private hours flown across the 23 years of this study is very similar to hours flown for all operations combined (seen in Figure 2), due to the vast majority of amateur-built aircraft operations being private flying.

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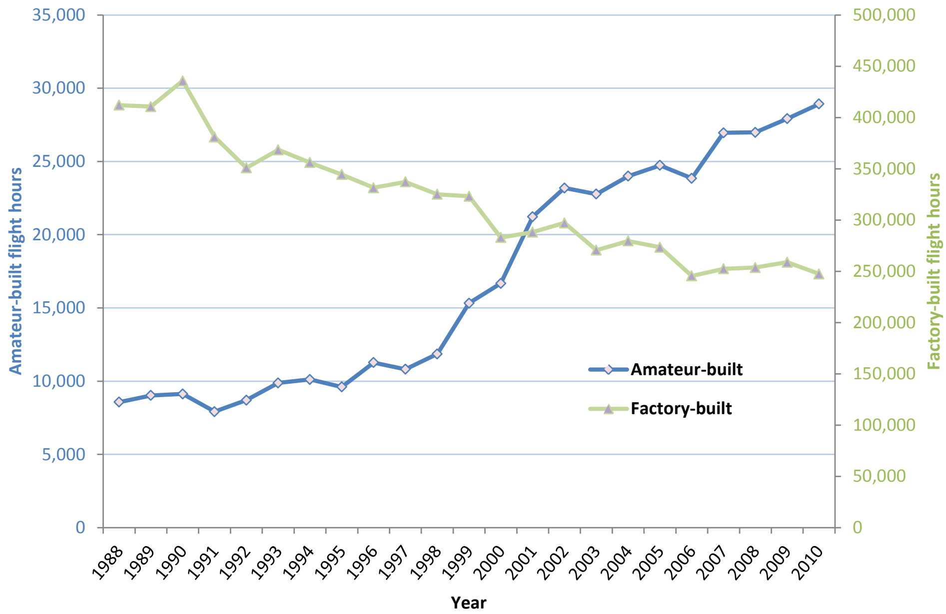
8 Business operations are those not for hire or reward as in private operations, but are associated with a business or profession. For the purpose of this report, these are included in private operations.

9 Operations shown reflect the self-reported operations by operators or owners of aircraft in the annual *General Aviation Activity Survey* conducted by the Bureau of Infrastructure, Transport, and Regional Economics.

Figure 6 shows that factory-built aircraft private operations decreased considerably from 1988 to 2010, while amateur-built aircraft operations increased considerably.

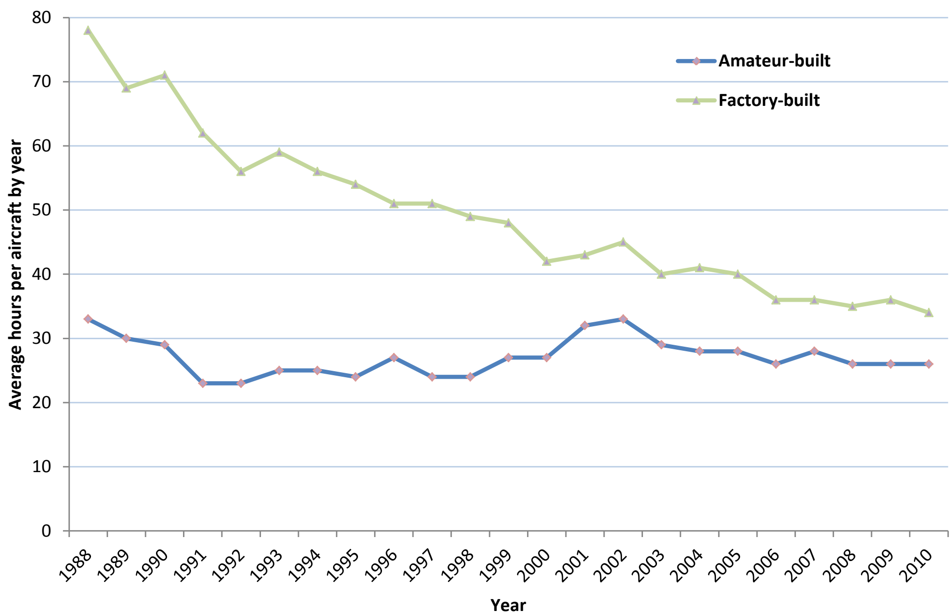
Figure 6: Single-engine aeroplane private operations flight hours 1988 to 2010 (note different scales for flight hours)



The average number of hours flown by year for amateur-built aircraft was lower than that for factory-built aircraft flying private operations.

Figure 7 shows that the average private hours flown per aircraft have converged for amateur and factory-built aircraft from 1988 to 2010 due to a decline in hours flown per factory-built aircraft.

Figure 7: Average flight hours of single-engine aeroplanes for private operations 1988 to 2010



There are a number of factors that have most probably contributed to the decline seen in factory-built aircraft flying for private uses, and the growing popularity of amateur-built aircraft in this role. On the whole, factory-built aircraft used in general aviation are:

- getting older on a fleet-wide basis
- have less type support from manufacturers for older out-of-production models
- more expensive due to the high capital cost for certified new-build aircraft and engines
- required to be maintained by licensed personnel
- built by a relatively small number of manufacturers
- relatively more expensive to insure
- relatively more expensive with regard to fuel consumption and fuel type
- in most cases, imported from overseas (there are few Australian manufacturers), resulting in high capital costs

While some of these points also apply to amateur-built aircraft, amateur-built aircraft generally are:

- available at a lower capital cost, with popular models ranging from $130,000 AUD up to four seat high performance aircraft being around $250,000 AUD to $350,000 AUD.[10]
- constructed to be more weight efficient to save on fuel costs, have newer engines, and a design emphasis towards low running costs
- in some cases, constructed to have a higher airframe efficiency and performance when compared with the factory-built aircraft fleet
- in some cases, available from Australian-based kit manufacturers, and the cost of importing kits from overseas is a lot less than shipping a fully assembled aircraft
- in some cases, customisation commensurate with the owner's needs and typical flying (for example, some aircraft can be transported on road by trailer, some are designed for short or rough fields, some are amphibious)
- a challenge if the owner is building the aircraft
- supported by a large number of associations and clubs for pilots and builders that provide technical and operational guidance (such as the Sport Aircraft Association of Australia, and type-specific clubs such as the Van's Air Force)

[10] Information provided by the Sport Aircraft Association of Australia.

3 METHODOLOGY

3.1 Data sources

3.1.1 Aviation accident data sources

ATSB Occurrence and notifications database

The ATSB occurrence database was used as a primary source of accident information for amateur and factory-built aircraft accidents from 1988 to 2010. Only Australian VH-registered single-engine aeroplane accidents were extracted. This dataset included 212 accidents involving amateur-built aircraft.[11]

An *accident* is defined in the *Transport Safety Investigation Act* 2003 as a matter involving an aircraft where a person dies or suffers serious injury, the aircraft is destroyed or seriously damaged, or any property is destroyed or seriously damaged, as a result of an occurrence associated with the operation of the aircraft.

Data sourced from the ATSB occurrence database included:

- type and sub-type of operation (private/business (including pressure/travel, aerobatics), test and ferry, training (including check flights and transition training)
- occurrence event type (e.g. partial power loss, loss of control, landing gear issues, wirestrike)
- contributing safety factors (e.g. aircraft handling and other pilot actions, technical failures, environmental conditions)
- pilot licence and flying experience details
- phase of flight
- accident outcomes in terms of aircraft damage and injuries to persons.

The above data was not available for every accident as over half of the accidents, both amateur-built and factory-built, had no formal ATSB investigation. Seven per cent had an on-site investigation, while about 30 per cent had an office-based investigation. As a result, many details concerning the accidents in the ATSB database were based on information supplied by the pilot or police at the time of the accident only. A number of secondary sources of information were used to supplement the existing information in the ATSB database, and are discussed below.

Civil Aviation Safety Authority records

Aircraft registration files held by the Civil Aviation Safety Authority (CASA) and its precursor departments were used as a major source of information on

[11] In addition to the 212 aeroplane accidents used in this study, there were also four glider accidents and 20 helicopter accidents involving amateur-built aircraft between 1988 and 2010.

certification, testing, modifications to, and performance aspects of Australian VH-registered amateur-built aircraft over the last 20 years.

Coronial records

A number of coronial findings and proceedings were used to enrich fatal accident information where a formal ATSB investigation was not conducted. These were sourced from the Northern Territory, New South Wales, Queensland, Victorian and Western Australian Coroner's courts.

Survey responses

A survey was sent to owners of amateur-built aircraft involved in non-fatal accidents to gather information not captured at the time of the accident in the ATSB database. This included information about the nature of the accident, including whether any aircraft modifications had been performed.

3.1.2 Aircraft specification data

To support the comparison between VH-registered amateur and factory-built aircraft, technical data on aircraft limitations, dimensions, weights and undercarriage type were gathered from various sources described below.

This data was mainly used for the formation of a matched-sample group between amateur and factory-built aircraft (as described in section 3.2.2 below). The following publications were used to gather aircraft specification data:

- *Jane's All the World's aircraft*, 1989-1990,1994-1995 and 2010-2011
- *The International Directory of Civil Aircraft*, First, Third and Fifth edition, Gerard Frawley and Jim Thorn, 1995, 1999 and 2003
- *Standard catalog of Piper Single Engine Aircraft*, First edition, Jim Cavanagh, 1993
- *Standard catalog of Cessna Single Engine Aircraft*, Second Edition, Jim Cavanagh Revised by Kim Shields, 1995.

3.1.3 Aviation activity data

The Bureau of Infrastructure, Transport and Regional Economics (BITRE) provided data aggregated across aircraft for flying hours across Australia by year, separately for amateur-built and factory-built aircraft. This data was sourced from the annual BITRE *General Aviation Activity Survey*[12] and was for VH-registered single-engine aeroplanes only.

Hours flown data was provided by the type of operation conducted: private/business, test and ferry, and training. The hours flown data allowed the calculation of aircraft accident rates per hour flown by each aircraft build type and operation type.

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12 The BITRE *General Aviation Activity Survey* records hours of operation for each VH- registered aircraft by operation type category. This information is provided by the owners of the aircraft.

Hours flown for operational sub-types were not collected by BITRE, such as the various types of private flying and the types of training, nor separately for testing and ferrying aircraft. As such, accident rates could not be calculated at the operation sub-type level. Therefore, only factory-built private accident rates were used for comparison, as discussed in section 3.2.1 below.

Aircraft landings could not be used to calculate accident rates as this data is not collected for individual aircraft operation types.

Accident aircraft total flight hours data

The BITRE also provided de-identified flight hours joined to ATSB amateur-built accidents. Calculations performed within the BITRE approximated the total hours flown at the time of the accident for each accident aircraft in the matched sample set (described in section 3.2.2 on page 16).

ATSB accident data such as whether the accident involved loss of control or was related to a mechanical problem was provided to the BITRE to match by registration and aircraft model. The de-identified data set contained estimated aircraft (airframe) flight hours at the time of the accident, and key factors in amateur-built aircraft accidents, which were identified throughout the analysis.

This allowed relationships to be determined between key factors, such as mechanical problems, and the accumulated airframe flight hours. For amateur-built aircraft, this also provided an indication of whether the aircraft was beyond the initial flight testing period (as required by Civil Aviation Regulation 262AP(3)) at the time of the accident.

3.2 Comparisons with factory-built aircraft accidents

To examine whether the number and types of accidents involving amateur-built aircraft were representative of the rest of private flying, the accident data was compared to similar factory-built aircraft accidents. To determine whether there was anything specific about the way amateur-built aircraft are built, maintained, piloted and operated, the control groups were matched, as close as possible, to the types of aircraft operations and aircraft performance, size and configuration as existed in the amateur-built aircraft accident set.

As all amateur-built aircraft accidents in the analysis were on single-engine propeller driven aeroplanes, only factory-built single-engine propeller driven aeroplane accidents were included in the factory-built comparisons.

As amateur-built aircraft are flown not-for-reward, only not-for-reward factory-built aircraft data was used.

Due to very limited information being available on amateur-built and factory-built aircraft registered with Recreational Aviation Australia, these comparisons include only VH registered aircraft.

In addition to overall comparisons, limited comparisons have been made within specific operation types and operation sub-types to further refine the analyses. However, the majority of comparisons in the analyses are within private operations, as most amateur-built accidents fall within this category.

3.2.1 Accident rates

Accidents and hours flown were obtained for the two aircraft categories: amateur-built and factory-built. Using hours flown as a normaliser allows for an accident comparison between amateur-built and factory-built aircraft that is independent of the amount of flying activity each group conducts.

Private, test and ferry, and training flying hours made up 99 per cent of amateur-built flight hours from 1988 to 2010, as shown by Figure 5 on page 9. However, test and ferry and training operations aircraft hours are significantly different for amateur-built and factory-built aircraft for the following reasons.

- Most amateur-built test and ferry accidents occur during flight tests, and most factory-built test and ferry accidents occur during ferry flights.
- Amateur-built training is mainly transition training, compared with factory-built transition training, which only makes up about 22 per cent of all factory-built training accidents.
- Both training and test and ferry factory-built aircraft operations include flights both for reward and not-for reward. However, the amateur-built hours flown and accident data included only not-for-reward flights by virtue of involving amateur-built aircraft.

As a result, the only factory-built aircraft operations used for accident rate comparisons were private flying, as these rates were not affected by the above issues. However, comparisons between test and ferry, training and private operations are performed *within* the amateur-built data set.

Private accidents made up 76 per cent of all amateur-built aircraft accidents.

3.2.2 Comparisons using matched-samples

To examine the types of factors affecting amateur-built aircraft accidents, a matched data set of factory-built aircraft was used. This involved linking similar factory and amateur-built aircraft accidents by common flying operations and aircraft characteristics.

The aim of the matched-sample study was to reduce the variability between the two data sets so that any differences found between amateur-built and factory-built aircraft accidents should be a result of the amateur/factory build type and not something else that co-varies between the build types (such as aircraft use, performance and configuration). The result of this matching process is that the two samples are very similar in most ways with the exception that one aircraft group was produced in a factory, and the majority of the manufacture of the other aircraft group was performed by the owner.

Eligible factory-built aircraft accidents were initially taken from the entire population of factory-built single-engine propeller driven aeroplane accidents in the ATSB database. This sample was further reduced by removing all accidents involving operation for profit or reward aircraft (keeping only private operations, training involving check flights or transition training, and test and ferry operations).

The factory-built accident matched-sample data set was then formed by selecting common aircraft factors for *each* amateur-built accident on four factors:

1. wing loading
2. landing energy
3. operation type and sub-operation type (where matches were available)
4. landing gear configuration (where matches were available).

The matching metrics for the four factors are described below.

1. Wing loading

The wing loading is defined as the aircraft weight divided by the wing area, and is used as an indication of the average amount of weight a unit area (square metre) of wing needs to support for level flight.

Factory-built aircraft were eligible for pairing with an amateur-built aircraft if the wing loading was within 1 standard deviation of the amateur-built aircraft set, in this case 27 kg/m^2. Priority was given to factory-built aircraft with a smaller difference to the relevant amateur-built wing loading. Half of all factory-built aircraft were within 8 kg/m^2 of the amateur-built aircraft they were matched to.

Wing loading was selected as a measure of equivalent aircraft performance and characteristics.[13, 14]

2. Kinetic energy on landing

The kinetic energy on landing is related to the speed and mass of the aircraft. It was selected as a measure of the energy required to decelerate a fully laden aircraft, and, in part, for the susceptibility of an aircraft to be affected by environmental conditions such as wind.

Kinetic energy is calculated by the equation:

$$\text{Kinetic energy} = \tfrac{1}{2} \times \text{mass} \times \text{velocity}^2$$

Where:

- mass is the maximum take-off weight of the aircraft as a highest energy case;
- velocity is the approximate landing speed of the aircraft, calculated as the landing configuration stall speed[15] multiplied by a factor of 1.2.

Factory-built aircraft were eligible for pairing with an amateur-built aircraft if the landing energy was within 1 standard deviation of the amateur-built aircraft set, in

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13 For example, gliders generally have a relative low wing loading in the order of 20 kg/m^2, and have lower stall speeds; high performance single-engine aircraft generally have a higher wing loading in the order of 90 kg/m^2, and have higher stall speeds. Some aircraft, such as the Lancair IV, have wing loadings above 150 kg/m^2, which is similar to the World War II Supermarine Spitfire.

14 Other performance measures such as power to weight ratio could not be used as actual engine data was unavailable for many aircraft.

15 The aerodynamic stall speed of the aircraft wings with the landing gear extended, and flaps and any other aerodynamic devices set for landing. This is often denoted as V_{S0}. Where V_{S0} was not available, for example where the aircraft had no configuration changes for landing such as no wing flaps, the clean stall speed, V_{S1} was used.

this case 207 kilojoules. Priority was given to factory-built aircraft with a smaller difference to the relevant amateur-built landing energy. Half of all factory-built aircraft were within 142 kilojoules of the amateur-built aircraft they were matched to.

The landing kinetic energy is also proportional to the kinetic energy the aircraft is likely to contain in emergency stopping scenarios such as forced landings and rejected take-offs, as these speeds are generally relative to the stall speed of the aircraft.

3. Operation type and operation sub-type

As stated, accidents involving operation for profit or reward were removed from the set prior to the matched-sample matching process. However, further refinements for matching each amateur-built aircraft accident to the same specific type of operation and sub-operation were performed. This includes matching of sub-operations such as pleasure and travel. When matches for operation type and/or operation sub-type were not available, factory-built aircraft matches on the above criteria only were still included in the control set. Operation type was matched for 83 per cent of factory-built controls, and operation sub-type was matched for 71 per cent.

4. Aircraft undercarriage configuration

In the aircraft matching process, factory-built aircraft with the same undercarriage configuration (tricycle, tail-wheel, floats; fixed or retractable) were given priority over other aircraft, although if factory-built aircraft involved in accidents with the same configuration were not available, matches on the above criteria only were still included in the control set. Landing gear configuration was matched for 43 per cent of factory-built controls.

Factory-built aircraft matching with each amateur-built aircraft accident

Up to three factory-built aircraft accidents were paired with each amateur-built aircraft accident. For a small proportion of amateur-built accidents (7 out of 212), it was not possible to find any eligible matches due to there being insufficient comparable factory-built aircraft. Table 1 shows the number of factory-built aircraft accidents each amateur-built aircraft accident was paired with. The majority had three factory-built aircraft accident matches per amateur-built accident.

Aircraft with no matches were still analysed in the set, however, all of these aircraft were indirectly matched to the set by some (but not all) of the matching variables and effectively ‘share’ matches with other aircraft. In addition, all inferential statistical tests conducted using the factory-built aircraft accident sample were based on *independent samples*[16], and so were not dependent on case by case matches.

16 This means that when performing statistical tests, there is no assumption of similarity between individual matches of factory-built aircraft to the amateur-built aircraft.

Table 1: Total factory-built aircraft accident matches with amateur-built aircraft accidents

Number of factory-built control matches	Number of amateur-built accidents
0	7
1	4
2	59
3	142

At the end of the pairing process, the matched-sample data set contained 548 factory-built aircraft involved in accidents.

A complete list of matches by aircraft model, incorporating the type of operation is found in Appendix B.

Partial matches for outlier data

For the seven amateur-built aircraft accidents where no eligible matches were found, this was due to insufficient aircraft matching data being available, the wing loading and/or kinetic energy being unknown for the amateur-built aircraft model, or one of these parameters not meeting the one standard deviation criteria. There were some aircraft where partial matches were possible, as discussed below.

Where no factory-built aircraft could match both of the initial criteria (kinetic energy and wing loading) within one standard deviation of an amateur-built aircraft, then either the approach kinetic energy *or* the wing loading of the aircraft was matched. For example, the Lancair IV was matched with a Cessna 207 aircraft accident due to these aircraft models having a similar kinetic energy on approach, even though the Lancair IV has a significantly higher wing loading. While these matches were not expected to provide an 'equivalent' aircraft match, it is expected that they strengthen the overall analysis in certain conditions.

Due to very few amateur-built aircraft accidents having partial or no matches with factory-built aircraft accidents, it is not expected to affect the overall analysis or conclusions.


FEET
ALT
LANCAIR
mb
IN.Hg
SYSTEMS
TIME RELAY
SYSTEMS RELAYS
AVION FAN
CABIN FAN
PITOT HEAT
STROBE LIGHTS
NAV LIGHTS
INSTR
AVION

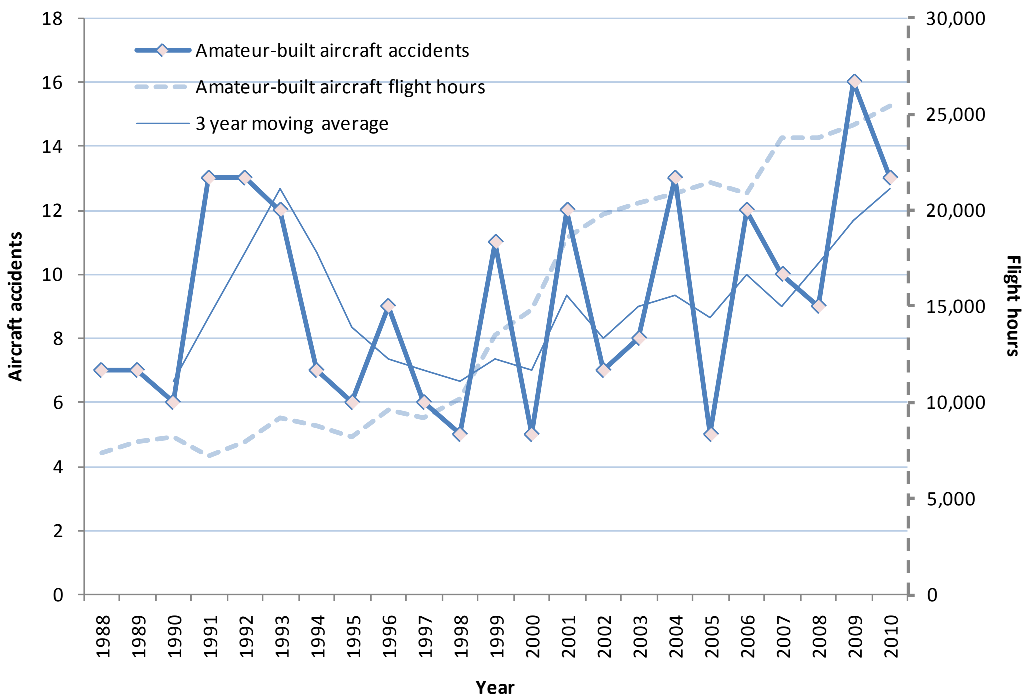
4 GENERAL ACCIDENT RATES

4.1 Number of accidents

There were a total of 212 accidents involving amateur-built aircraft between 1988 and 2010. A list of all amateur-built aircraft accidents can be found in Appendix C.

The total number of amateur-built aeroplane accidents increased slightly between the two decades of the study (Figure 8). The average number of accidents per year was 8.5 from 1988 to 1999, compared with approximately 10 accidents per year from 1999 to 2010. The slight increase can be attributed to the increased number of amateur-built aircraft hours flown (shown by the dotted line below) as the accident rate per hour flown decreased from 1988 to 2010 (discussed below). The largest number of amateur-built aircraft accidents in a single year was 16 in 2009.

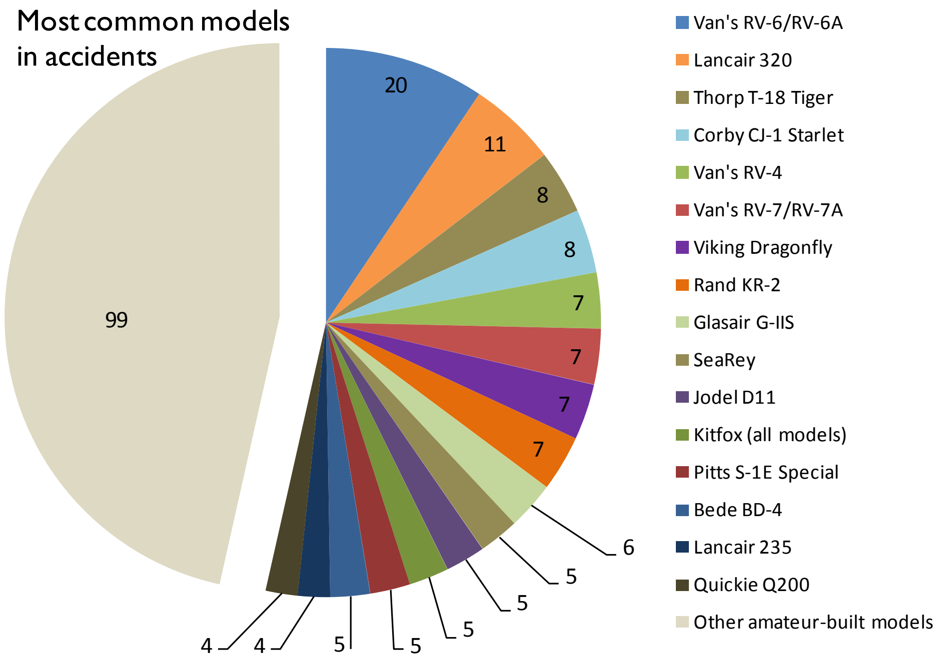
Figure 8: Australian registered single-engine aeroplane accidents 1988 to 2010



4.1.1 Fleet mix of amateur-built aeroplane accidents

A review of the 212 accidents involving amateur-built aircraft between 1988 and 2010 (Figure 9) shows that most accidents involved the same aircraft models that were also the most common on the aircraft register in 2012 (Figure 3 on page 7).

Figure 9: Most common models involved in accidents (1988-2010)



A comparison of the above graph with Figure 3 shows that kits manufactured by Van's Aircraft make up a significant proportion of amateur-built aircraft, which is reflected in the number of these aircraft involved in accidents, as shown in Figure 9. A notable aircraft that has been involved in a large number of accidents in the last twenty years, but is not as common on the register in 2012, is the Lancair 320.

It is important to note that over time, aircraft that have had accidents may have been removed from the aircraft register, and therefore the relative proportions shown in Figure 3 may have been different at the time of the accident. Aircraft being removed from or added to the aircraft register for other reasons will also affect these proportions.

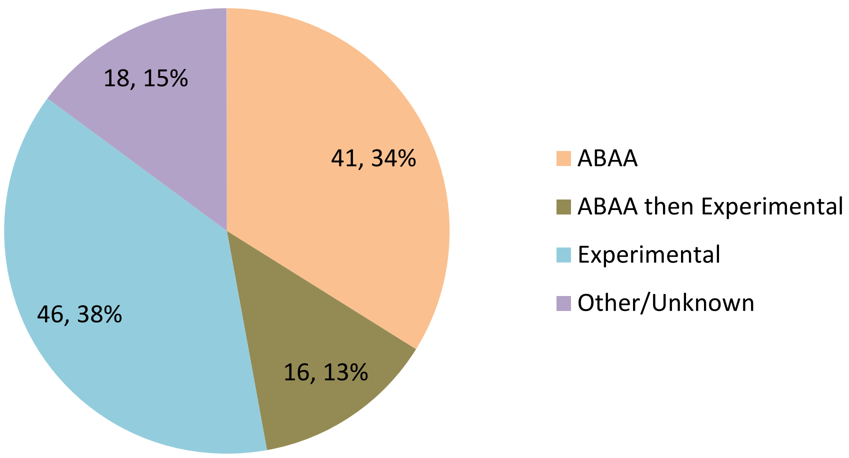
4.1.2 Amateur-built experimental (ABE) and amateur-built aircraft acceptance (ABAA) accidents

Due to the introduction of the amateur-built experimental aircraft scheme mid-way through the study period, it is not possible to determine the relative likelihood of an accident in a particular scheme with the aircraft hours data available. However, a comparison of the second-half of the study period is presented for indicative purposes.

ABAA aircraft accidents made up 34 per cent of amateur-built accidents from 1999 and 2010, similar to ABE aircraft which made up 38 per cent of all amateur-built aircraft accidents between 1999 and 2010 (Figure 10). It is currently not possible to determine the relative safety per aircraft flight hour or flight for ABE and ABAA aircraft groups.

Some amateur-built aircraft (13%) transitioned from the ABAA to the ABE scheme prior to an accident. In 18 cases it was not possible to determine which scheme the aircraft was operating. Further analysis is contained in section 6.1.1 on page 43.

Figure 10: Proportion of ABE and ABAA accidents 1999 to 2010



4.2 Accident rates

Private flying hours made up over 91 per cent of amateur-built flight hours from 1988 to 2010 (see Figure 5 on page 9). As noted in section 3.2.1 on page 16, only private factory-built aircraft accidents and flying hours are suitable to be used to compare accident rates with amateur-built aircraft. However, the overall accident rate[17] when all operation types are included was similar in distribution and slightly higher than that depicted below in Figure 11 and Figure 12.

4.2.1 Private operations accident rate per flight hour

The private operation accident rate per 10,000 flight hours is shown in Figure 11. The rate of amateur-built private accidents per 10,000 hours flown (average 4.93) was significantly higher than private factory-built single-engine aeroplanes (average 1.45) across all years.[18] The accident rate was over three times higher for amateur-built aircraft.

There was a decreasing trend for both amateur-built and factory-built aircraft accidents for the years from 1988 to 2010. Both the amateur-built and factory-built accident rates dropped from the earlier period 1988 to 1999 to the later period

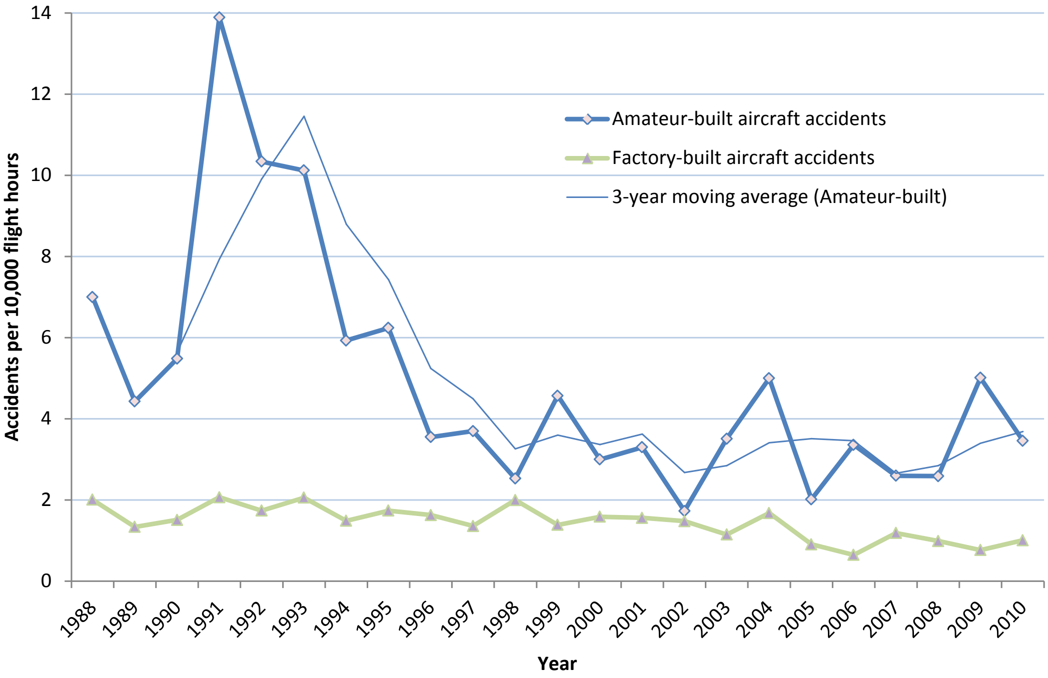
[17] The overall amateur-built accident rate for all amateur-built operations was:
7.56 accidents per 10,000 movements from 1988 to 1999 and
4.04 accidents per 10,000 movements from 1999 to 2010.

[18] Statistical significance (analysis of variance) of difference between accident rates for private operations amateur-built and factory-built aircraft $F_{(1,21)} = 48.7$, $p < 0.001$.

1999 to 2010 of the study. However, the accident rate for the amateur-built aircraft reduced significantly more (from 6.5 accidents per 10,000 flight hours to 3.3) than did the factory-built accident rate (from 1.7 to 1.2).[19] In the most recent 10 years only (1999-2010), the accident rate was still nearly three times higher for amateur-built aircraft than factory-built aircraft.

The 1991 to 1993 spike has a significant influence on the average accident rate from the earlier years, however, the accident rate for the 1988 to 1999 period remains higher at 4.8 accidents per 10,000 flight hours with these data points removed.

Figure 11: Accident rate per 10,000 flight hours for private operations



The increase in amateur-built flight hours from 1998 onwards (refer Figure 2 on page 6) did not result in a proportional increase in the number of accidents, thereby resulting in a slight reduction in the amateur-built aircraft accident rate during the latter period of the study, even though there were more accidents on average.

With the exception of the years from 1991 to 1993, the relatively larger rate fluctuations between consecutive years in amateur-built aircraft accidents seen in Figure 11 is due to the smaller number of hours flown, and thus a larger rate change per accident between each year. A much smaller variation in the factory-built aircraft rate exists due to the larger number of hours flown resulting in a more stable accident rate.

Typically, accidents involving private operations were flights conducted for the purpose of pleasure or travel, making up almost 76 per cent of all amateur-built private accidents. The next most frequent private operations involved in accidents were related to aerobatics or air shows for amateur-built aircraft (4.9%).

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19 Statistical significance (analysis of variance) of interaction between decade and aircraft built type for private operations $F_{(1,21)} = 7.5$, $p < 0.05$.

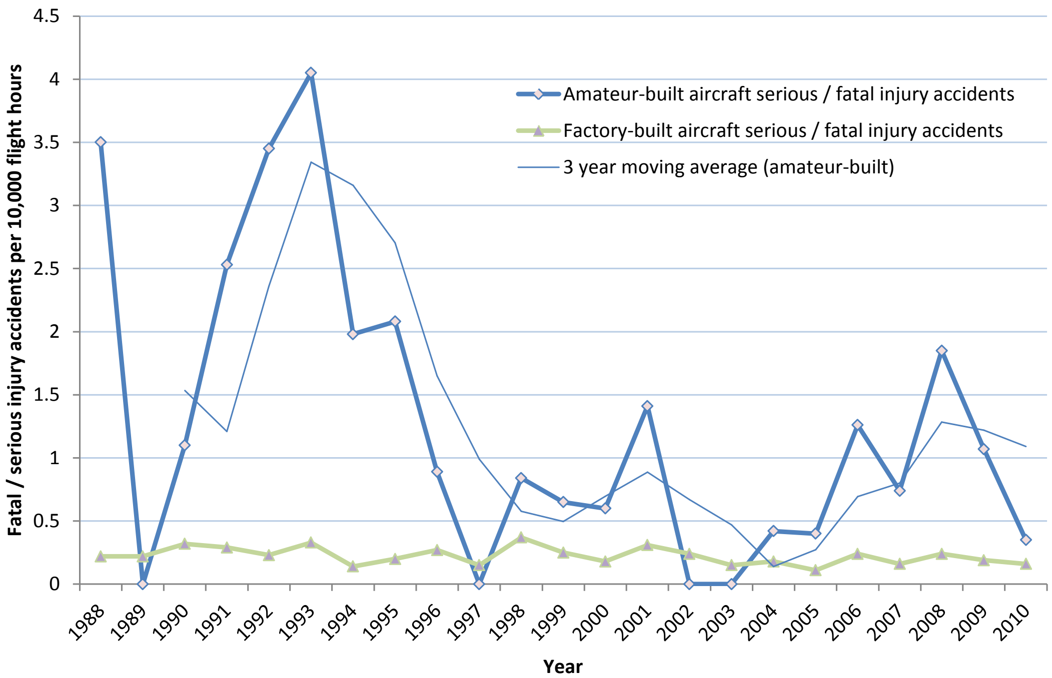
Business operations were only recorded against less than 1 per cent of amateur-built and 6.1 per cent of factory-built accidents within private operations. However, due to uncertainty about the precise purpose of some accident flights, the number of business accidents is likely to be higher.

4.2.2 Fatal and serious injury accident rates in private operations

The accident rate for accidents in private operations resulting in either fatal or serious injuries is shown in Figure 12. The fatal/serious injury accident rate across the period of the study was significantly higher for amateur-built aircraft (average 1.27 per 10,000 hours) than it was for similar factory-built aircraft (average 0.22).[20] The fatal and serious injury accident rate was more than 5.5 times higher for amateur-built aircraft compared to factory-built during private operations.

Similar to the total accident rate, the fatal/serious injury accident has reduced from 1988-1999 to 1999-2010, but the reduction has been significantly greater for amateur-built aircraft.[21] In the second half of the period of study from 1999-2010, the fatal/serious injury accident rate was more than 3.5 times higher for amateur-built aircraft.

Figure 12: Fatal and serious injury accident rate per 10,000 flight hours for private operations



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20 Statistical significance (analysis of variance) of difference between fatal/serious injury accident rates for private operations amateur-built and factory-built aircraft $F_{(1,21)} = 23.9$, $p < 0.001$.

21 Statistical significance (analysis of variance) of interaction between decade and aircraft built type for fatal/serious injury private operations accidents $F_{(1,21)} = 6.1$, $p < 0.05$.

4.3 Accidents by types of operation

The total accidents by the amateur-built types of aircraft operation types can be seen below in Table 2.

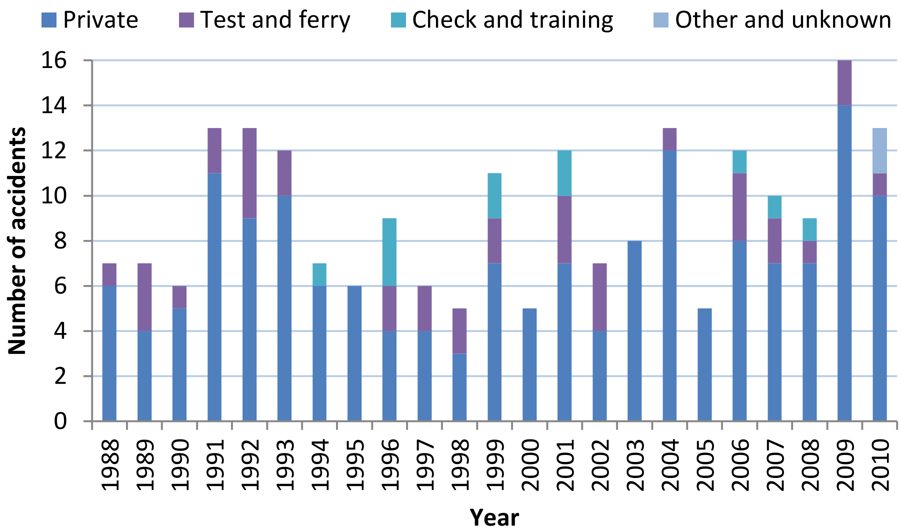
Table 2: Total accidents by build type within amateur-built operation types

Operation type	Amateur-built
Private	162
Test and ferry	37
Check and training	11
Unknown	2
Total	212

Operation type by year

Figure 13 shows amateur-built aircraft accident distributed by operations per year. It shows that all three operation types were distributed across the full range of years within the study, although there were no training accidents from 1988 to 1993. There was a relatively high number of test and ferry related accidents from 1991 to 1993, with eight accidents over the three years. This, however, must be considered in context, as there were also a relatively large number of private operations accidents during this time when compared with surrounding years, the combination of which resulted in the high accident rate for these years.

Figure 13: Amateur-built aeroplane accidents by operation type, 1988 to 2010



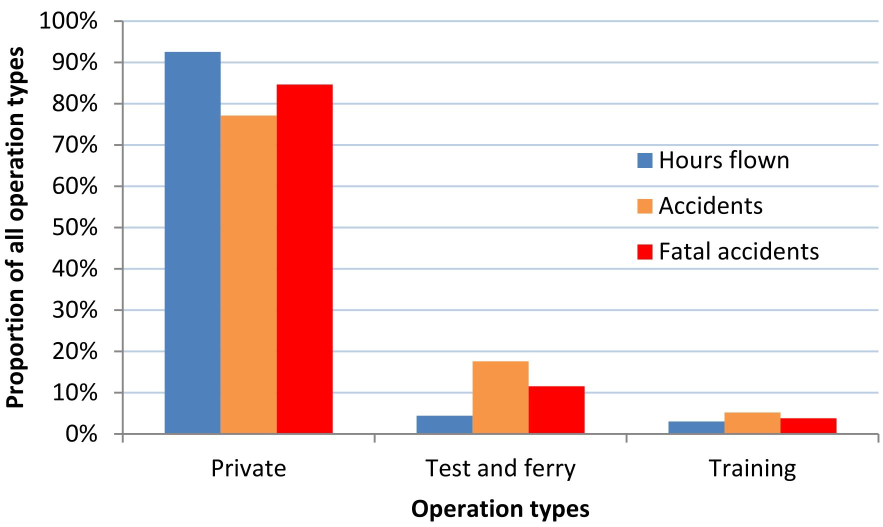
Operation type as proportion of hours flown

The proportion of all aircraft accidents compared with the various operation types is shown in Figure 14. Accident data collected by the ATSB that could not be categorised is not expected to affect the validity of the displayed data, making up 0.9 per cent of amateur-built aircraft accidents. These are typically from accidents where it could not be ascertained what the intended type of operation was.

Most accidents occurred in private operations for amateur-built aircraft. The proportion of amateur-built aircraft hours flown was slightly higher than the proportion of accidents in this operation type.

In contrast, Figure 14 shows amateur-built aircraft accidents during test and ferry flight were considerably over-represented compared to the amount of flying for these operations. Although very few amateur-built aircraft training hours were reported, the proportion of amateur-built aircraft training accidents was more than one and a half times higher than the proportion of training hours flown.

Figure 14: Amateur-built aircraft hours flown and accidents by type of operation 1988 to 2010

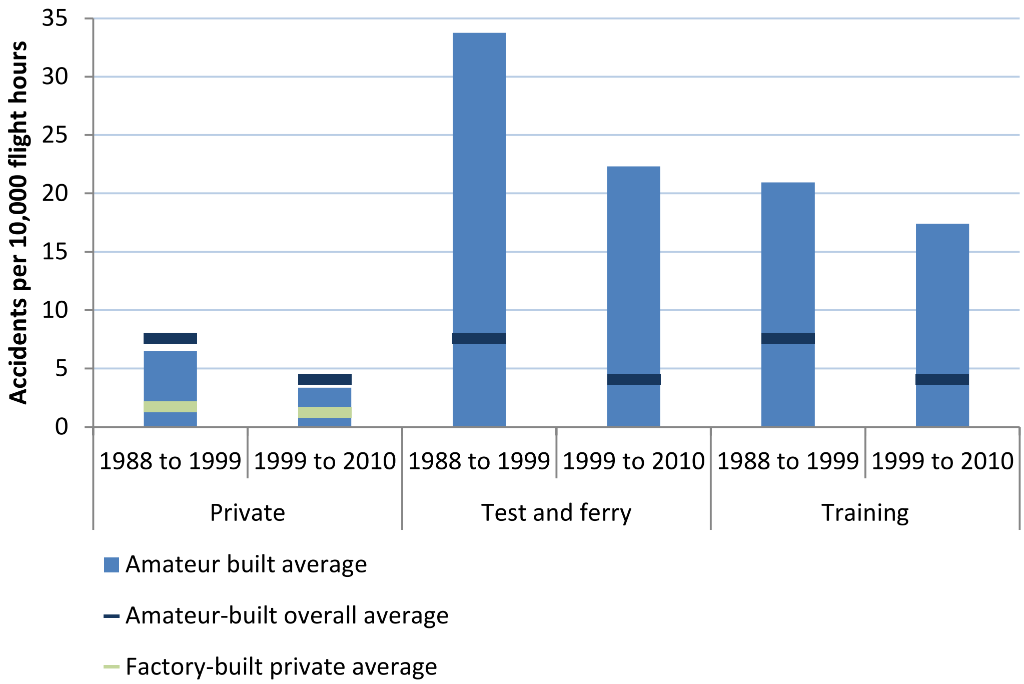


4.4 Accident rate by operation types

The average accident rate per 10,000 flight hours for the three amateur-built aircraft operations is shown in Figure 15 below. The factory-built aircraft private operation accident rate is shown, however, the factory-built test and ferry and training rates are omitted due to these operations not being comparable between amateur-built and factory-built data sets.[22] As shown in section 4.2.1 above, the private operations accident rate was significantly higher in both periods of study for amateur-built aircraft compared with factory-built aircraft.

Both test and ferry flights and training flights accounted for relatively small numbers of hours flown and accidents for amateur-built aircraft. However, the high accident rate within these operation types show that there is a considerable risk associated with these activities when compared to other amateur-built aircraft flying.

Figure 15: Average accidents per 10,000 flight hours per year for amateur-built aircraft operation types



4.4.1 Test and ferry operations

Test and ferry operations had the most accidents per hour flown for amateur-built aircraft. The amateur-built aircraft rate for test and ferry operations was significantly higher (almost six times higher) than the amateur-built aircraft private

22 This is because the factory-built accident rate includes all training related accidents and hours flown, not just check and training type activities which solely make up the amateur-built accident training rate. The majority of amateur-built test and ferry accidents are in testing, whereas the majority of factory-built test and ferry accidents occur during ferry flights.

operations accident rate.[23] This result is reflective of 32 out of the 37 amateur-built accidents involving testing, with only 5 accidents occurring during ferry flights.

Amateur-built testing accidents were typically during testing of engines, stall speed assessments, and testing associated with an aircraft modification. It is important to note that although more than half of the amateur-built testing accidents were associated with aircraft and engine related problems, a significant proportion of these accidents were related to aircraft handling, assessing and planning and monitoring and checking, with no indications of mechanical or aerodynamic problems.

The large number of accidents during testing not relating to aircraft problems may be related to general lower pilot experience with the aircraft type due to pilots (mostly the owner/builder) being unfamiliar with the aircraft characteristics and handling in varying conditions. The typical number of pilot flight hours on aircraft type for amateur-built test and ferry accidents was only 6.5 hours, and four accidents occurred where the pilot flying had less than 1 hour on type (see the analysis of pilot hours in section 5.3.2 on page 35 for more details).

4.4.2 Training operations

The average accident rate for training operations was significantly higher than the overall amateur-built aircraft accident rate, with over 17 accidents per 10,000 flight hours compared with about 4 accidents per 10,000 flight hours for all amateur-built operations. It should be noted that there were only 11 training-related amateur-built accidents during the period of the study.

All eleven amateur-built training accidents were training conducted for the purpose of a check, such as that performed when transitioning onto a new aircraft or during an aeroplane flight review[24].

Five of the eleven amateur-built training accidents were related to aircraft handling. Generally, aircraft handling accidents could be attributed to inexperience, flight currency and wind. Five involved landing gear collapses (nose wheel shimmy and hard landing related), and one was due to engine problems. There was also an accident involving a wirestrike due to low level flying, and one accident due to a kangaroo strike.

As explained in detail below (section 5.3.2), pilots involved in accidents of amateur-built aircraft during training had less experience on the aircraft type they were flying at the time of the accident when compared with pilots of factory-built aircraft involved in accidents during check and transition training. Two of the amateur-built aircraft involved in training accidents were single seat aircraft, and the pilots of both had little or no experience on the aircraft they were flying. However, in these cases, inexperience was not identified as being a factor contributing to the accident, although it could not be ruled out as playing a part.

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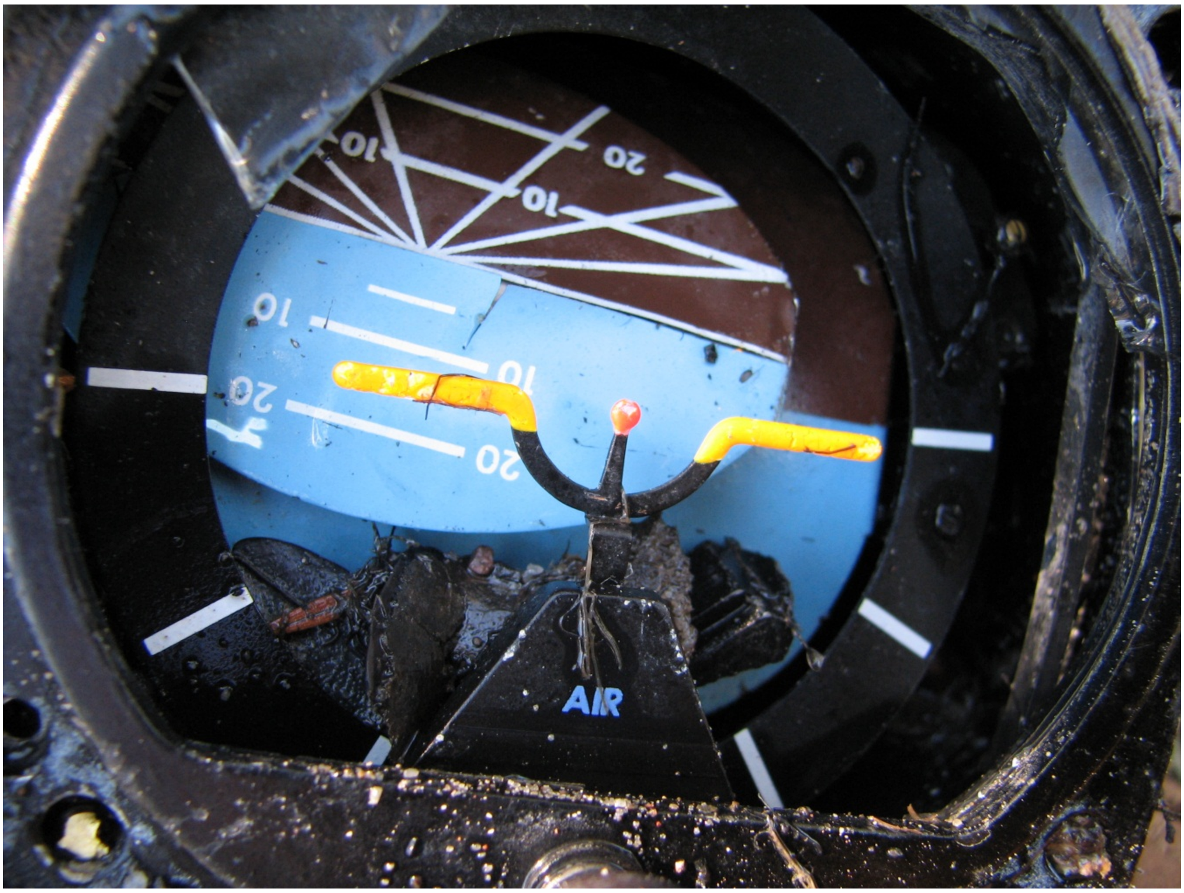
23 Statistical significance (independent t-test, 2-tailed, equal variances not assumed) between amateur-built private accident rates and amateur-built test and ferry accident rates $t_{(23)} = 4.4$, $p < 0.001$.

24 An aeroplane flight review is required for all licensed pilots (except student pilots) at least every 2 years.

Although more seats were often available on the accident aircraft for a more experienced pilot on type, most amateur-built training accidents involved self-training, with only the pilot on board. This may be related to the challenges faced by an owner / builder flying the aircraft within the test flying period, when no other persons are permitted on board. This is discussed further in the section *Amateur-built phase one risk assessment period* on page 33.



5 PILOT AND AIRCRAFT CHARACTERISTICS AND INJURIES – MATCHED-SAMPLE COMPARISON

For the analysis of pilot injuries, demographics and experience, the factory-built aircraft accident matched-sample data set was used as the comparison group. As discussed above, this ensures that aircraft-build comparisons are between very similar aircraft models and types of aircraft operations (see section 3.2.2 on page 16 for more details).

5.1 Accidents resulting in injuries

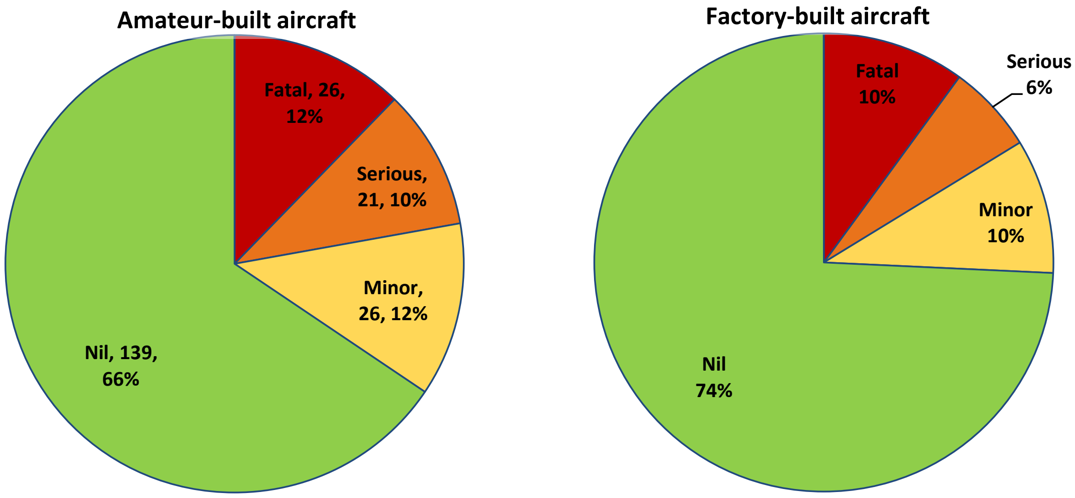
Figure 16 below depicts proportions of accidents by the highest injury recorded for amateur-built aircraft (left) compared with the matched-sample set of factory-built aircraft (right).

There were significantly more (by 8%) amateur-built accidents which had some form of injury when compared with (matched-sample) factory-built aeroplane accidents.[25]

The higher proportion of injury accidents in amateur-built accidents mostly related to serious injury[26] accidents which were relatively more common in amateur-built aircraft accidents when compared with factory-built accidents, however, this was not statistically significant.

Fatal and minor injury accidents were similar but slightly higher for the amateur-built accidents.

Figure 16: Single-engine aeroplane accidents by highest injury sustained 1988 to 2010



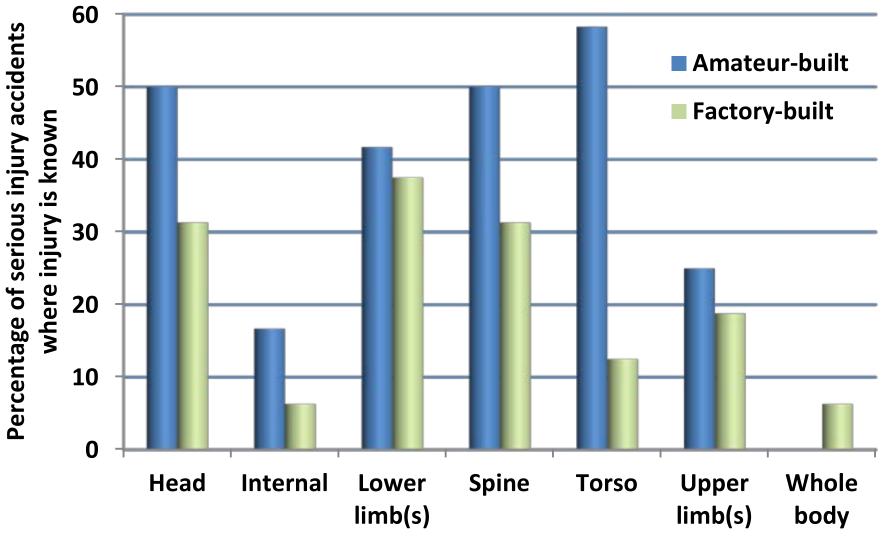
[25] Statistical significance (chi-square cross-tab) between injury and aircraft build, $\chi^2_{(1,\ n = 760)} = 5.725$, $p < 0.05$, 2-tailed.

[26] Serious injury means an injury that requires, or would usually require, admission to hospital within 7 days after the day when the injury is suffered.

Serious injuries

Figure 17 below shows the proportion of body areas injured during serious injury accidents where some injury information was available[27]. Torso, head, spinal and internal injuries were higher than expected in amateur-built aircraft serious injury accidents compared with factory-built serious injury accidents.

Figure 17: Proportion of serious injuries by injured body area for amateur-built and factory-built accidents (where injury information was available)



From the serious injuries examined, burns due to post-accident fires were not significantly different when comparing amateur-built aircraft to factory-built aircraft.

The nature of events resulting in further injuries is discussed further in section 6.2.2 on page 68.

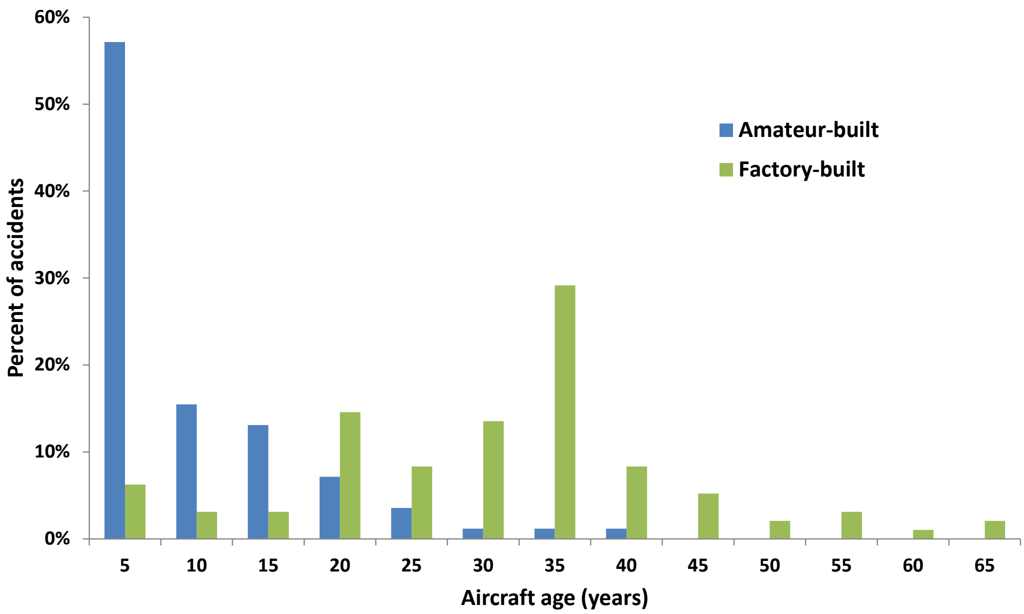
[27] Details about the nature of personal injuries incurred were available in 57 per cent of amateur-built and 50 per cent of factory-built serious injury accident records.

5.2 Aircraft characteristics

5.2.1 Aircraft age (years) at accident

The aircraft age in years from the date of manufacture is shown in Figure 18 below. More than half of all amateur-built aircraft involved in accidents were less than 6 years old, compared with factory-built aircraft accidents where more than half of the aircraft were over 31 years old.

Figure 18: Proportion of accidents by aircraft age (years) at accident (where known)



5.2.2 Aircraft age (hours) at accident

Amateur-built phase one risk assessment period

All amateur-built aircraft are required to undergo an assessment period of flying (the *phase one* period), where conditions are placed on the nature of operations which may be conducted. The restrictions vary between builders and aircraft, however, no passengers are allowed, and flight must be over a non-populated area generally within a certain proximity to a set aerodrome. This period of testing is used to demonstrate that the aircraft: [28,29]

(a) is controllable throughout its normal range of speeds and throughout all the manoeuvres to be executed; and

(b) has no hazardous operating characteristics or design features.

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[28] Civil Aviation Regulation (CAR) 262AP (3).

[29] These are outlined for ABE aircraft; however, flight test requirements also existed for ABAA aircraft prior to being issued a special Certificate of Airworthiness.

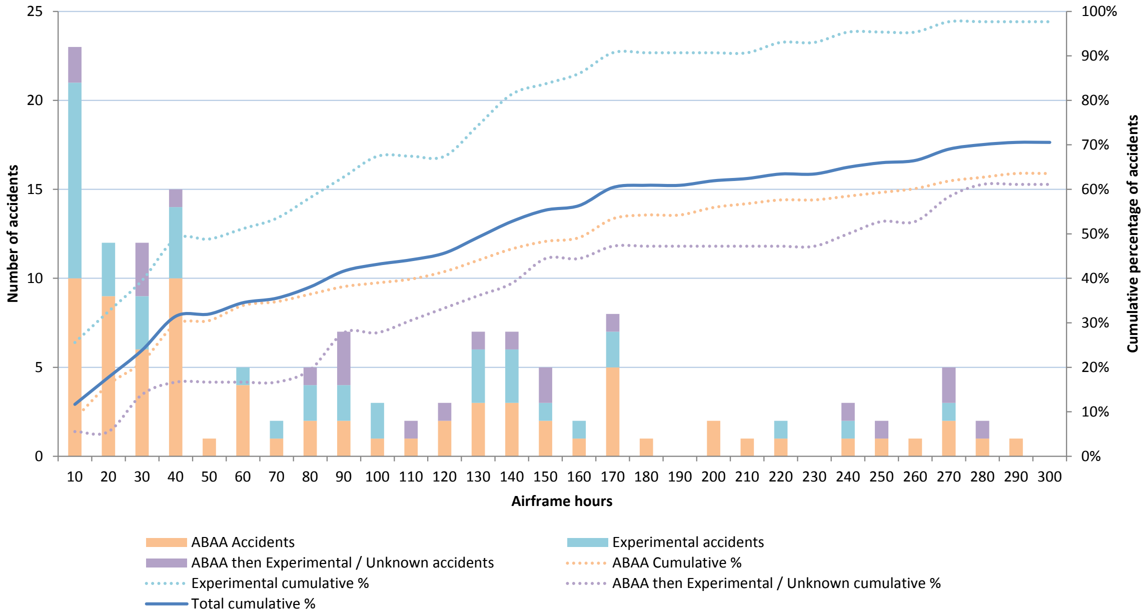
The Sport Aircraft Association of Australia (SAAA) have advised that typically, these restrictions are in place for the first 25 to 40 airframe flight hours for amateur-built experimental aircraft

Figure 19 shows the total accidents by airframe hours for amateur-built aircraft. It shows that while many amateur-built aircraft accidents occur within the first 40 hours of operation (31%), at least 69 per cent of all amateur-built accidents occur in aircraft after the phase 1 testing period. (In comparison, less than 3 per cent of the factory-built aircraft accident sample involved aircraft with less than 40 airframe hours at the time of the accident.)

Slightly less than half of accidents occurring in *amateur-built experimental* aircraft occurred in the first 40 hours of operation, with 90 per cent of all accidents occurring prior to 200 hours being accumulated on the airframe. Accidents occurring to aircraft operating under the amateur-built aircraft approval (ABAA) scheme had a similar distribution to that for all amateur-built aircraft (about 30 per cent occurred within the first 40 hours), as these made up the largest proportion of amateur-built aircraft accidents.

Further analysis by airframe age is provided later in the report for mechanical and non-mechanical related accidents (Section 6.1.1 on page 43).

Figure 19: Proportion of accidents by aircraft age (hours) at accident (where known)



5.3 Pilot demographics and experience

As this study only looked at VH- registered aircraft, the pilot licence and medical requirements are largely the same for pilots of amateur-built and factory built aircraft when the latter is flown for non-commercial purposes.[30]

5.3.1 Pilot demographics

The age of amateur-built aircraft accident pilots' in command, (median 54 years), was significantly older than the factory-built pilots involved in accidents (median age of 46 years).[31]

A higher proportion of pilots involved in amateur-built aircraft accidents were owners of the aircraft (about 78%) compared to pilots of factory-built aircraft accidents (about 49%). Of the amateur-built aircraft accident pilots, at least 40 per cent were the owner builder of the aircraft, while at least 31 per cent were a non-builder owner of the aircraft. The vast majority of accidents involved one pilot flying.

5.3.2 Pilot experience and recent hours flown at the time of accident

Median total pilot hours and hours flown in the 90 days prior to the accident are shown for all aircraft and just those on the accident aircraft type in Table 3 below.

Table 3: Median pilot hours flown for amateur and factory-built aircraft accidents, 1988 to 2010

Build type	Total hours	Total hours on type	Total hours last 90 days	Total hours on type last 90 days
Amateur-built	782	33.5	13	8
Factory-built	383	103.5	18	10

Amateur-built aircraft pilots' in command involved in accidents were significantly more experienced overall than factory-built aircraft accident pilots. However, they were significantly less experienced on the aircraft type that they were flying at the time of the accident.[32] Twenty per cent of amateur-built accident pilots had less than 10 hours experience on the aircraft type at the time of the accident, and a further 26 per cent had between 10 and 30 hours total experience on type.

The reason for amateur-built aircraft accident pilots having more overall experience is expected to be related to the older average pilot age, where more time is available to accrue flight hours. Furthermore, more amateur-built aircraft pilots have air

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30 An older population (discussed in section 5.3.1) of accident pilots could be expected to have a higher incidence of medical conditions and corresponding licence restrictions, however, no evidence has been found to indicate this as a systemic problem in amateur-built aircraft accidents.

31 Statistical significance (Mann-Whitney) of pilot age by aircraft build type $U = 6{,}963$, $n_1 = 86$, $n_2 = 230$, $p < 0.001$ two-tailed.

32 Statistical significance (Mann-Whitney)
Total experience: $U = 21{,}320$, $n_1 = 136$, $n_2 = 420$, $p < 0.001$ two-tailed.
Experience on type: $U = 34{,}188$, $n_1 = 134$, $n_2 = 388$, $p < 0.001$ two-tailed.

transport pilot licences (see section 5.3.4 on page 40 below), which also would allow the accrual of more flight hours.

The Civil Aviation Safety Authority have advised that there are very few suitable aircraft available for type-training and instruction for amateur-built aircraft when compared to factory-built aircraft, where a large percentage of these aircraft can be used for training. This is consistent with amateur-built aircraft accident pilots being less experienced on the aircraft type.

In terms of recent experience, pilot in command hours on the accident aircraft type in the 90 days prior to the accident was significantly lower (by 2 hours) for pilots of amateur-built aircraft accidents (8 hours) compared with factory-built aircraft accidents (10 hours).[33]

Experience by operation type

The median total pilot hours on type for amateur-built aircraft is driven by private operations, as these make up the majority of amateur-built aircraft accidents, with the other two main types of operation, training, and testing having a significantly lower number of accidents. A breakdown of pilot hours by these operation types in Figure 20 and Figure 21 shows that amateur-built aircraft pilots involved in accidents while operating privately generally had lower hours of flying experience than those conducting testing and training. Factory-built aircraft pilots involved in accidents while operating in privately typically also had lower overall experience than those pilots conducting test and ferry operations, although generally had more experience than those factory-built pilots involved in training accidents.

In contrast, pilots involved in accidents while conducting private operations generally had more experience on the accident aircraft type than pilots involved with testing and training for both aircraft types.

[33] Statistical significance (Mann-Whitney) Last 90 days on type: $U = 10{,}655$, $n_1 = 83$, $n_2 = 215$, $p < 0.01$ two-tailed.

Figure 20: Median total pilot hours on all aircraft (left) and accident aircraft type (right)[34]

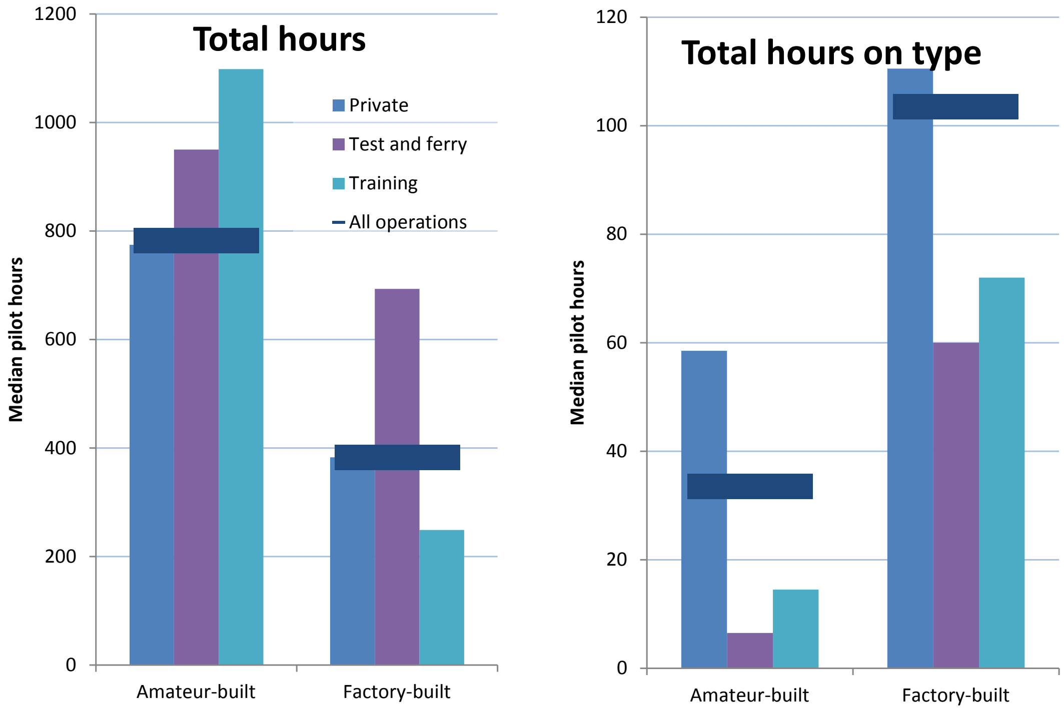
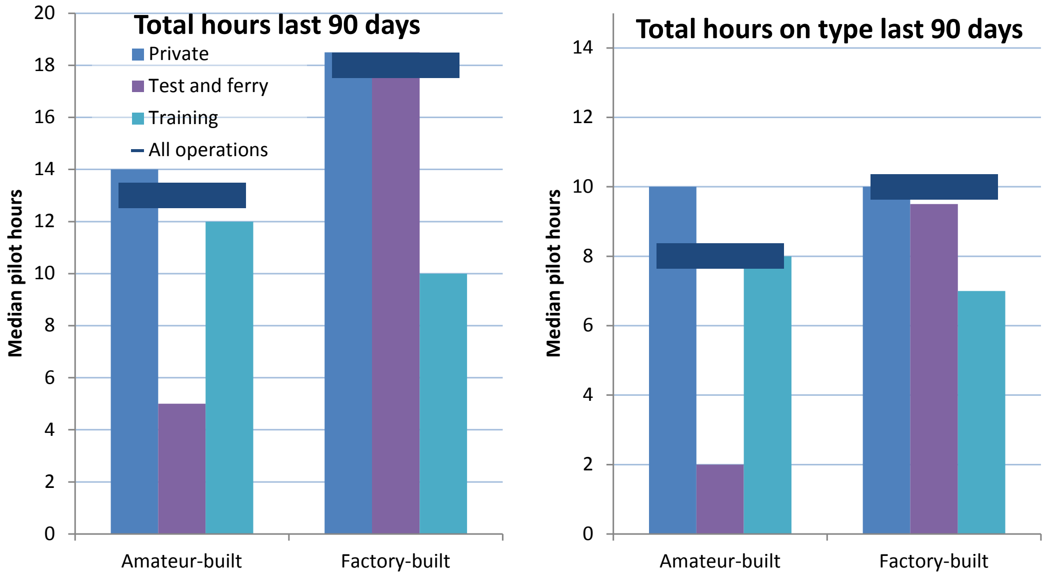


Figure 21: Median pilot hours 90 days prior to accident on all aircraft (left) and accident aircraft type (right)



Private operations pilot hours

In line with the overall results discussed above, pilots involved with accidents during amateur-built aircraft private operations were significantly more experienced (median 774.5 hours) than pilots of factory-built aircraft (median 383 hours). In

34 Training flights for factory-built accidents only include transitional training and check flights.

addition, they had significantly less experience on aircraft type (median 58.5 hours) compared with pilots of factory-built accident aircraft (median 110.5 hours).[35]

However, as seen in Figure 21, recent experience levels (last 90 days) for pilots involved with accidents while conducting private operations was similar between pilots of amateur-built and factory-built aircraft.

Test and ferry pilot hours

The difference between total pilot hours and pilot hours on type for amateur-built aircraft involved in test and ferry accidents was very large. More than half of all pilots involved in amateur-built test and ferry accidents had more than 950 hours total flight experience, compared with a median of only 6.5 hours on type, with several accidents occurring within the pilot's first flight hour for that type of aircraft. Accordingly, there were also very few hours flown on the aircraft type in the last 90 days, with half of the pilots recording less than 2 hours.

Despite the large differences, the small sample sizes of pilot experience data from test and ferry accidents meant that the only statistical difference was amateur-built pilots had significantly less experience on type (median 6.5 hours) than did factory-built test and ferry accident pilots (median 60 hours).[36]

This flight experience suggests that experienced pilots are often involved with test flying amateur-built aircraft for the first time, or during significant test phases, such as stall testing. However, due to the unique designs of many of these aircraft, it may not be possible to become experienced with the aircraft type before testing.

Unusually, more than half of the amateur-built aircraft pilots involved with accidents in test and ferry operations had less than 5 hours total flying recorded in the past 90 days on any aircraft.

The higher currency levels for pilots of factory-built test and ferry accidents are likely to be during ferry flights.

Training pilot hours

More than half of the pilots involved with amateur-built training related accidents had just below 1,100 hours total flight experience, which is the highest out of any relevant operation types for factory or amateur-built aircraft. This is in contrast to more than half of amateur-built aircraft pilots having less than 15 hours experience on the aircraft type at the time of the accident.

A comparison between the total pilot experience involved in the accident for those pilots involved in check and transition training accidents shows that pilots of amateur-built aircraft had significantly more overall experience (median of 1,098

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35 Statistical significance (Mann-Whitney) for private operations:
Total experience: Mann-Whitney $U = 14{,}547.5$, $n_1 = 104$, $n_2 = 368$, $p < 0.001$ two-tailed.
Experience on type: Mann-Whitney $U = 21{,}116.5$, $n_1 = 102$, $n_2 = 340$, $p = 0.001$ two-tailed.

36 Statistical significance (Mann-Whitney) total experience on type for test and ferry operations:
$U = 267$, $n_1 = 22$, $n_2 = 15$, $p < 0.01$ two-tailed.

hours) than pilots of factory-built aircraft conducting similar check and transition training operations (median of 249 hours).[37]

The pilot experience on the aircraft type involved in the accident (Figure 20) for pilots involved in training accidents was consistent with the overall trends, with amateur-built aircraft accident pilots having significantly less hours on the aircraft type (median of 14.5 hours) when compared with similar factory-built training accidents (median of 72 hours).[38]

The hours flown on all aircraft in the last 90 days, and the hours flown in the accident type aircraft in the last 90 days (Figure 21) were very similar between amateur-built and factory-built aircraft for check and training accidents.

5.3.3 Accident pilot experience and recency compared to all amateur-built aircraft pilots

Pilot hours were compared between those pilots involved in accidents in amateur-built aircraft and those who responded to the *ATSB amateur-built aircraft owners survey* published in the first part of this report series[39]. The survey results represented 353 owners of amateur-built aircraft in 2007 that responded to the ATSB survey.

In terms of total hours of flying experience, the accidents pilots were very similar to the survey pilots. However, for hours on type (estimated from the survey results from the total hours flown on any amateur-built aircraft), Figure 22 shows that the accident pilots had significantly less experience (median 34 hours) than the survey respondents (median 200 hours).[40]

Further analysis of accidents by pilot hours on type is explained in the Section 6.1.3 for accidents related to loss of control.

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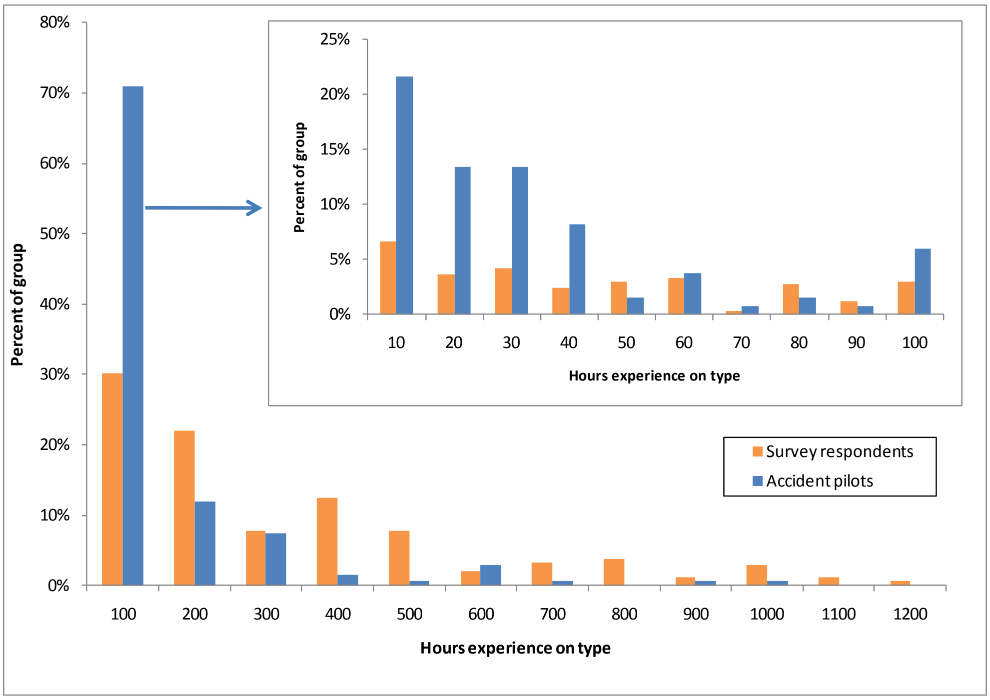
37 Statistical significance (Mann-Whitney) total pilot experience for training operations: $U = 96.5$, $n_1 = 10$, $n_2 = 37$, $p < .05$ two-tailed.

38 Statistical significance (Mann-Whitney) total pilot experience on type for training operations: $U = 246$, $n_1 = 10$, $n_2 = 33$, $p < .05$ two-tailed.

39 ATSB (2009). *Amateur-built and experimental aircraft Part 1: A survey of owners and builders of VH- registered non-factory aircraft* (AR-2007-043(1)). Section 3.2.4 of that report describes the pilot hours for respondents of the survey.

40 Statistical significance (Mann-Whitney) Survey respondents compared to accident pilots hours on type: $U = 11{,}224$, $n_1 = 335$, $n_2 = 134$, $p < .001$ two-tailed.

Figure 22: Hours experience on type for amateur-built aircraft accident pilots and owners of amateur-built aircraft

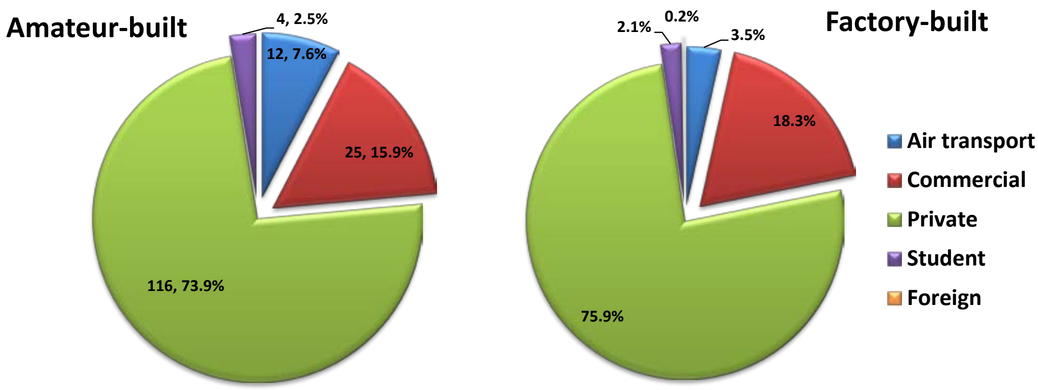


5.3.4 Licences held by pilots

Figure 23 below shows that a higher proportion of air transport pilot licence holders were involved with accidents in amateur-built aircraft when compared with factory-built aircraft accidents. This is consistent with the higher overall median experience of amateur-built pilots.

Private pilots were in the majority of accidents involving factory-built and amateur-built aircraft. There were a higher proportion of pilots holding a commercial pilot licence involved in factory-built aircraft accidents.

Figure 23: Types of licences held by pilots flying accident aircraft



6 THE NATURE OF AMATEUR-BUILT AIRCRAFT ACCIDENTS – MATCHED-SAMPLE COMPARISON

The following chapter describes typical amateur-built aircraft accidents, and provides a comparison with factory-built aircraft accidents using the matched-sample data set. It is divided into two sections – the first describing the occurrence events that led to amateur-built aircraft accidents (accident precursors), and the second describes the accident events themselves. In doing so, this chapter also explores the contributing safety factors for both the precursor and actual accident events.

6.1 Accident precursor occurrence events

Accident precursors are those events which describe the significant parts of an accident occurrence that happen before injuries or damage to the aircraft occur. They are the facts of an occurrence prior to the accident, and as such are instructive to identify some of the factors contributing to an accident.

An example of an accident precursor is an engine failure, which describes what happened to lead to the pilot conducting a forced landing in which the aircraft sustained damage. However, these events do not always necessitate an accident, for example a rejected take-off may not result in an accident, although there are accidents following some of these occurrences.

There can be more than one precursor in each accident, such as loss of control which is preceded by an engine failure after take-off.

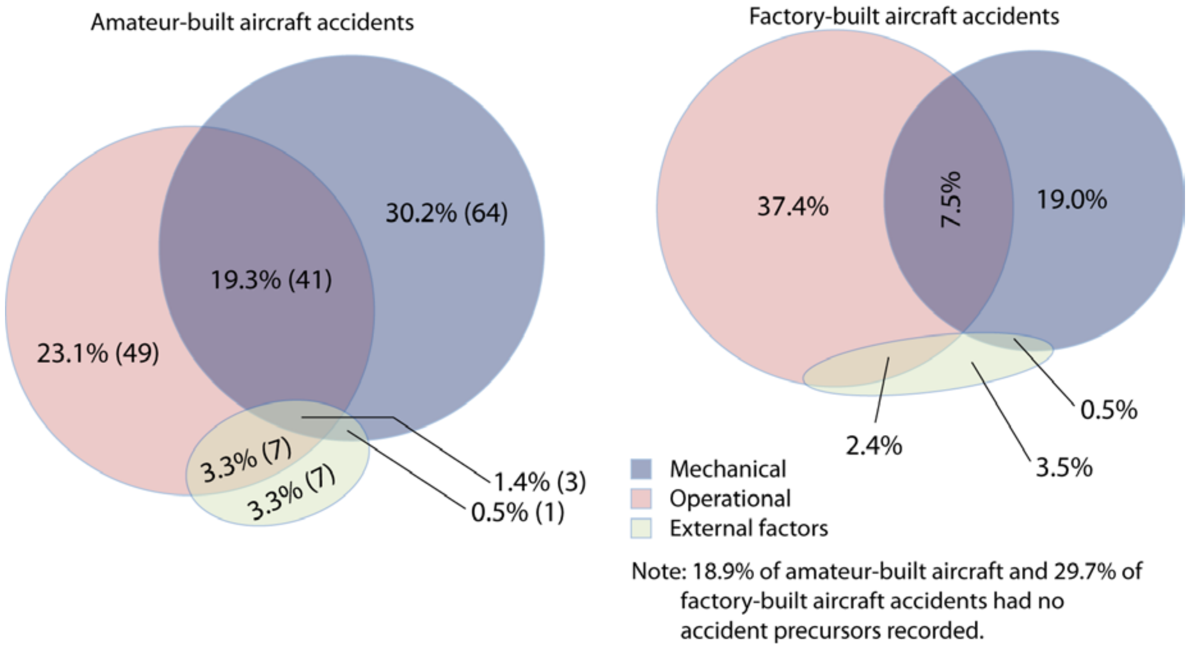
Figure 24 below illustrates the differences between amateur-built and factory-built accident precursor events that eventually led to an accident. This is divided into three categories:

- Operational – non-mechanically originated events which occur within the aircraft, such as a loss of aircraft control or fuel exhaustion. These are a result of human influences to an aircraft.
- Mechanical – mechanical events which originate from within the aircraft, such as in flight break-up and other airframe failures, power loss to an engine, or the failure of an aircraft system. These are related to system failures, rather than internal influences to an aircraft.
- External events – events which relate to airspace, such as mid-air collisions, aerodromes and airways facilities, such as runway lighting failures, and the natural environment, such as birdstrikes and poor weather.

The numbers shown in Figure 24 are the number of accidents which were identified as having a combination of any operational, mechanical or external event or condition that led to the accident. The overlapping areas of the circles in the Venn diagram show where more than one category of accident precursor was attributed to the accident.

Some accidents did not have accident precursors recorded, for example where a hard landing occurred (the accident event) and it could not be determined what events (if any) led to the hard landing. Approximately 19 per cent of amateur-built and 30 per cent of factory-built aircraft accidents did not have any precursor events identified.[41]

Figure 24: Accidents with precursors 1988 to 2010



Note: Occurrence type intersections are indicative, but not to scale.

Amateur-built aircraft accidents were almost three times more likely to involve mechanical problems before the accident, with over half of all accidents having mechanical related occurrence types prior to the accident occurring. This is significantly higher than the factory-built aircraft control group where only about 27 per cent of accidents had some form of mechanical occurrence prior to the accident.[42]

Furthermore, the mechanically related accident rate was over four times higher in private amateur-built aircraft accidents (2.11 mechanical accidents per 10,000 flight hours) when compared to private factory-built aircraft accidents (0.51 mechanical accidents per 10,000 flight hours). [43]

Pilots involved in mechanically related accidents in amateur-built and factory-built aircraft did not have any significant differences between their hours of experience on the accident aircraft type nor hours overall than those involved in non-mechanically related amateur-built aircraft accidents. This suggests that unfamiliarity with the aircraft's systems is generally not the reason why amateur-built aircraft pilots are having accidents.

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41 It is probable that some of these accidents did have precursor occurrence events, but as over half of the accidents had no investigation conducted, these precursor events were difficult to identify unless reported by the pilot. However, this is not expected to affect the results.

42 Statistical significance (chi-square cross-tab) between accidents involving mechanical precursors and aircraft build, $\chi^2_{(1,\, n = 760)} = 40.69$, $p < .001$, 2-tailed.

43 The factory-built dataset used for rate calculation was a subset of the factory-built private operations rate used in section 4.2.1, not the matched sample set used throughout this chapter.

Operational accident precursors were present in a similar proportion of accidents, about 47 per cent, for both amateur and factory-built aircraft.[44]

There were a small number of external factors for both groups: 8.5 per cent of amateur-built and 6.4 per cent of factory-built aircraft accidents having external factors attributed as accident precursors. However, it should be noted that weather and other environmental conditions are usually considered as contributing safety factors which were recorded for many accidents, and as such there are more external factors than indicated in the figure above.

6.1.1 Accident pre-cursors and amateur-built total airframe hours

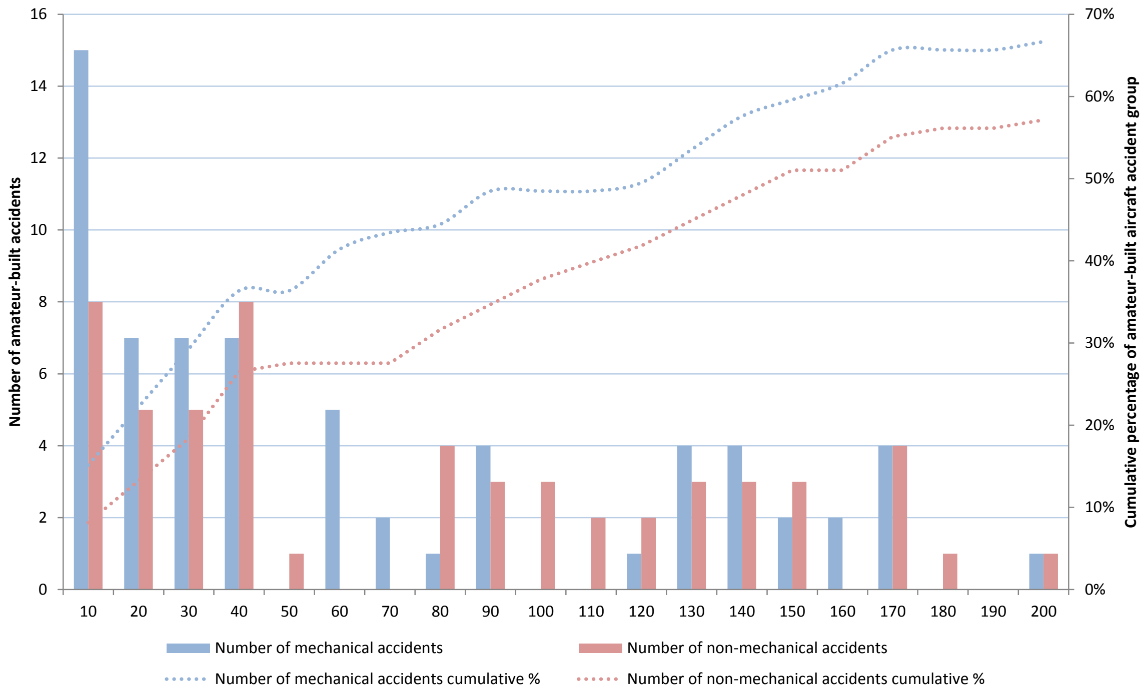
As can be seen in Figure 25, amateur-built accidents occurred across a range of airframe hours, with more accidents occurring after the initial testing period. Half of all amateur-built aircraft had less than 131 hours accumulated prior to the accident occurring, as shown in Table 4. Mechanically related accidents had lower median airframe hours when compared with non-mechanically related accidents, although this difference was not statistically significant. (As explained in section 6.1.3 below, most of the non-mechanically related accidents involved loss of control.)

Table 4: Median airframe hours at time of accident for amateur-built aircraft accidents, 1988 to 2010

Build type	All accidents	Mechanically related accidents	Non-mechanically related accidents
Amateur-built	131	122	146.5

[44] Note that due to the significantly higher amateur-built aircraft accident rate, although the proportion of operational accidents was similar, there were significantly more amateur-built operational accidents per 10,000 flight hours.

Figure 25: Total airframe hours for amateur-built aircraft accidents with mechanical and non-mechanical accident pre-cursors



Amateur-built phase one risk assessment period

All amateur-built aircraft are required to undergo an assessment period of flying (the phase one period), where conditions are placed on the nature of operations which may be conducted (see section 5.2.2 on page 33). Typically, these restrictions are in place for the first 25 to 40 airframe flight hours.

One-third of mechanically related accidents occurred within the first 40 airframe hours, in particular in the first 10 flight hours, as shown in Figure 25 above. One quarter of non-mechanically related accidents were within the first 40 airframe hours, which appears to be largely related to pilot inexperience on the aircraft type.

The majority of amateur-built testing and training accidents occurred within this period, making up approximately 57 per cent of all amateur-built accidents on aircraft with less than 40 accumulated flight hours

Airframe hours are not directly related to total pilot hours on type, as a significant proportion of aircraft are second-hand, and some are not flown by the aircraft owner (see section 5.3.1). This probably accounts for the non-mechanical accidents being slightly more evenly distributed than mechanically related accidents.

Table 5: Proportion of mechanical and non-mechanically related accidents within amateur-built airframe hours compared with all matched-sample factory-built aircraft accidents

	Amateur-built			Factory-built
Airframe hours	**< 40 hours (n=60)**	**≥ 40 hours (n=137)**	**Unknown (n=15)**	**All[45] (n=548)[46]**
Mechanical accidents	36 (60%)	63 (46%)	10 (67%)	27%
Non-mechanical accidents	24 (40%)	74 (54%)	5 (33%)	73%
Total	*60 (100%)*	*137 (100%)*	*15 (100%)*	*100%*

Table 5 shows that mechanically related accidents were more common, relative to non-mechanical accidents, in the first 40 hours compared with amateur-built aircraft accidents after this period.

As mentioned above, there were significantly more mechanically-related accidents for amateur-built aircraft than factory-built aircraft. However, even when comparing only those amateur-built accidents that occurred after the airframe had accrued more than 40 hours, there were still significantly more mechanically related amateur-built accidents than factory-built accidents.[47]

This shows that while the phase one risk assessment period is capturing many mechanically related problems prior to flight restrictions being lifted, when compared with factory-built aircraft accidents, there is a significantly higher proportion of mechanically related amateur-built aircraft accidents after the phase one risk assessment period is complete. These factors are discussed below.

Figure 26 indicates the typical proportions of accidents that occur within the first 40 airframe hours, corresponding to the upper limit of the test-flying period. As stated in 4.1.2 on page 22, it is not possible to directly compare ABE and ABAA aircraft groups, as the overall airframe and pilot hours are not currently known for each amateur-built aircraft build group. However, Figure 26 and the following analysis are included for indicative purposes. It should be remembered, however, that the

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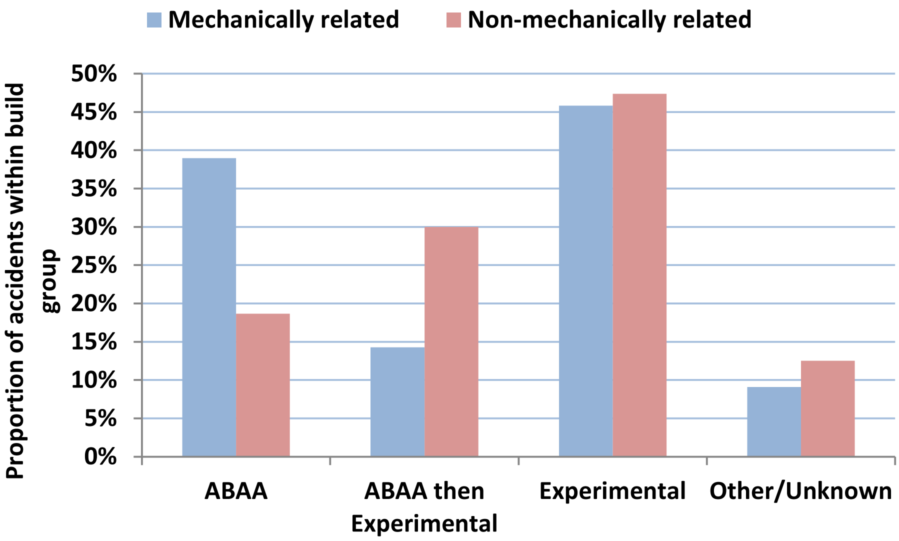
45 As discussed above, very few (less than 3%) of factory-built accidents involved aircraft with under 40 airframe hours, so a comparison for factory-built accidents by airframe hours is not shown.

46 It is important to remember that the data shown for the factory-built accidents represent a sample of all factory-built accidents, based on the matched-sample technique (described in section 3.2.2) of selecting three accidents from similar factory-built aircraft for each amateur-built aircraft involved in an accident. For this reason, only percentages will be shown for the factory-built accidents to show how the proportion of various types of accidents differs between the amateur-built and factory-built data sets.

47 Statistical significance (chi-square cross-tabulation) for amateur-built aircraft with airframe hours above 40, factory-built aircraft and mechanical accident precursors:
≥40 amateur-built airframe hours, $\chi^2(1, n = 685) = 18.520, p < 0.001$, 2-tailed.

majority of ABAA aircraft accidents with under 40 airframe hours were before 1998, while all of the ABE accidents were after 1998.

Figure 26: Proportion of amateur-built aircraft having accidents with less than 40 accumulated airframe hours by build group for mechanical and non-mechanically related accidents



Mechanically related accidents occurred only slightly more frequently in the first 40 airframe hours for ABE aircraft when compared with ABAA aircraft.

Amateur-built experimental aircraft had a very similar proportion of accidents with mechanical and non-mechanical accident pre-cursors in aircraft with less than 40 accumulated airframe hours (Figure 26). This is likely to be due to the vast majority of these aircraft being flown by the original owner (78%) and therefore, the airframe hours being similar to the pilot experience on the aircraft type.

In contrast, ABAA aircraft accidents had a lower proportion of non-mechanically related accidents with less than 40 airframe hours, which is expected to be related to the higher proportion of second hand ownership (50%), and that ABAA aircraft are older than ABE.

6.1.2 Mechanical accident precursors

Mechanical accident precursors make up the largest proportion of amateur-built aircraft accidents, as shown in Figure 24 on page 42. The largest proportions (above 5%) of these are shown in Figure 27 below.

Figure 27: Mechanical accident pre-cursors for amateur-built and factory-built accidents 1988 to 2010

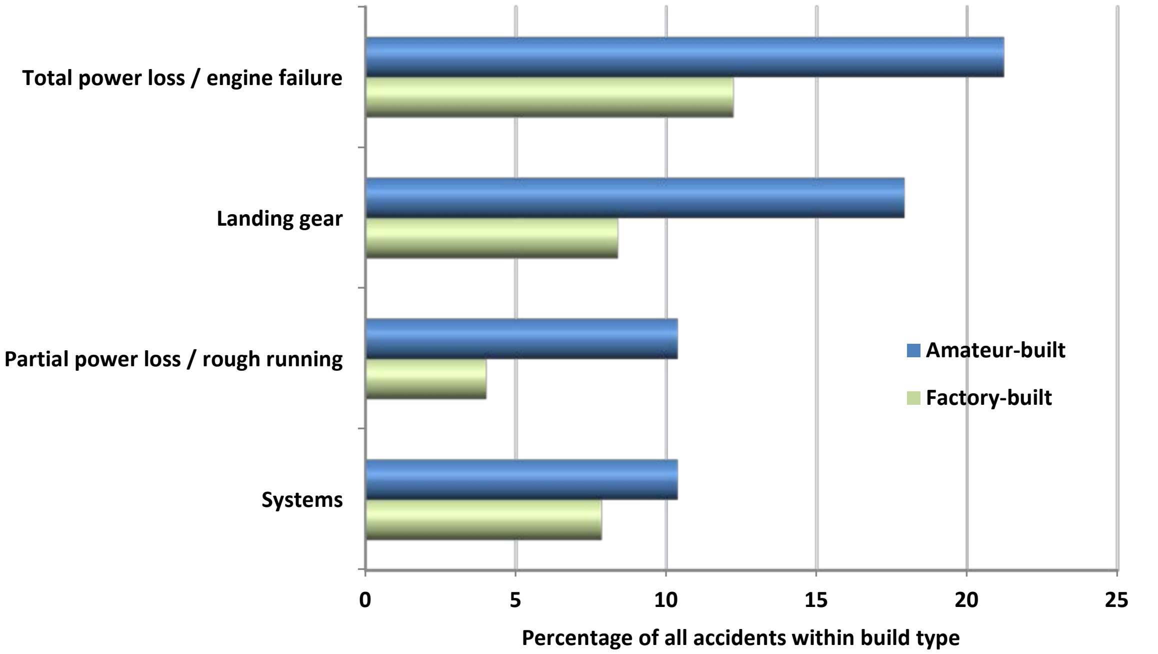
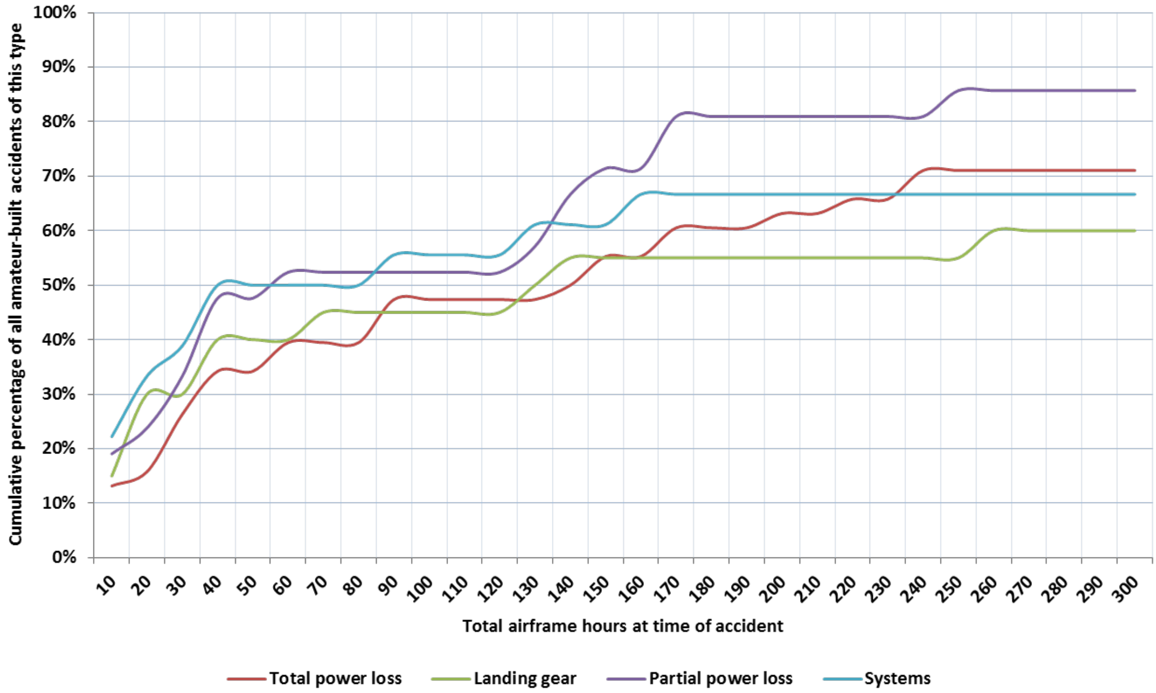


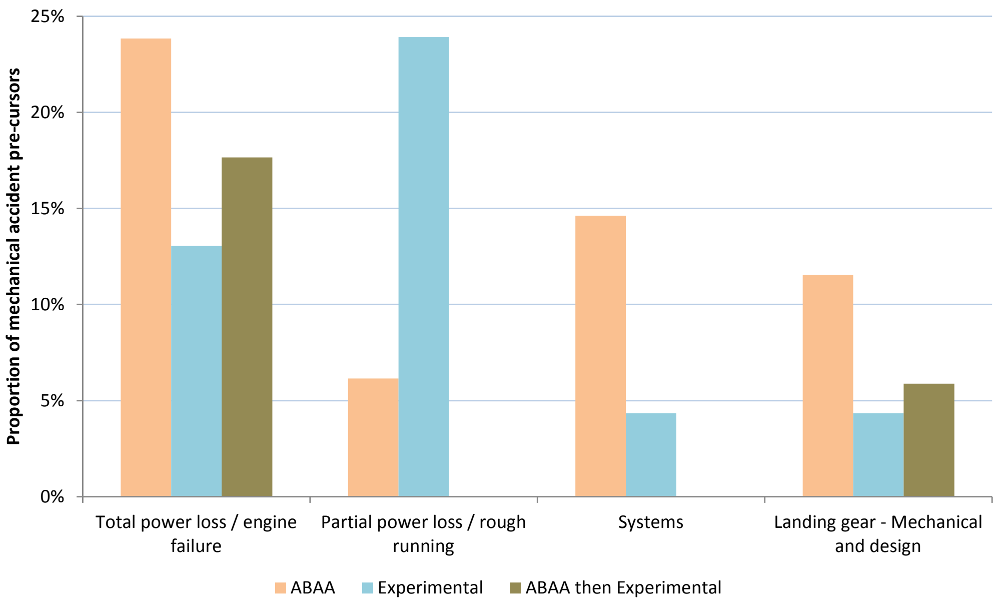
Figure 28 below shows that a similar trend exists for all significant mechanical amateur-built accident pre-cursors with respect to airframe hours, in particular during the first 150 airframe hours.

Figure 28: Cumulative percentage by airframe hours of mechanical accident pre-cursors for amateur-built aircraft 1988 to 2010



ABAA aircraft were relatively more susceptible to total power loss, systems problems and mechanical and design related landing gear issues, as shown in Figure 29 below. However, partial power loss was more common in experimental aircraft.

Figure 29: Proportion of mechanical occurrence types within amateur-built aircraft build groups, 1988 to 2010



Case study – Chain reaction: landing gear problems then engine failure

Neico Aviation Incorporated Lancair 320, 11 November 2002

Following the failure of the nose landing gear to deploy, the pilot came into land with a strong cross-wind from the left. During the flare, the pilot detected the rudder losing effectiveness and commenced a go-around. At about 30 feet above ground level, and while in a left turn, the engine failed, and the pilot conducted a forced landing in a paddock.

Factors affecting the nose gear not deploying were:

1. The nose landing gear hang-up bolt had been replaced in reverse, leading to it not being able to deploy.

Factors reportedly affecting the engine failure were:

1. The aircraft was not fitted with a header fuel tank.
2. There was a strong left cross-wind, and it is likely that this would have required the aircraft to be in a prolonged side slip (right wing up) during landing.

Engine failures and partial power loss

Engine failures and partial power loss occurrences were significantly more common in amateur-built aircraft accidents, being more than twice as likely when compared with factory-built aircraft accidents.[48] These events occurred in 30 per cent of all amateur-built aircraft accidents, compared with 16 per cent of factory-built accidents.[49]

The amateur-built engine power loss accident rate (1.23 accidents per 10,000 flight hours) was nearly five times higher than the factory-built aircraft engine power loss accident rate (0.26 accidents per 10,000 flight hours) over the period of study in private operations. Although the private operations amateur-built engine power loss rate halved between 1988 to 1999 and 1999 to 2010, the amateur-built engine power loss rate (0.85 accidents per 10,000 flight hours) remained more than three times higher than factory-built private operations engine power loss rate (0.26 accidents per 10,000 flight hours) between 1999 and 2010.

For amateur-built aircraft with more than 40 accumulated airframe hours between 1999 and 2010, this equated to an accident rate of about 0.64 engine related accidents per 10,000 flight hours in private operations. Furthermore, 24 per cent of amateur-built aircraft accidents occurring in aircraft with more than 40 accumulated airframe hours were due to engine failures and partial power loss, which is also significantly higher when compared with factory-built aircraft accidents.[50, 51] This is consistent with the larger proportion of mechanical accident pre-cursors for aircraft with more than 40 airframe hours, as identified in section 6.1.1 on page 43.

There were a higher proportion of amateur-built partial power loss accidents occurring within the first 40 airframe hours when compared with amateur-built total power loss accidents (shown in Figure 28 on page 47). Almost half of all partial power loss occurrences occurred with less than 40 accumulated airframe hours, compared with total power loss, where 34 per cent of these accidents occurred in the first 40 airframe hours.

Engine failures and partial power loss events occurred most commonly on initial climb in amateur- built aircraft (35 per cent of all engine malfunctions), followed by cruise (27%), as shown in Figure 30. In contrast, factory-built engine failures and partial power losses were more common during cruise (43%) than on initial climb (27%).

A description of the specific nature of these engine problems is described in the following pages.

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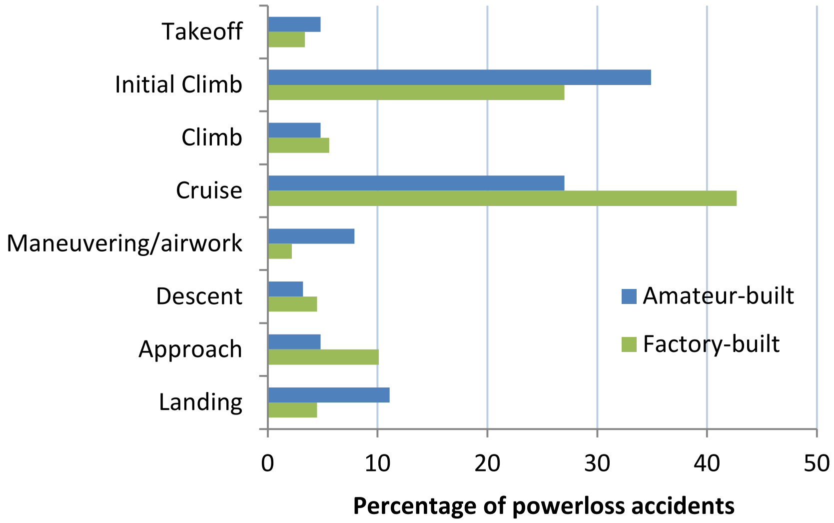
48 Statistical significance (chi-square cross-tabulation) between aircraft build type and partial or total power loss events, $\chi^2(1, n = 760) = 17.350$, $p < 0.001$, 2-tailed.

49 Note that the sum of the proportions of engine failure and partial power loss is slightly higher than the combination, due to some partial power loss events leading to complete engine failures.

50 Statistical significance (chi-square cross-tabulation) between factory-built and amateur-built aircraft >= 40 airframe hours and partial or total power loss events, $\chi^2(1, n = 685) = 4.610$, $p < 0.05$, 2-tailed.

51 Less than 3 per cent of factory-built engine failure and partial power loss accidents had less than 40 accumulated airframe hours, which does not affect the significance of power loss accidents for factory-built versus amateur-built aircraft accidents with more than 40 airframe hours.

Figure 30: Proportion of engine failures and partial power loss accidents by phase of flight and build type



Case study – Redundant design or false sense of security?

Vans RV-6A fitted with Honda 2.7 litre engine and Eaton supercharger, 7 September 2007

Just after take-off from runway 27, the engine lost power and the pilot returned the aircraft to Yarram for a precautionary landing. The take-off had been in nil wind conditions, but on return to land on runway 09, the aircraft encountered a tailwind. During the landing roll, the aircraft overshot the runway causing substantial damage to the left fuel tank and fuselage skin. The pilot was the only occupant and was not injured.

Factors affecting the partial power loss were:

1. On initial climb the main bearing in the supercharger seized.
2. The redundant supercharger bypass was not large enough to provide sufficient airflow and therefore engine power to maintain height.

The pilot reported that the engine fitted was overweight and underpowered, and that he had added a supercharger for extra power.

Table 6 below shows factors and events related to engine failures and power loss events which make up more than 5 per cent of these occurrences in amateur-built accidents. A full list of all amateur-built accidents is included in Appendix C to assist with future mitigation strategies.

Table 6: Factors and events related to engine failures and partial power loss in amateur-built and factory-built aircraft accidents

Event or factor	Amateur-built (n = 63)	Factory-built (n = 89)
Technical failure	40% (25)	20%
Design faults	11% (7)	0%
Fuel starvation	8% (5)	2%
Carburettor icing conditions	6% (4)	10%
Repairing, replacing or installing	6% (4)	3%

During the initial climb phase, design faults, mechanical discontinuities, fuel starvation, carburettor icing and incorrect maintenance were the most common factors related to amateur-built engine failures and partial power losses.

Case study – Mechanical discontinuity – Fuel filter outlet blockage due to silicone sealer

Grega GN-1 Air Camper, 27 March 1989

After take-off, the engine failed completely. The pilot attempted to land straight ahead, but the aircraft airspeed was less than optimum, and the aircraft touched down heavily, collapsing the right main landing gear leg. The pilot and passenger were not injured.

Factors affecting the engine failure were:

1. While conducting engine maintenance the pilot had used silicone that he believed was fuel resistant on a fuel system gasket. However, it is not certain whether the silicone in fact did react with the fuel and degrade, or whether an excessive amount was used.
2. The investigation determined that the fuel filter outlet was blocked by the silicone sealer that had been used on the gasket.

ATSB Investigation 198901539

Technical failures resulting in engine failures and partial power loss (Median airframe hours – 142)

Engine technical failures were identified as being present in 25 of 63 amateur-built accidents with an engine failure or partial power loss. Nine of the 25 accidents involved aircraft with less than 40 airframe hours recorded. The different types of technical failures are summarised below.

- Mechanical discontinuities (14) - Engine failures and power losses that resulted from the disruption of a physical connection in a mechanical or hydraulic system. Some examples are loose fuel lines, broken seals, the failure of fuel pumps, and seized superchargers.
- Fractured and deformed components (5) - The physical separation or deformation of an engine component that included a broken engine crankshaft, a cylinder valve rocker arm, a broken timing belt and bent push-rods.
- Electrical discontinuity (2) - The disruption of an electrical connection at a wiring level.

- Software / firmware anomaly (1). In one example, the engine was reported to have failed due to a fault in the engine management computer.
- Other technical failures (4) included fuel vaporisation in the fuel lines.

Design faults (Median airframe hours – 130)

There were 7 out of 63 accidents involving engine failure or partial power loss where the design, including the inappropriate selection of a component was identified as being a factor in the accident. Two of these accidents occurred within the first three airframe hours, with the remainder of these accidents occurring after the accumulation of at least 100 airframe hours. It includes cases where the design resulted in decreased redundancy in a system. Some examples include a supercharger bypass valve being too small, a single ignition switch, no carburettor heat, and ineffective engine cooling due to poor cowling design.

Case study – Design issues – Single point of failure

Quickie Aircraft Corporation Q2, 22 June 2011

At 3,000 ft during the climb in a Quickie Q2-100 aircraft, the engine stopped. The pilot elected to conduct a forced landing back to the aerodrome of departure. However, on final approach for the runway, the aircraft encountered sink (descending parcel of air), and the right canard collided with an airport boundary fence post. The pilot was uninjured and exited the aircraft.

Factors affecting the engine failure:

1. The aircraft was fitted with a dual magneto ignition system, but with only a single ignition selector, reducing the level of redundancy of the system at the ignition selector.
2. The pilot reported that the ignition system failed on the aircraft resulting in the engine stopping.

The pilot reported that a forced landing could have been prevented if the aircraft was fitted with two separate switches for each of the dual circuits.

Fuel starvation (Median airframe hours – 33)

In five cases, fuel starvation was identified as being a factor leading to an engine failure in amateur-built aircraft accidents. Three of the five cases occurred in aircraft with less than 40 accumulated airframe hours. The causes were fuel filter blockages, un-porting of a wing tank while in a climbing turn, a loose fuel line connector and a leaking fuel filter.

In many cases, fuel starvation and exhaustion related engine failures cannot be positively established due to limited evidence. Due to this, engine failures resulting from fuel starvation and exhaustion numbers are expected to be higher than presented for both amateur-built and factory-built engine failures.

Pilot inexperience affecting the outcome of an occurrence following an engine failure or partial power loss

There are indications that loss of control and aircraft handling is related to a lack of pilot experience on the aircraft type, as explored further on page 58. Loss of aircraft control was identified as a factor in 14 per cent of amateur-built partial or total power loss accidents, compared with 4 per cent of factory-built partial or total power loss accidents.

However, the difference between engine failure and partial power loss accidents which did not have loss of control as a factor was still significantly different between amateur-built (34%) and factory-built (19%) aircraft accidents.[52] This shows that while loss of control is a factor in some amateur-built engine failure accidents, it does not account for the entire difference between the aircraft build types.

Landing gear

Landing gear related problems were recorded against 16 per cent of amateur-built and 8 per cent of factory-built aircraft accidents. Unintentional wheels up landings (where the pilot forgot to lower the landing gear) were not included in this analysis.

The blue bars in Figure 31 below show that landing gear accidents with identified mechanical issues were significantly higher in amateur-built aircraft accidents (9.9 %) compared with only 2.9 per cent of factory-built aircraft accidents, meaning that mechanical landing gear issues were over 3.5 times more likely in amateur-built aircraft accidents.[53] These accidents are explored further below.

Landing gear accidents where no pre-existing mechanical issue was identified (red bars in Figure 31) were similar in proportion of all accidents between amateur-built aircraft and factory-built aircraft accidents. Aircraft handling, assessing and planning and wind were the main factors identified and mostly resulted in hard landings or runway excursions.

In some accidents, there was some indication of a mechanical landing gear issue, although insufficient evidence was available to determine if the issue was pre-existing, however, these numbers were relatively low in both groups.

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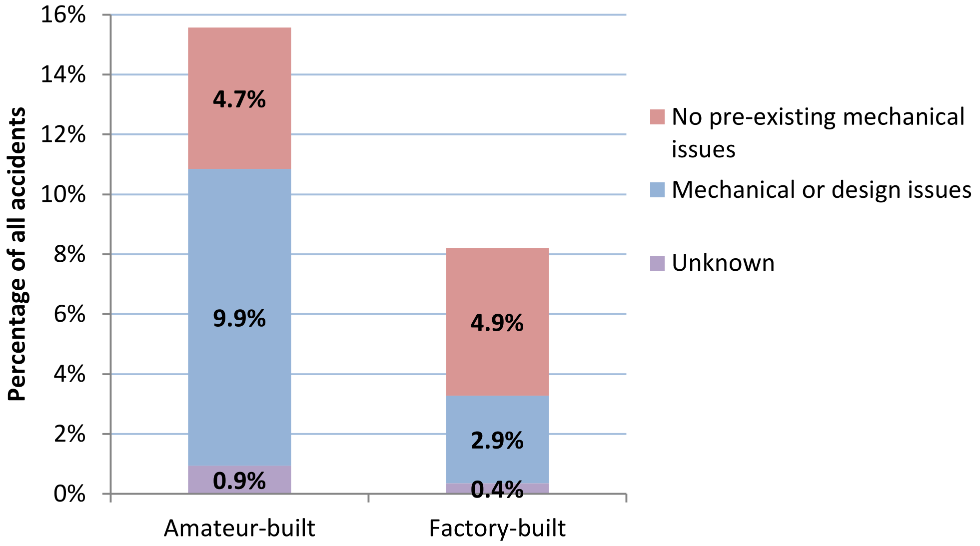
[52] Statistical significance (chi-square cross-tabulation) between aircraft build type and total or partial power loss accidents where loss of control was not a factor, $\chi^2(1, n = 604) = 14.162$, $p < 0.001$, 2-tailed.

[53] Statistical significance (chi-square cross-tabulation) between aircraft build type and mechanical landing gear events, $\chi^2(1, n = 760) = 16.108$, $p < 0.001$, 2-tailed.

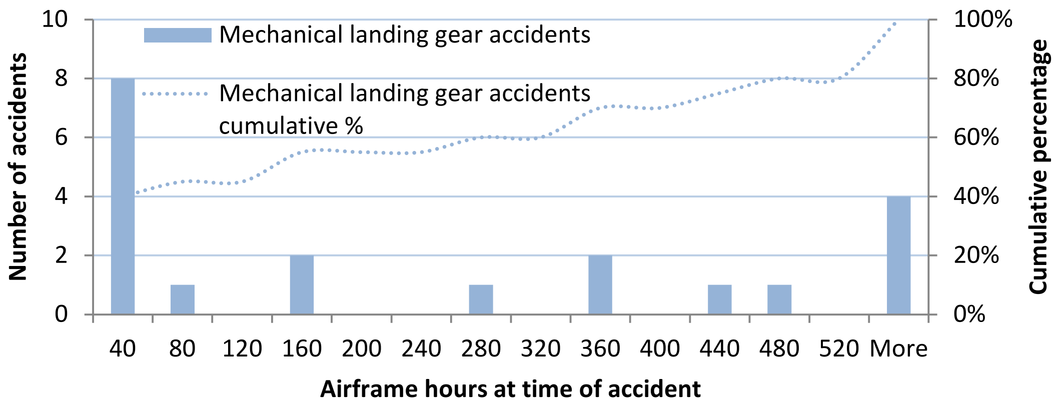
Figure 31: Landing gear accidents by build type divided by identified factors



For accidents that were a result of landing gear mechanical failures, technical failures, landing gear design, and incorrect installation were the main factors identified leading to the accidents. These mechanical failures are explained in further detail in the following pages.

Figure 32 below shows a breakdown of mechanically related landing gear accidents by airframe hours for amateur-built aircraft. Accidents involving aircraft with less than 40 hours are over-represented; however, more than half of these accidents occur after 40 hours has accumulated on the airframe, which is still significantly higher than factory-built aircraft mechanical landing gear problems.[54]

Figure 32: Accidents involving mechanical landing gear problems by accumulated airframe hours (where hours are known) for amateur-built aircraft 1988 to 2010



[54] Statistical significance (chi-square cross-tabulation) between factory-built and amateur-built aircraft >= 40 airframe hours mechanical landing gear events, $\chi^2(1, n = 685) = 9.533$, $p < 0.01$, 2-tailed.

Case study – A bit of a dampener at the end of a flight

Stoddard-Hamilton Glasair III, 17 April 2005

During the landing roll, the aircraft's nose wheel oscillated from side to side then turned sideways causing the nose to contact the ground. The aircraft pitched inverted and came to rest on its back. The aircraft was substantially damaged and the pilot received minor injuries.

Factors affecting the nose gear problems were:

1. It is probable that during a hundred-hourly maintenance inspection the nose wheel shimmy damper was incorrectly tensioned.
2. A nose-wheel shimmy developed on landing leading to the wheel turning sideways and the aircraft overturning.

Table 7 shows the types of mechanical failures of the landing gear that led to the amateur-built aircraft accidents. The majority of amateur-built mechanical landing gear problems resulted in the collapse of one or more landing gear legs, followed by wheels up landings resulting from some form of aircraft malfunction. Nose landing gear issues were more commonly involved than the main landing gear.

There were a similar number of gear collapses for both retractable and fixed undercarriage aircraft.

Table 7: Mechanical amateur-built landing gear accidents by wheel position

Accident type	Nose landing gear	Main landing gear	All landing gear	Total
Gear collapse	8	5	0	**13**
Wheels up landing	2	1	1	**4**
Brake failure	0	2	0	**2**
Detached wheel	1	0	0	**1**
Nose over	1	0	0	**1**

Case study – Nose up, shimmy up

Neico Aviation Incorporated Lancair 320, 2 September 1991

Following a local flight, the aircraft experienced a nose-wheel shimmy during the landing roll. The aircraft nose was then raised to take the weight off the nose-wheel until the aircraft was at a speed where the elevator could not hold the nose off the ground. As the nose-wheel again made contact with the runway, the shimmy re-developed causing the down-lock link to fail and the strut assembly to collapse.

Factors identified as causing the nose gear collapse were:

1. Following testing of the nose-strut, it was determined that when the strut was fully extended, the damper function was reduced, resulting in nose-wheel shimmy.
2. The down-lock link failed in overload due to the nose-wheel shimmy.

Following this accident, a modification was designed and incorporated to correct this problem.

Design, construction and maintenance factors

Nose landing gear problems

A common factor present prior to nose landing gear failures was nose wheel shimmy (excessive wobbling), but only in aircraft with retractable or castoring nose wheels.

- There were four design related nose gear collapses which included:
  - two cases of severe nose wheel shimmy resulting from the use of a Cessna 185 castoring tail-wheel and an ineffective shimmy damper
  - two cases of fracture of the nose wheel strut attachment due to poor welding and a weak design during testing of the aircraft at the most forward centre of gravity.
- There were also four landing gear problems related to maintenance and checking errors which included:
  - an incorrectly tensioned shimmy damper causing the nose wheel to turn sideways and leading to the aircraft tipping nose-over onto its back
  - a gear collapse due to an over-lubricated nose wheel shimmy damper causing cyclic fatigue and fracture of the landing gear support frame
  - a nose wheel collapse resulting from a loose retaining nyloc nut not being identified during previous pre-flight inspections resulting in the main retaining bolt slipping out on landing
  - the nose landing gear not deploying due to a bolt being installed in reverse.
- Remaining issues included a stripped nose landing gear nut resulting in a detached wheel after take-off from a rough strip, the fracture of the nose wheel leg and another gear collapse following excessive nose wheel shimmy.

Case study – Folding under pressure: knowing what your aircraft is made of

Rand Aircraft KR-2, 24 February 1990

About 20 minutes after departure, the pilot advised Coffs Harbour Tower that he was returning after observing a reduced oil pressure indication. Soon after he reported oil fumes in the cockpit and requested a priority landing from a straight in approach. The aircraft touched down heavily on the left main and tail wheel, collapsing the main landing gear and shattering the wooden propeller.

Factors affecting the engine failure and gear collapse were:

1. The pilot reported the oil leak had emanated from an incorrectly assembled firewall fitting on the oil line to the oil pressure indicator. That fitting had been installed prior to the present owner purchasing the aircraft.
2. The aircraft touched down heavily on the left wheel, leading to one of two mechanical latches slipping from the locked position.
3. The other mechanical latch had never engaged due to incorrect rigging.

Main landing gear problems

Main landing gear problems were related to either gear collapses or brake failures.

- Gear collapses included:
  - an incorrectly installed landing gear down-lock
  - right wheel locking and skidding resulting in significant side loads
  - fatigue cracking and fracture of the right main landing gear
  - a stress corrosion fracture of the main landing gear attachment bolt heads resulting from the use of counter-sunk bolts.
- Both cases of brake failures were on the same model of aircraft. One involved a brake fade and runway excursion, the other involved a brake fire while taxiing.

The single accident involving mechanical issues with all landing gears involved a wheels up landing from a design issue from a single flare, rather than a double flare fitting being used, resulting in a hydraulic fluid leak and the landing gear not deploying.

Mechanical system failures and problems

Mechanical systems failures occurred in 10.4 per cent of amateur-built and 8.2 per cent of factory-built accidents, which is not statistically different. Half of the amateur-built aircraft systems failure related accidents occurred in the first 58 airframe hours. The vast majority of these failures were related to the engine or fuel system, and are covered in the section *Engine failures and partial power loss* above. Failures related to landing gear issues are covered above.

The remaining three accidents from systems failures were related to propeller failures and a flap failure. One accident related to a propeller failure involved part of a propeller breaking off in flight. It is possible that this resulted from the spinner fracturing in flight. The other propeller failure is described in the case study below.

Case study – Propeller separation: A change in the air – environmental effects on wooden propellers

Christen Eagle, 20 January 1989

The pilot was carrying out a series of aerobatic manoeuvres when the propeller separated from the airframe. During the subsequent forced landing the pilot sustained minor injuries and the aircraft was substantially damaged.

Factors affecting the propeller failure were:

1. The aircraft had recently been moved from a cool moist climate to a warm dry climate, which is likely to have resulted in shrinkage of the propeller wood, and subsequent loosening of the propeller attachment bolts.
2. The recommended maintenance procedures were not adequately carried out which involved checking the wooden propeller in accordance with the 'Wooden Propellers – Inspection' airworthiness directive
(currently CASA AD/PFP/1 Amendment 3).
3. The loose bolts were able to move, resulting in cyclic fatigue stresses on the bolts and lock wire. This resulted in the loss of one of six bolts prior to the propeller separation, the failure of the lock wire, and the failure of the remaining five bolts.

ATSB Investigation 198900230

The remaining system failure involved an amphibious aircraft's flaps failing to deploy due to a failed screw. The aircraft was travelling near take-off speed when it settled and partially submerged. The screw failed in overload, but it is not clear how this occurred. The pilot reported that the flap selector handle was down for take-off, but it is likely that he did not check the physical deployment prior to the take-off run.

6.1.3 Operational accident precursors

The only operational accident precursor event that represented more than 5 per cent of events for amateur-built aircraft was loss of control (52 per cent of operational precursor events). Similarly, 40 per cent factory-built aircraft accidents with an operational precursor event involved loss of control with no other prominent event types.

Loss of control

Loss of control was attributed to 25 per cent of all amateur-built accidents compared with 19 per cent of the factory-built aircraft accidents used in the analysis. These proportions were not statistically significant. However, the private operations amateur-built loss of control accident rate per hour flown (1.08 accidents per 10,000 flight hours) was over 4 times higher than factory-built private operations (0.26 accidents per 10,000 flight hours)[55]. The amateur-built private operations loss of control accident rate halved between the periods 1988 to 1999 and 1999 to 2010 (1.64 to 0.81 accidents per 10,000 flight hours), but the same factory-built rate decreased by a greater proportion for the same time periods (from 0.34 to 0.14 accidents per 10,000 flight hours).

There were very similar proportions of ABAA and ABE aircraft loss of control accidents.

A significantly higher proportion of amateur-built aircraft loss of control accidents resulted in injury (64 %) when compared with factory-built aircraft (41 %), as shown in Table 8 below.[56] However, a very similar proportion of loss of control accidents resulted in a fatal injury for amateur-built (29%) and factory-built (27%) aircraft. Serious injury was 3 times more likely, and minor injuries were 2.8 times more likely after loss of control in amateur-built aircraft than factory-built.

Table 8: Loss of control accidents by highest injury incurred

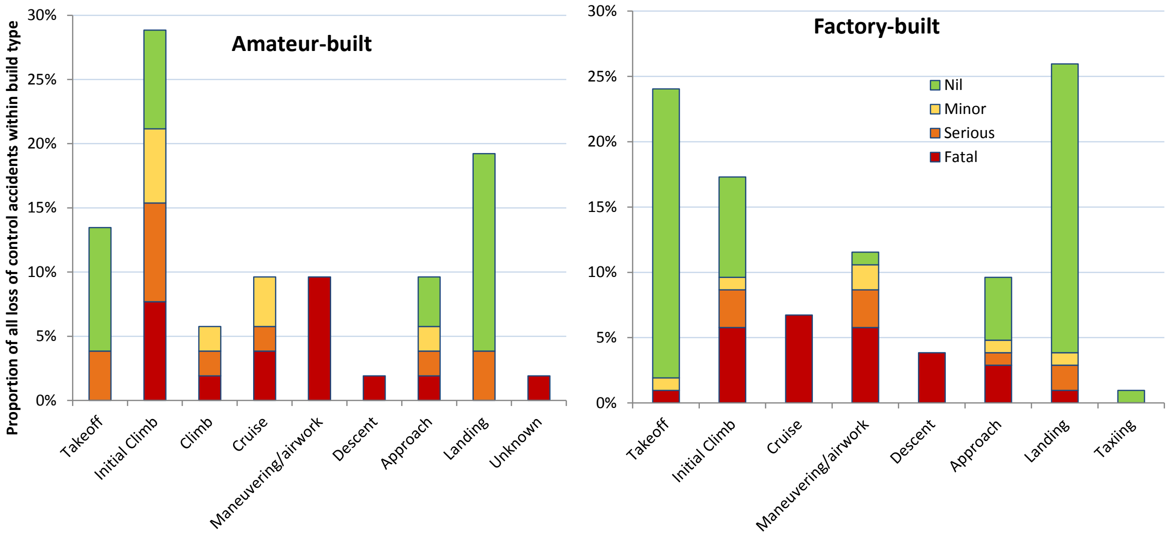
Build type	Fatal	Serious	Minor	Nil	Total
Amateur	15 (28.8%)	11 (21.2%)	7 (13.5%)	19 (36.5%)	52
Factory	28 (26.9%)	9 (8.7%)	6 (5.8%)	61 (58.7%)	104

The proportion of accidents where loss of control was a precursor event is shown by phase of flight in Figure 33. This shows that accidents involving a loss of control were most common during take-off, initial climb and landing for all aircraft. For amateur-built aircraft, loss of control on initial climb was over-represented and accounted for 29 per cent of loss of control accidents (but only 17 per cent of factory-built accidents). Not surprisingly, injury was more likely when the loss of control was in an airborne phase of flight.

55 The factory-built dataset used for rate calculation was a subset of the factory-built private operations rate used in section 4.2.1, not the matched sample set used throughout this chapter.

56 Statistical significance (chi-square cross-tab) between injury and aircraft build within loss of control accidents, $\chi^2_{(1,\, n = 156)} = 6.787$, $p < 0.01$, 2-tailed.

Figure 33: Loss of control accidents by phase of flight and highest injury incurred



The proportion of amateur-built accidents that involved loss of control did not significantly vary across the three main operation types.

Pilot hours on type were significantly lower in amateur-built aircraft loss of control accidents when compared to factory-built loss of control accidents.[57] This is similar with overall trends identified in section 5.3.2 on page 35, and indicates that inexperience is a factor for amateur-built loss of control accidents.

A higher proportion of second-hand owner pilots were involved in loss of control accidents, making up approximately 31 per cent of all second hand owner amateur-built aircraft accidents. Half of these pilots had less than 26 hours on the aircraft type.

Figure 34 shows that more than 65 per cent of amateur-built aircraft pilots involved in loss of control accidents had less than 45 hours on the aircraft type at the time of the accident, compared with factory-built aircraft loss of control accidents, where 45 hours or less on type equated to less than 30 per cent of factory-built loss of control accidents. Almost 80 per cent of all amateur-built aircraft loss of control accidents occurred prior to the pilot accumulating 100 hours on the aircraft type.

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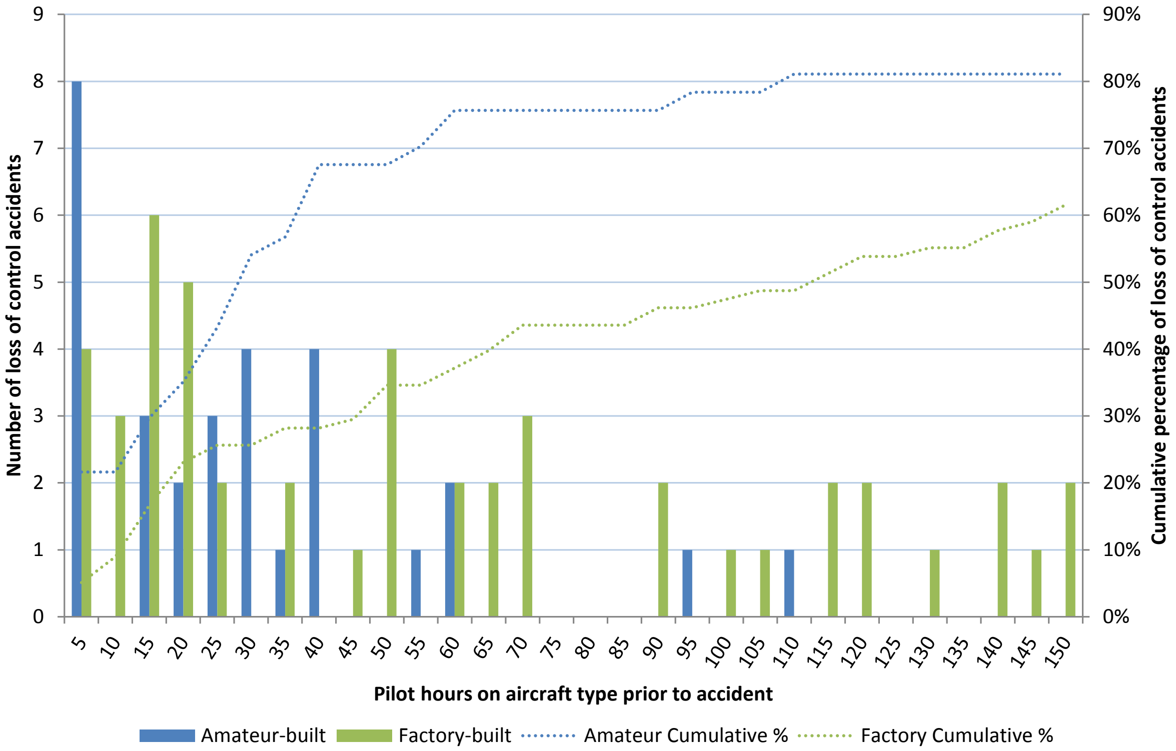
[57] Statistical significance (Mann-Whitney) of total pilot hours on aircraft type by aircraft build type for loss of control accidents $U = 1{,}955.5$, $n_1 = 37$, $n_2 = 78$, $p < 0.005$ two-tailed.

Figure 34: Pilot hours on type for amateur and factory-built aircraft accidents involving loss of control, 1988 to 2010



The table below shows accident precursors and safety factors that were present in five or more amateur-built loss of control accidents.

Table 9: Factors and events present during loss of control accidents[58]

Event or factor	Proportion of amateur-built loss of control accidents by phase of flight		Proportion of factory-built loss of control accidents by phase of flight	
	In Air (N = 35)	Take-off / landing (N = 17)	In air (N = 51)	Take-off / landing (N = 52)
Aircraft handling	54.3% (19)	58.8% (10)	37.3%	32.7%
Assessing and planning	31.4% (11)	11.8% (2)	25.5%	9.6%
Power plant / propulsion	28.6% (10)	0% (0)	5.9%	1.9%
Wind	14.3% (5)	35.3% (6)	15.7%	25.0%
Physical environment	8.6% (3)	23.5% (4)	9.8%	1.9%
Knowledge, skills and experience	8.6% (3)	11.8% (2)	7.8%	0%

58 All cases where the aircraft phase of flight was unknown were where the aircraft was airborne prior to loss of control. Loss of control while taxiing is not included in this analysis.

Aircraft handling and loss of control (Median pilot hours on type – 23)

The aircraft handling factor is attributed to an accident when there is sufficient evidence that through the direct manipulation of the flight controls, the pilot has mishandled the aircraft. There were significantly more amateur-built aircraft accidents involving loss of control where aircraft handling factors were present. [59]

Amateur-built aircraft pilots involved in loss of control accidents where aircraft handling was a factor had the relatively lower median hours when compared with the overall amateur-built accident set. This supports that aircraft handling and inexperience are related.

In most cases on the ground, this is in the form of a hard landing, or a mishandled cross-wind take-off or landing. In the air, typical examples include stall and spin related accidents on take-off in cross-wind conditions or following an engine malfunction.

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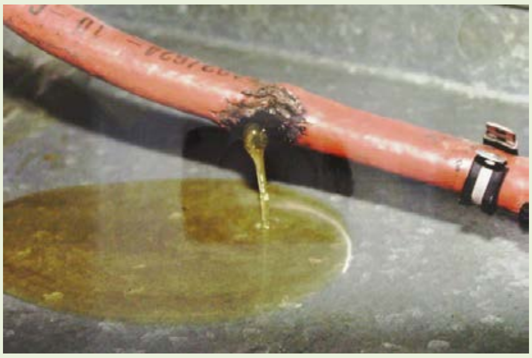
[59] Statistical significance (chi-square cross-tab) between aircraft handling and aircraft build within loss of control accidents, $\chi^2_{(1,\, n = 156)} = 6.382$, $p \leq 0.05$, 2-tailed.

Case study – Collision with terrain following loss of control and oil system problems

Lancair 320, 12 March 1998

The pilot in command transmitted a MAYDAY to Brisbane Sector 3L, stating that the engine had lost oil pressure and that it was her intention to land on a road. After a search involving a number of aircraft, the wreckage of the aircraft was found in a recently cleared paddock surrounded by coastal scrub country. The pilot received fatal injuries.



On-site investigation indicated that the aircraft was banked left at more than 90 degrees, and was approximately 45 degrees nose-down at impact. The aircraft then cartwheeled and broke up when it struck a windrow of felled trees. The landing gear was extended at impact. Engine oil was streaked along the lower fuselage aft of the engine compartment.

Factors contributing to the engine system problem were:

1. The engine was fitted with an incorrect oil hose with a significantly lower than required heat rating.
2. The oil hose rubbed on the exhaust manifold resulting in an oil leak and a low oil pressure indication.

ATSB Investigation 199800740

Power plant and propulsion problems related to loss of control (Median pilot hours on type – 39)

A significantly higher proportion of power plant related problems occurred prior to amateur-built aircraft loss of control accidents compared to factory-built aircraft loss of control accidents.[60] However, this is significantly lower in proportion to the overall proportion of amateur-built power plant and propulsion problems.

The median pilot hours on type for amateur-built loss of control accidents resulting from power plant related problems (39 hours) were slightly higher than the overall amateur-built median pilot hours on type (33.5 hours). Two pilots had less than 20 hours on type, and where known pilots typically accumulated 4 hours on all types in the past 90 days.

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60 Statistical significance (chi-square cross-tab) between power plant problems and aircraft build within loss of control accidents, $\chi^2_{(1,\, n = 156)} = 10.044$, $p < 0.005$, 2-tailed.

Half of amateur-built loss of control accidents relating to power plant issues occurred after the aircraft had accumulated 141 hours. Only three of these accidents had airframe hours below 40, indicating that most of these accidents were beyond the phase one assessment period.

Seven out of ten loss of control occurrences following a partial or total engine power loss were after take-off. The natures of these losses of control was an aerodynamic stall and possibly spin, often resulting from turning back toward the runway at a height at which this could not be achieved. The nature of these accidents is explored further in an ATSB report on managing partial power loss after take-off.[61]

Loss of control and engine power loss is also discussed in section 6.1.2 on page 53.

Assessing and planning related to loss of control (Median pilot hours on type – 28.5)

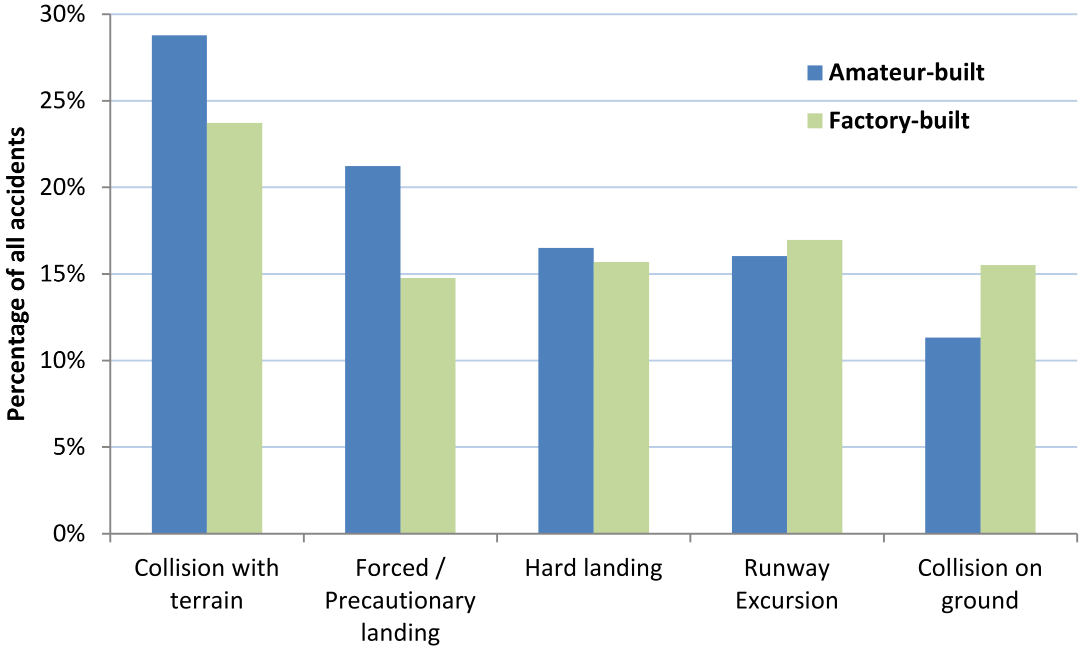
Assessing and planning errors were present in more amateur-built loss of control accidents (25%) when compared with and factory-built (17%) loss of control accidents, however these numbers were not significant. Assessing and planning is attributed to an accident when problems are identified with decisions or the decision making process. A typical example for take-off and landing is the assessment of the wind conditions for a crosswind take-off or landing that is beyond the limitations of the aircraft, or the capability of the pilot. A typical example of an in-flight assessing and planning problem often materialises on the ground. For example, the lack of consideration for a plan of action following engine malfunctions, such as a pre-flight safety brief before take-off. Other less frequent cases of this factor are the decision to fly low, conduct low level aerobatics, or continue a visual flight into bad weather, resulting in flight into instrument meteorological conditions.

61 ATSB (2011). *Managing partial power loss after takeoff in single-engine aircraft*. (Aviation Research and Analysis Report AR-2010-055). Canberra.

6.2 Accident events

Accident events describe the final event or events in the occurrence where aircraft damage and/or injuries occur. The six most common types are shown in Figure 35 below; each one of these accident types makes up at least 10 per cent of all accident events. Note that there were often multiple accident events in an occurrence, such as a collision on ground following a runway excursion.

Figure 35: Most common accident events for amateur and factory-built aircraft 1988 to 2010



6.2.1 Different accident events between amateur-built and factory-built aircraft accidents

As shown in Figure 35 above, collision with terrain and forced landings occur more frequently in amateur-built aircraft accidents compared with factory-built aircraft accidents. The reasons for this are discussed below.

Case study – Partial and complete engine power loss on initial climb followed by loss of control and collision with terrain

Van's RV-3, 12 March 2000

Hours on type: 5, Hours total: 16,574

After a normal take-off and when the aircraft was about 200 ft above ground level, the engine lost power rapidly. The pilot lowered the aircraft nose attitude and the engine restarted itself. Following a further short climb the engine again failed and did not restart.

The pilot turned the aircraft to the left, apparently with the intention of returning for a landing on the grass runway. During the turn the aircraft lost altitude rapidly and collided with the ground in a sports oval. The pilot received fatal injuries.

The investigation found a loose fuel line connection on the suction side of the fuel pump. The engine had failed due to fuel starvation, with the engine running lean immediately prior to stopping.

ATSB Investigation 200000885

Collision with terrain

Collision with terrain had the second largest proportional difference between factory and amateur-built aircraft accidents behind forced landings, making up 29 per cent of amateur-built accident events, compared with the 24 per cent of factory-built accident events, however these overall proportions were not significantly different. Most amateur-built aircraft collisions with terrain were on level ground, usually on open ground or among trees. Collision with terrain in urban environments was uncommon. The main factors leading to collisions with terrain for amateur-built aircraft are shown in Table 10 below.

Table 10: Main factors in amateur-built accidents resulting in a collision with terrain

Accident factor	Amateur-built (n = 61)	Factory-built (n = 130)
Loss of control	59.0% (36)	35.4%
Aircraft handling	37.7% (23)	34.6%
Engine / propeller related	29.5% (18)	10.0%
Assessing and planning	24.6% (15)	27.7%
Wind	16.4% (10)	20.0%
Monitoring and checking	8.2% (5)	5.4%

The larger proportional difference for collisions with terrain was mainly due to significantly higher proportions of loss of aircraft control[62] and engine related[63] occurrences in amateur-built aircraft accidents. Engine related problems were over 3.7 times more likely in amateur-built aircraft collision with terrain accidents compared to factory-built aircraft collision with terrain accidents. These aspects are discussed in further depth above in sections 6.1.3 and 6.1.2 on pages 58 and 46, respectively.

Monitoring and checking related errors were the most common factors generally not involving loss of control for amateur-built and factory-built aircraft collision with terrain accidents. These involved the misjudgement of powerlines resulting in a wirestrike, collision with terrain during low level aerobatics and the failure to detect a high sink rate on approach to land resulting in a runway undershoot.

Forced and precautionary landings

A forced or precautionary landing was conducted in 21 per cent of amateur-built accidents, significantly more than the 15 per cent of factory-built aircraft accidents.[64] The main difference between these groups is accounted for by the increased number of complete engine failures and partial power loss, as shown in Table 11 below. The mechanisms of these failures are discussed above in section 6.1.2 on page 46.

Table 11: Forced landings from power-plant problems

Power-plant problem	Amateur-built (n=45)	Factory-built (n=81)
Complete engine failure / Partial power loss	77.8% (35)	58%
Other power-plant/propellers	8.9% (4)	1.2%

The vast majority of these landings were forced rather than precautionary for amateur-built aircraft accidents (89%), compared with a lower proportion for factory-built aircraft accidents (70%). This is driven by the number of engine or

62 Statistical significance (chi-square cross-tab) between collision with terrain accidents resulting from loss of control and aircraft build, $\chi^2_{(1, n = 191)} = 9.464$, $p < 0.005$, 2-tailed.

63 Statistical significance (chi-square cross-tab) between collision with terrain accidents resulting from power plant related factors and aircraft build, $\chi^2_{(1, n = 191)} = 11.621$, $p = 0.001$, 2-tailed

64 Statistical significance (chi-square cross-tab) between forced landings and aircraft build, $\chi^2_{(1, n = 770)} = 4.592$, $p < 0.05$, 2-tailed.

propeller related problems in amateur-built aircraft accidents, which were a significantly more common contributing factor to forced and precautionary landings in amateur-built aircraft accidents than factory-built aircraft accidents.[65]

The remainder of forced and precautionary landing accidents for factory-built aircraft had a significant proportion of fuel starvation and exhaustion events (17%), and also assessing and planning issues (7%) related to field selection, often following the decision to make a precautionary landing. Precautionary landings were made due to fuel concern and concerns about degraded visibility and last light during visual flight rules operations.

6.2.2 Accident severity

Figure 36 shows all accident events with serious or fatal injuries for amateur-built aircraft. Of particular note is collision with terrain, with the largest number of fatal accidents. However, the proportion of fatal accidents following a collision with terrain is only slightly higher for amateur-built compared with factory-built aircraft, as shown below in Figure 37.

With the exception of in-flight break-up, the remaining proportions of fatal accidents were similar between amateur-built and factory-built aircraft. In-flight break-up events are not considered to be a systemic concern in amateur-built aircraft accidents, and are discussed further in section 6.3 on page 73.

The increased proportion of in-flight break-up and fatal collision with terrain accidents account for the slightly higher proportion of overall fatal amateur-built accidents.

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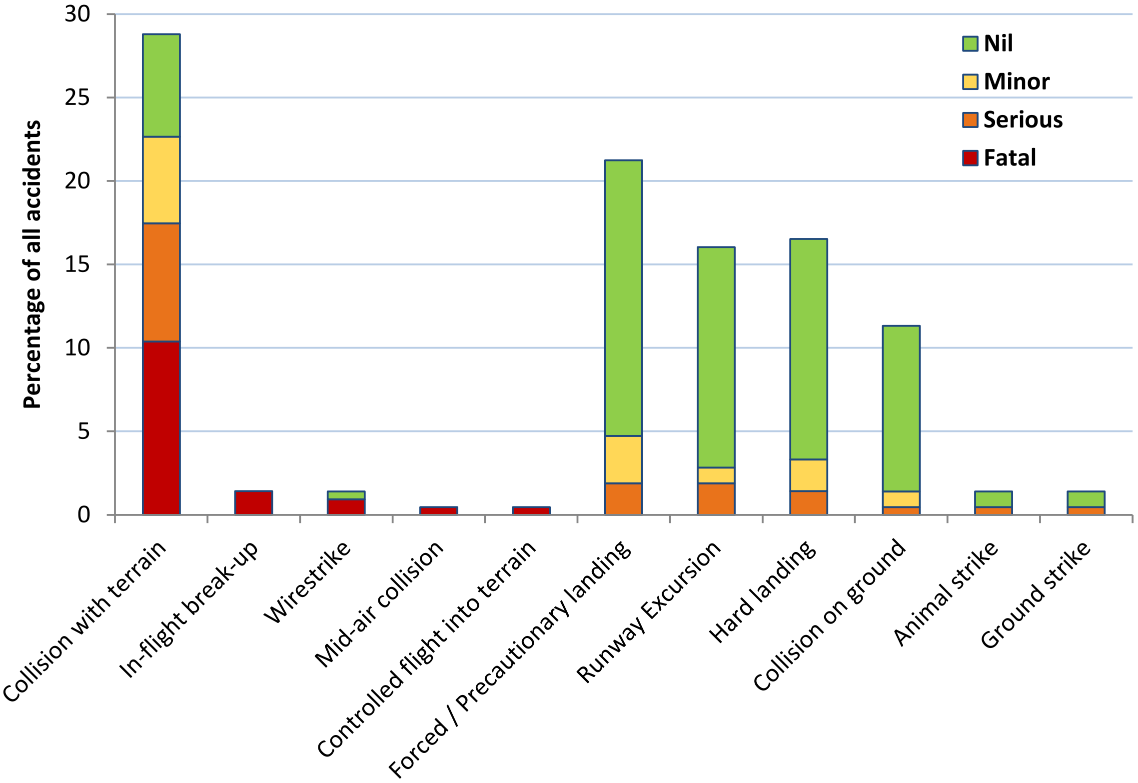
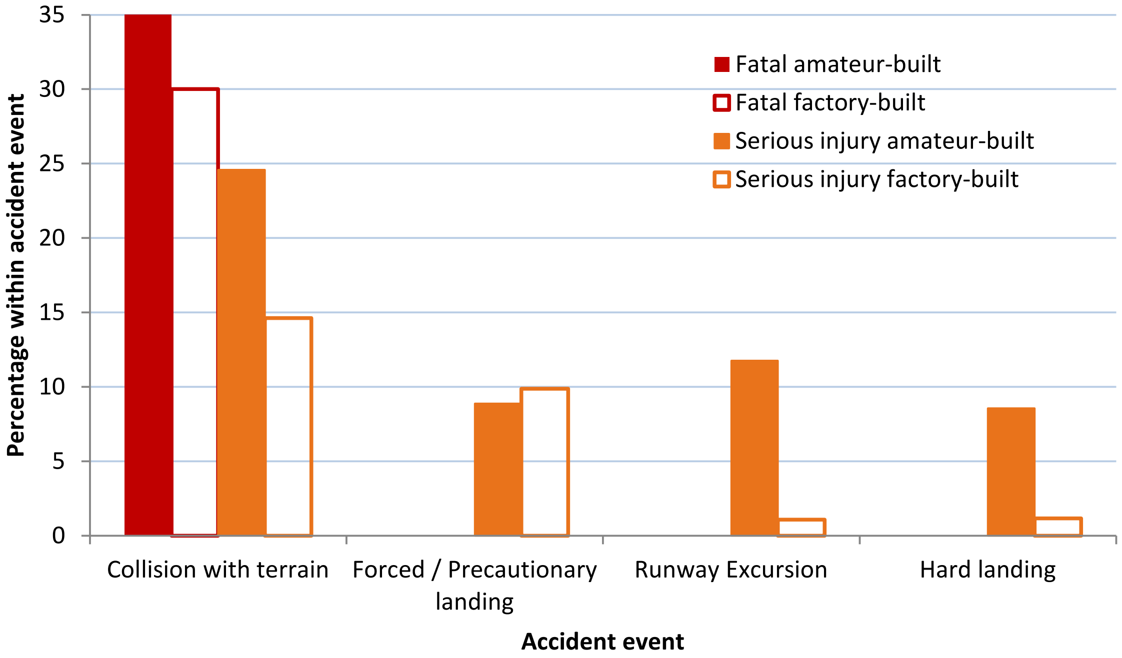
65 Statistical significance (chi-square cross-tab) between forced/precautionary landings resulting from power plant related factors and aircraft build, $\chi^2_{(1,\, n = 126)} = 10.168$, p = 0.001, 2-tailed.

Figure 36: Amateur-built aircraft accidents with serious or fatal injuries



Serious injury accidents were relatively higher in amateur-built aircraft as a proportion of all accidents compared with factory-built aircraft accidents, as shown in Figure 16 on page 31. This difference is largely accounted for by the higher proportions of serious injury accidents in collision with terrain, runway excursions and hard landings as indicated in Figure 37 below.

Figure 37: Proportion of serious and fatal injuries within four most common accident events



Serious injuries from collision with terrain

Serious injury occurred in 25 per cent of amateur-built collision with terrain accidents, compared with only 15 per cent of factory-built aircraft collision with terrain accidents. The number of known injuries is relatively small, however, a higher proportion of torso, spinal, upper limb and internal injuries were observed for collision with terrain as shown in Table 12 below.

Table 12: Collision with terrain serious injuries by affected body area

Affected body area	Nature of amateur-built serious injuries following a collision with terrain	Proportion of collision with terrain accidents with known injuries: Amateur-built	Proportion of collision with terrain accidents with known injuries: Factory-built
Torso	Fracture (6), Soft tissue damage (1), Other injuries (1)	78% (7)	20%
Head	Open wound (2), Burns (1), Other injuries (2)	56% (5)	50%
Lower limb(s)	Fracture (4), Open wound (1)	56% (5)	60%
Spine	Fracture (3), Other injuries (1)	44% (4)	30%
Upper limb(s)	Fracture (2), Other injuries (1)	33% (3)	10%
Internal	Injury to internal organ (2)	22% (2)	10%
Unknown	Other injuries (2)	22% (2)	20%
Whole body	Not applicable	0% (0)	10%

Typically, fractures to the torso were broken ribs, with other load based injuries present such as soft tissue damage from the aircraft occupant restraint system. In some cases, internal injuries such as punctured lungs occurred in conjunction with fractured ribs.

Head injuries included gashes, lacerations and burns.

The same proportion of lower limb injuries were observed with collision with terrain comparing amateur-built aircraft with factory-built aircraft, with these being mainly fractured ankles and legs.

Spinal injuries were relatively more common in amateur-built aircraft, with the main injury being fractured vertebrae.

Case study – Lucky to be alive

Jodel D11, 2 September 1990

Hours on type 16, Hours total: 185

Injuries – Impact and fire related

Pilot: Broken ribs, punctured lungs, broken right arm, burns to left side of hand and minor head injuries

Passenger: Broken sternum, burns to hands, face and legs.

The aircraft was observed to take off and climb to about 500 feet before commencing a right turn. It then appeared to abruptly change attitude in pitch and roll a few times before adopting a nose low attitude and disappearing behind trees. The aircraft crashed into a shallow swamp and caught fire. On-site examination revealed that the aircraft struck the ground in a steep nose and right wing low attitude. The pilot reported that the engine began running roughly and lost power shortly after take-off. An examination found no fault with the engine or carburettor; however, fire damage precluded testing of the magnetos. The aircraft attitude at impact was indicative of it being in a stalled condition.

The following factors were considered relevant to the development of the accident:

1. For reason(s) which could not be established, the engine apparently lost power.
2. The pilot lost control of the aircraft.

ATSB Investigation 199003098

Serious injuries from hard landings and runway excursions

Serious injuries in amateur-built aircraft runway excursions were relatively more common than for factory-built aircraft, with 12 per cent of amateur-built aircraft runway excursions involving serious injury compared with only 1 per cent of factory-built aircraft runway excursions. Head and spinal injuries of an unknown nature were reported in these accidents.

Of the 35 amateur-built aircraft hard landing accidents, three involved serious injury (9%) compared with 1 per cent in factory-built hard landing accidents. Injuries such as lacerations to the knees and head, and general head injuries were reported following hard landings and subsequent events such as the aircraft nosing over onto its back or cart wheeling, in one case following a runway excursion.

Case study - Hard landing, runway excursion and nose over

Van's RV-7A, 27 September 2008

Pilot experience: 11.4 hours on type, 1,200 hours total

The aircraft landed hard on the runway and bounced twice before the nose landing gear bent backwards. The aircraft veered off the side of the runway which caused the front strut to dig into the soil and caused the plane to roll over nose first.

During the accident sequence the pilot sustained serious head injuries.

The aircraft was substantially damaged.

6.2.3 The nature of impact versus the effectiveness of occupant protection systems

As no accident occurs in precisely the same way with regard to the impact sequence, it is not possible compare the relative effectiveness of aircraft occupant restraint systems. However, the combination of the impact characteristics combined with the level of occupant protection in the aircraft affects the severity of the accident.

Amateur-built aircraft have a significantly higher accident severity in most types of accidents. In particular, collision with terrain, hard landings and runway excursions, make up a large proportion of amateur-built aircraft accidents and have relatively more injuries than factory-built aircraft accidents, in particular serious injuries. From the information currently available, it is not possible to ascertain why this is the case.

6.3 Atypical accident events

This section provides a review of fatal amateur-built aircraft accidents which were unusual when compared with factory-built aircraft accidents, although did not appear to represent a systemic problem within amateur-built aircraft. It is important to note that the vast majority of amateur-built aircraft accidents have similar mechanisms to factory-built aircraft accidents, although some accidents are relatively more frequent in amateur-built aircraft. Conversely, the accident events described below involving amateur-built aircraft group are highly atypical. As such, these accidents serve as reminders to take care during construction and flight. Another example also exists in Part 1 of this report[66].

Unsolved tragedy – Potential elevator restriction leading to loss of control

Van's Aircraft RV-4, 22 November 1994

The pilot had said to his wife that he intended to do a few more circuits and landings following a number of circuits and a local flight with his wife. The aircraft was heard taking off a few minutes later, and witnesses located to the south of the strip saw it making what appeared to be a "flat" left turn onto a northerly heading. The witnesses said the aircraft was about 100 m above ground level and that the engine noise level was low. The aircraft then went out of their field of view.

A short time later, the crashed aircraft was discovered by a neighbour who was driving towards the property. The impact was consistent with the pilot having lost control of the aircraft.

The investigation could not conclusively determine the nature of the loss of control of the aircraft; however, there was evidence of a fibreglass fairing from the base of the tailfin becoming detached in such a way that it could have restricted the movement of the elevator control surface, which offers an explanation for the circumstances of the accident.

ATSB Investigation 199403499

Other accidents included a canopy failure in overload and an in-flight breakup due to an aircraft overload. However, no build defects were identified with either of these accidents.

[66] ATSB report AR-2007-043(1) Page 13.

7 CONCLUSIONS

- Amateur-built aircraft on the Australian VH-register had an accident rate three times higher than comparable VH-registered factory-built aircraft conducting similar flight operations between 1988 and 2010.
- The amateur-built aircraft accident rate was significantly lower after 1999, coinciding with the Experimental Certificate legislation introduction in 1998 and a significant increase in the number of hours flown. However, the rate was still nearly three times higher than the factory-built aircraft accident rate.
- The fatal and serious injury accident rate was more than five-times higher in amateur-built aircraft than similar factory-built aircraft.
- Serious injuries were relatively more common in amateur-built accidents. These injuries were more likely to be from injuries to the torso, spine and head in amateur-built aircraft accidents than for factory-built accidents.
- Most accidents occurred in private operations for both amateur-built and factory-built aircraft, reflective of private operations accounting for most of the hours flown. However, amateur-built aircraft accidents during aircraft testing were considerably over-represented compared to the amount of flying for this operation. Transition training accidents were also elevated compared to the amount of reported flying training.
- Amateur-built testing accidents were typically during testing of engines, stall speed assessments, and testing associated with an aircraft modification, although more than half of these accidents were related to aircraft handling, assessing and planning and environmental factors, with no indications of mechanical or aerodynamic problems.
- Amateur-built aircraft pilots involved with accidents were significantly more experienced overall than factory-built aircraft accident pilots. However, they were significantly less experienced on the aircraft type that they were flying at the time of the accident, compared to both pilots of factory-built aircraft accidents and amateur-built aircraft owners in general. Twenty per cent of amateur-built aircraft accident pilots had less than 10 hours experience on the accident aircraft type.
- Amateur-built aircraft accidents were almost three times more likely to have mechanical events leading to an accident, with half of all accidents having a mechanical issue prior to the accident occurring. Furthermore, the mechanically related amateur-built accident rate was over four times higher than comparable factory-built aircraft. The number of mechanically related amateur-built aircraft accidents following the phase one risk assessment period was still significantly higher than factory-built aircraft accidents. Most problems identified related to the aircraft engine and fuel systems.
- Engine failures and partial power loss occurrences were twice as likely in amateur-built aircraft accidents (accounting for 30 per cent of accidents) when compared with factory-built aircraft accidents. Engine failures are very common in amateur-built aircraft accidents on initial climb.
- Loss of aircraft control led to 25 per cent of all amateur-built accidents, slightly more than for factory-built aircraft accidents, however, the loss of control accident rate was over four times higher. Serious injury was three times more likely after loss of control in amateur-built aircraft accidents than for factory-

built. Loss of control accidents were more likely to be from aircraft handling issues where pilots had relatively less experience on the aircraft type, and to a lesser extent, engine problems. Aircraft loss of control was more likely to occur in the initial climb phase of flight in amateur-built accidents.

- Engine failure and partial power loss accidents which did not have loss of control as a factor were still significantly different between amateur-built and factory-built aircraft accidents. This shows that while loss of control is a factor in some amateur-built engine failure accidents, it does not account for the entire difference between the aircraft build types.
- Landing gear problems related to mechanical failures accounted for 10 per cent of accidents and were more than three and a half times more common in amateur-built aircraft accidents than factory-built aircraft accidents.
- Amateur-built experimental (ABE) aircraft are more likely to be involved with a partial power loss accident, whereas aircraft flown under the amateur-built aircraft acceptance (ABAA) scheme are more susceptible to total power loss, systems failures and mechanically related landing gear problems. Loss of control accidents occurred in similar proportions for ABE and ABAA aircraft accidents.
- Collision with terrain and forced landings occurred more frequently in amateur-built aircraft accidents compared with factory-built aircraft accidents. Collisions with terrain, which accounted for most fatal and serious injury accidents, were more commonly a result of pilots losing control of the aircraft for amateur-built aircraft accidents relative to factory-built. Engine and propeller problems were also significantly higher in amateur-built collision with terrain accidents. For forced landings, mechanically related engine failures or power loss were significantly higher in amateur-built aircraft accidents.
- Collisions with terrain, hard landings, and runway excursions were more likely to result in a serious injury from an amateur-built aircraft accident than for factory-built accidents.
- Structural failures are not common in amateur-built aircraft. While infrequent, there are a very small number of notable cases of aircraft accidents resulting from in-flight loss of control due to structural modifications, control surface jamming and in-flight breakups, however the in-flight breakups were not attributed to construction issues.

8 SAFETY ACTION

8.1 The Sport Aircraft Association of Australia

The Sport Aircraft Association of Australia (SAAA) currently has a number of initiatives at various stages of development aimed at reducing the current accident rates for amateur-built aircraft. These initiatives include the following.

- Education of the SAAA membership on the risks that can be encountered in phase one flight testing.
- Working with the Civil Aviation Safety Authority (CASA) to provide a legal framework for better training in amateur-built aircraft.
- Initiating more detailed technical inspections prior to first flight to mitigate the risk of engine stoppages/failures.
- More active involvement of the SAAA Flight Test Advisors prior to the first test flight of a new aircraft.
- Working with CASA to allow a legal framework for suitably qualified pilots to give instruction in amateur-built aircraft both for the aeroplane flight review (AFR) and transition training for pilots (post-phase one).

The SAAA have also indicated that it accepts the findings of the report and will do what it can as a volunteer organisation, with limited funding, to address the matters raised in the report.

8.2 Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) will establish a routine reporting to the SAAA of all occurrences (accidents and incidents) reported to the ATSB involving amateur-built aircraft.

APPENDIX A : SOURCES AND SUBMISSIONS

Sources

The below sources of information were used for this research investigation and are explained in Chapter 3:

- ATSB Occurrence and notifications database
- Civil Aviation Safety Authority Aircraft (CASA) registration records
- Coronial findings and proceedings records
- Survey responses from owners of amateur-built aircraft involved in non-fatal accidents
- Bureau of Infrastructure, Transport and Regional Economics (BITRE) for aircraft flying hours and landings data.

Submissions

A copy of the draft report was provided to:

- CASA
- Sport Aircraft Association of Australia (SAAA)
- Recreational Aviation Australia
- BITRE.

Submissions were received from the CASA, BITRE and the SAAA, and where considered appropriate, the text of the report was amended accordingly.

APPENDIX B : MATCHED-SAMPLE MATCHES

The table below shows the matched-sample matches for each of the 212 amateur-built aircraft models (de-identified) in the analysis sample.

Amateur-built aircraft model	**Matched factory-built aircraft models**
ACRO SPORT AIRCRAFT - Acro II	Cessna: 150L, 177; Piper: PA-28-161
AIR CHARTER AVIATION - Bristol F-2B Replica	Aero Commander: 100; Cessna: 170A
AIRDROME AIRPLANES - Nieuport 17 Replica (Full scale)	Piper: J-3C-65
AIRDROME AIRPLANES - Sopwith Pup Replica (Full scale)	ACA: 7; Cessna: 150M
AUSTRALIAN AIRCRAFT KITS - Hornet AG	Cessna: 140; Cessna: 152; Piper: PA-22-150; Pitts: S-1
AUSTRALITE - Ultrabat	No match
AVIAT AIRCRAFT (CHRISTEN) - Eagle II	Cessna: 172B, 180A; Stinson: 108
BEDE - BD-4	AAC: AA-5B; Beech: C23; Cessna: 182Q; Piper: PA-28-235
BEDE - BD-5	AAC: AA-5; Cessna: R172K; Maule: M-7-235
BOWERS - Fly Baby	Avtech: Jabiru; Piper: PA-22-108
BUSHBY - Mustang II	AAC: AA-5A; Beech: 23; Cessna: 180, 182, 182A; Cessna: 180, 182A; Cessna: 180A, 182, 182B; Cessna: 182B; Extra: EA 300L
CASSUTT - Sport Racer	Cessna: 172B, 172H; Cessna: 172K; Maule: M-6-235; Pitts: S-2A
CORBY - Starlet	ACA: 7FC; Auster: J5; Avtech: Jabiru; Cessna: 150G; Cessna: 150G, 152; Cessna: 152; Cessna: 152, A150M; Cessna: 152, A152; Piper: PA-20; Skyfox: Skyfox
DENNEY (SKYSTAR / KITFOX AIRCRAFT) - Kitfox	Cessna: 150F, 152; Cessna: A152; Storch: SS-MK4
DENNEY (SKYSTAR / KITFOX AIRCRAFT) - Kitfox III	Cessna: 152; Storch: SS-MK4
DENNEY (SKYSTAR / KITFOX AIRCRAFT) - Kitfox IV	Cessna: 152; Piper: J-3C-65
DRUINE - Turbi	Cessna: 150G; Piper: PA-18-150
DYN AERO - Banbi (Club)	AAC: AA-1C; Cessna: 172N
EUROPA - Europa	Cessna: 172D, 172F, 172N
EUROPA - Europa XS	Cessna: 172N; Piper: PA-22-150
EVANS - Volksplane	Bellanca: 7; Cessna: 150M; Cessna: 152; Piper: PA-38-112; Skyfox: Skyfox; Taylorcraft: BC12-D
FLIGHTSTAR SPORTSPLANES - Flightstar II	Cessna: 150G, 152

Amateur-built aircraft model	**Matched factory-built aircraft models**
GARDAN - Minicab	Avions Robin: R-2160; Ryan: ST-M/2
GILES (AKROTECH) - G-200	Cessna: 180E, 182E, 182F
GLASAIR (STODDARD HAMILTON) - Glasair II	Cessna: 210E, 210F, A185F
GLASAIR (STODDARD HAMILTON) - Glasair III	S.O.C.A.T.A: Trinidad
GLASAIR (STODDARD HAMILTON) - Glasair II-S	Cessna: A185F; Piper: PA-28-151; Victa: AIRCRUISER
GLASAIR (STODDARD HAMILTON) - Glasair II-S	No match
GLASAIR (STODDARD HAMILTON) - Glasair II-S	No match
GLASAIR (STODDARD HAMILTON) - Glasair II-S	No match
GLASAIR (STODDARD HAMILTON) - GlaStar	Cessna: 172N; Piper: PA-28-151
GREGA - Aircamper	Cessna: 150; Skyfox: Skyfox
JABIRU - J400	Beech: A23A; Cessna: 172M; Cessna: R172K; Piper: PA-28-140, PA-28-151
JABIRU - J430	AAC: AA-5; Eagle: 150B; Piper: PA-28-161
JABIRU - SP	Cessna: A150L; Piper: PA-22-108
JABIRU - UL	ACA: 7FC; Cessna: 150G
JDT MINI-MAX - Mini-Max	Bellanca: 7; Piper: PA-18-150
JODEL - Bebe	Piper: J-3C-65; Skyfox: Skyfox
JODEL - Club	Auster: V; Avtech: Jabiru; Cessna: 150F; Cessna: 150G; Cessna: 150L; Piper: PA-18-150; Skyfox: Skyfox
KIS - TR-1	Cessna: 150M, 172N; Piper: PA-28-140
KOLB - Twinstar Mk.3	Cessna: 150A; Skyfox: Skyfox
LANCAIR INTERNATIONAL - 235	Cessna: 172G, 172N; Cessna: 172N, 177; Cessna: 177; Eagle: EAGLE X-TS; Maule: M-7-235; Piper: PA-22-160, PA-28-140; Piper: PA-28-140
LANCAIR INTERNATIONAL - 320	AAC: AA-5B; Cessna: 182P; Cessna: 182P, 210D; Cessna: 182P, 210E; Cessna: 182P, A185F, TR182; Cessna: 182P, R182; Cessna: 182Q, 210E; Cessna: 182Q, R182; Cessna: 182Q, TR182; Extra: EA 300L; SM: F.260
LANCAIR INTERNATIONAL - 360	Cessna: 182Q, A185F; Cessna: 182Q, R182; SM: SM-1019
LANCAIR INTERNATIONAL - IV	Cessna: 207A
LANCAIR INTERNATIONAL - IV	No match
LANCAIR INTERNATIONAL - IV-P	Piper: PA-46-310P
LUTON - Minor	Auster: IIIF; Bellanca: 7; Cessna: 120, 150F

Amateur-built aircraft model	Matched factory-built aircraft models
MARCEL JURCA - Sirocco	Cessna: 180K, 182H; Piper: PA-28-161
MONNETT - Moni	Cessna: 150M, 152
MONNETT - Sonerai II	Cessna: 152
MUDRY - CAP 10	Cessna: 172N; Piper: PA-28-151
MURPHY - Rebel	Cessna: 152; Pitts: S-1
OSPREY AIRCRAFT - Osprey II	Cessna: 172B; Cessna: 172B, 172RG; Mooney: M20C
PIEL - Emeraude	Cessna: 150F, 172N; Piper: PA-28-140
PITTS - Roundwing	Bellanca: 8; Cessna: 150G, 172N; Cessna: 172N; Maule: M-7-235; Piper: PA-28-140; Piper: PA-28-161; Stampe Et Renard: SV4
PITTS - Samson Replica	Maule: M-5-235C; Piper: PA-28-180
PROGRESSIVE AERODYNE - SeaRey	ACA: 8GCBC; Aero Engine Service: 150; Avions Robin: R-2160; Bellanca: 8; Cessna: 150A; Cessna: 150G; Cessna: A152; Piper: PA-18-150; Piper: PA-22-108; Ryan: ST-M/2
PULSAR AIRCRAFT CORPORATION - Pulsar	Cessna: 152, A150M
QUICKIE AIRCRAFT - Q-200	AAC: AA-1B; Cessna: 177; Gyroflug: Speed Canard; Maule: M-6-235; Maule: MX-7-235; Piper: PA-28-140; Piper: PA-28-140, PA-38-112; Piper: PA-28-160, PA-38-112
RAND ROBINSON - KR-2	Bellanca: 8; Cessna: 172E; Cessna: 172E, 172M; Cessna: 172F; Cessna: 172F, 172L; Cessna: 172M; Maule: MX-7-180; Pitts: Roundwing; Pitts: S-2A
RIHN - Sabre	Cessna: 172K, 172N; Piper: PA-28-161
RJ FRANCIS - RJF2	No match
RUTAN - Long-EZ	Cessna: 172F, 172G, 177; Cessna: 172L, 172M, 177; Cessna: 172M; Cessna: 172P; Cessna: 172P, 177B; Piper: PA-28-161
SEQUOIA - Falco	Cessna: 177RG; Mooney: M20C; Piper: PA-28R-180
SINDLINGER - Hawker Hurricane Replica (5/8 scale)	Beech: 35, C35; Cessna: A150L; Piper: PA-28-151; Piper: PA-28-151, PA-28-161
SQUARECRAFT - Cavalier	Cessna: 172G, 172N; Piper: PA-28-161
STEEN AERO LAB - Skybolt S	Cessna: 172; Cessna: 182E, 182P; Mooney: M20C; Piper: PA-28-180
SUPERMARINE AIRCRAFT - Supermarine Spitfire Replica (3/4 scale)	No match
SUPERMARINE AIRCRAFT - Supermarine Spitfire Replica (80% scale)	Cessna: 172H; Cessna: 172N; Piper: PA-28-151
TAYLOR - Monoplane	Auster: IIIF; Auster: V; Cessna: 120, 152; Cessna: 150B; Cessna: A150K
THORP - Tiger	Cessna: 172RG, 180A, 182J; Cessna: 172RG, 180F, 182L; Cessna: 172RG, 180H,

Amateur-built aircraft model	Matched factory-built aircraft models
	180K; Cessna: 172RG, 180K, 182F; Cessna: 180J, 182F, 182P; Cessna: 180K, 182L, 182Q; Cessna: 180K, 182P; Cessna: 182M, 182Q; Piper: PA-28R-180
THORP (INDUS) - Sky Skooter	Cessna: 172M, A150L
VANS - RV-3	Cessna: 172M; Pitts: S-2A
VANS - RV-4	Cessna: 172D, 172F; Cessna: 172F, 172M; Cessna: 172H, 172L; Cessna: 172H, 172N; Cessna: 172M; Cessna: 172M, 172N; Piper: PA-28-161
VANS - RV-6	Beech: 19A; Cessna: 172F, 172P; Cessna: 172G, 172P; Cessna: 172H, 172P; Cessna: 172M; Cessna: 172M, 172P; Cessna: 172N; Maule: M-7-235; Maule: MX-7-235; Piper: PA-28-140; Piper: PA-28-161; Piper: PA-38-112; Pitts: S-2A
VANS - RV-6A	Cessna: 172C, 172G, 172H; Cessna: 172D, 172M, 177; Cessna: 172E, 172M, 172P; Cessna: 172F, 172M, R172K; Cessna: 172G, 172M, 172P; Cessna: 172L, R172K; Cessna: 172M, 177; Cessna: 172M, 177B; Cessna: 172M, R172K; Cessna: 172N, 172P; Piper: PA-28-161
VANS - RV-7	Cessna: 172RG, 182A, 182H; Cessna: 180D, 180E, 182C
VANS - RV-7A	AAC: AA-5A; Beech: C23; Cessna: 172N; Cessna: 182A, 182K; Cessna: 182B; Cessna: 182B, 182H; Cessna: 182C, 182H, 182L; Piper: PA-28-140; Piper: PA-28-140, PA-28-180; Piper: PA-28-161
VANS - RV-8	AAC: AA-5; Beech: A23-19; Cessna: 172N, 180K, 182G; Cessna: 180J, 182F; Cessna: 180K, 182F
VELOCITY - XL	Cirrus: SR22; Piper: PA-46-310P
VIKING - Dragonfly	Auster: J5; Cessna: 170, 172N; Cessna: 170A, 172, 172N; Cessna: 170A, 172N; Cessna: 170B, 172, 172N; Cessna: 172C, 172N; Cessna: 172N; Maule: M-7-260C
VOLMER - Sportsman	Cessna: 150G, 172B, 172N
WHEELER (EDI EXPRESS) - Express CT	Beech: A36, F33A; Cessna: 206; Cessna: P206, U206A; Cessna: U206D; Cirrus: SR20; Piper: PA-32-300
WRIGHT CARL - Jake Special	Beech: A23-24
ZENITH AIRCRAFT COMPANY (ZENAIR) - STOL CH801	Cessna: 172M, 172N
ZENITH AIRCRAFT COMPANY (ZENAIR) - Zenith CH200	Cessna: 172M, 172N; Piper: PA-28-161
ZENITH AIRCRAFT COMPANY (ZENAIR) - Zodiac XL	Cessna: 172M

APPENDIX C: ACCIDENT DATA

Date	Aircraft model	Accident summary	Highest injury
16/01/1988	Pitts S-1E Special	While conducting aerobatics with another aircraft, the aircraft was seen to make other manoeuvres different to those planned, going much too high and rolling during descent. The pilot was able to gain some control prior to ditching the aircraft into Port Phillip Bay.	Fatal
30/01/1988	Pitts S-1E Special	The aircraft touched down with about two-thirds of the available strip length used. When the aircraft entered a wet area on the runway surface, the pilot made a late decision to conduct a go-around. The pilot lost control of the aircraft, which veered to the left off the runway, striking a post and an embankment.	Nil
14/02/1988	Thorp T-18 Tiger	Shortly after take-off, the aircraft's engine failed at 100 ft AGL due to an over rich mixture. The pilot landed the aircraft on the remaining strip length, and the aircraft overran into soft sand. An engineering inspection found that the aircraft had been fitted with an incorrect model carburettor which was not noticed during certification or servicing. In addition, the aircraft engine was not approved for the use of mogas.	Serious
17/04/1988	Zenith CH200	During the landing roll, the aircraft drifted to the left. The pilot attempted to correct the drift, but due to his familiarity in flying hang gliders applied the wrong rudder. This caused the aircraft nose to swing rapidly to the left, leading to a nose gear collapse. The aircraft came to rest nose-down beside the bitumen runway.	Nil
06/08/1988	Viking Dragonfly	The aircraft's engine failed on take-off, and the aircraft landed heavily on the remaining runway. The engine failure was probably due to carburettor icing.	Nil
13/12/1988	Taylor JT-1 Monoplane	The aircraft's engine lost power in flight, apparently due to a magneto failure. The pilot lost control of the aircraft, which collided with the ground at high rate of vertical descent and low forward speed. The pilot was found in the wreckage some 12 hours later unconscious and seriously injured.	Serious
23/12/1988	Lancair 235	During take-off, the pilot rotated the aircraft below the optimum take-off speed, and failed to obtain and maintain flying speed. The aircraft's left wing dropped due to a fuel imbalance. The aircraft was being operated on a special permit to fly (first of type).	Nil
06/01/1989	Monnett Sonerai II	After encountering turbulence at 1,500 ft AGL, the pilot reduced power. The aircraft engine stalled when power was reapplied. The pilot conducted a forced landing on a grass strip, but due to excessive approach speed the main gear strut bent and there was a propeller strike. The aircraft skidded through a fence on to a road.	Nil
20/01/1989	Christen Eagle II	While performing aerobatic manoeuvres, the pilot reported that the propeller separated from the aircraft in-flight. The pilot conducted a forced landing in a paddock. It is thought that the propeller failure occurred due to wood shrinkage, which caused retaining bolts to loosen and failure of the securing lock wire.	Nil
29/01/1989	Pereira Osprey II	The pilot lost directional control of the aircraft during a take-off run due to a combination of adverse water conditions and poor control technique. The aircraft was undergoing flight testing for the issue of a certificate of airworthiness.	Nil

Date	Aircraft model	Accident summary	Highest injury
04/03/1989	Corby CJ-1 Starlet	The pilot was conducting stall turns when the aircraft engine failed. The engine was unable to be restarted, and the pilot conducted a forced ditching into a bay. The aircraft was towed ashore. Further inspection determined that the engine driven fuel pump had failed due to a split diaphragm. This caused a zero gravity condition within the engine, resulting in fuel starvation.	Nil
27/03/1989	Pietenpol / Grega GN-1 Aircamper	Immediately after take-off, the aircraft's engine failed. The pilot misjudged the level off and touchdown, and landed heavily resulting in the collapse of the right main landing gear. Further inspection determined that the fuel filter was blocked.	Nil
09/04/1989	Piel / Mudry CAP 10	The aircraft entered a heavy rain shower on final approach and visibility was greatly reduced. The pilot flared high and reduced power as was his usual landing technique. However, the aircraft dropped heavily on to the runway from an altitude of 40-50 ft AGL.	Nil
10/06/1989	Lancair 235	During the landing, the pilot experienced excessive nosewheel shimmy, and the nose gear leg collapsed. Further inspection revealed that the tubular engine mount frame had previously failed, allowing the landing gear trunnion to become dislocated. The reason for the engine mount failure was unknown.	Nil
24/02/1990	Rand KR-2	The pilot returned the aircraft to the aerodrome due to an oil leak. The aircraft landed heavily on the left wheel. Further inspection found that a maintenance error had led to the incorrect rigging of the left undercarriage hatch, and the remaining latch was overloaded during the heavy landing. The oil leak was due to an incorrectly assembled firewall fitting installed by the previous aircraft owner.	Nil
08/04/1990	Rand KR-2	The aircraft suffered a partial loss of engine power while in a low level turn after take-off. The pilot conducted a forced landing on unsuitable terrain, during which the aircraft collided with a ditch. The right main gear was torn from the aircraft, and the aircraft overturned. The aircraft was on its first flight at the time of the accident. A later engineering inspection of the engine indicated that some of the cylinder head retaining bolts were not torqued correctly, and a spark plug was seated incorrectly. There was damage to both the cylinder head and the exhaust valve seat.	Minor
31/05/1990	VIKING Dragonfly	During cruise, the aircraft's engine failed. The pilot conducted emergency checks but was unable to restore power, and conducted a forced landing in a paddock. The aircraft landed heavily, fracturing the main landing gear legs. Further inspection suggested that the fuel gascolator drain valve had been lost in flight, leading to fuel exhaustion. It was also thought that the electronic ignition may have failed.	Nil
12/08/1990	Pereira Osprey II	As the aircraft's left pontoon entered the water during landing, the nose of the aircraft dipped and the aircraft flipped over. The pilot had attempted the water landing despite the aircraft having a known directional control problem.	Nil
02/09/1990	Jodel D.11	The pilot reported that the engine lost power shortly after take-off. Witnesses reported that the aircraft suddenly changed attitude in pitch and roll before striking a swampy area in a nose and right wing-low attitude. There was a post-impact fire, which prevented further examination of the engine and magnetos.	Serious

Date	Aircraft model	Accident summary	Highest injury
28/12/1990	Bede BD-4	The pilot reported that the nosewheel fell off after take-off from a rough strip. During the landing, the aircraft settled on to its nose, causing minor damage. Further inspection found that the nosewheel retaining nut had stripped the axle bolt, and that the split pin was still in place.	Nil
07/01/1991	Jodel D.11	While conducting a survey flight in conjunction with a road vehicle, the aircraft was observed near the vehicle to commence a descending right-hand turn for landing. The aircraft lost altitude suddenly after completing 270 degrees of the turn, and the right-hand wing touched the ground. The aircraft cart wheeled on the ground and was destroyed.	Serious
02/02/1991	Taylor JT-1 Monoplane	Immediately after take-off, the aircraft's engine began to run roughly. The pilot abandoned the take-off, and conducted a forced landing on the remaining runway length. The aircraft overran the end of the runway strip, and collided with a boundary fence. The pilot reported that the power loss was due to a wasp nest in the engine intake.	Nil
08/03/1991	Glasair II-S-TD	During a test flight, the aircraft's engine stopped while the pilot was on the base leg of a circuit. The pilot conducted a forced landing in a paddock short of the runway. Further inspection of the engine revealed that the engine compartment had overheated, leading to fuel evaporation and starvation. The pilot reported that the engine cooling system was redesigned following the accident.	Nil
06/04/1991	Corby CJ-1 Starlet	During flight, the propeller spinner fractured and caused a part of one blade of the propeller to separate. The pilot conducted a precautionary engine shut down, and was required to make a forced landing in a timbered area.	Nil
05/05/1991	Bede BD-4	During taxi, the aircraft's nose wheel became caught in a crack in the taxiway. The nosewheel was torn from the aircraft, and the nose gear leg collapsed, puncturing the cabin floor.	Nil
07/07/1991	Lancair 320	Following an exhaust pipe failure in-flight, the pilot declared an emergency (PAN) and diverted to a nearby aerodrome for a straight-in approach. When the pilot attempted to extend the landing gear on approach, only the main gear locked down. On landing, the nose gear collapsed.	Nil
31/08/1991	Jodel D.11	Immediately after take-off in a gusting crosswind, the aircraft weathercocked toward a tree on the left side of the runway strip. The pilot attempted to bank the aircraft to the right, but lost control and landed heavily on the runway.	Nil
02/09/1991	Lancair 320	During the landing roll, the nosewheel began to shimmy. The pilot attempted to reduce the shimmy by lifting the aircraft weight off the nosewheel until elevator control was lost. As the nosewheel again made contact with runway, shimmy developed and caused the gear downlock link to fail. The nosewheel strut collapsed.	Nil
27/09/1991	Kitfox	While conducting a turn to the right, the left-hand fuel tank split in-flight, soaking the pilot in fuel. The pilot conducted a precautionary engine shut down, and attempted a forced landing on a road. During the landing, the aircraft collided with a tree and a railway sleeper, causing the landing gear to collapse.	Nil

Date	Aircraft model	Accident summary	Highest injury
31/10/1991	Thorp T-111	While on final approach to land, the aircraft collided with trees. The pilot reported that the aircraft may have possibly been affected by a downdraught on final, as a wind squall was passing through the area at the time of the accident. The pilot reported that he did not obtain a weather forecast prior to flight, and had only made a visual assessment of the prevailing weather.	Serious
19/11/1991	Rutan Long-EZ	During take-off, the pilot reported that the aircraft was unable to achieve take-off speed. The pilot rejected the take-off, but the aircraft overran the end of the runway strip and collided with bushes. The nose gear collapsed and the aircraft nosed over.	Nil
26/11/1991	Corby CJ-1 Starlet	Following fast taxi tests, the aircraft inadvertently lifted off from the runway and began to climb. During a return circuit, the aircraft's engine failed on downwind. The pilot conducted a forced landing downwind, during which the aircraft collided with a ditch.	Serious
10/12/1991	Squarecraft / Macfam SA102-5 Cavalier	During take-off from a rough agricultural strip, the nosewheel leg failed in overload causing the propeller and nose section to strike the ground.	Nil
19/01/1992	Spitfire Ultrabat	During flight, the pilot reported that the aircraft's engine had failed and advised carrying out a forced landing. During the forced landing, the landing gear leg attachment points were damaged. Further inspection of the engine found that oil-contaminated spark plugs had probably caused a loss of power.	Nil
07/03/1992	Evans VP-1 Volksplane	After take-off, the aircraft was observed by witnesses to be in a nose high attitude at 200-300 ft AGL. It was later observed to commence a steep descent while spinning to the right. The aircraft impacted the ground, right wing low, in a near vertical attitude. The pilot was fatally injured. Autopsy results indicated that the pilot suffered a physical incapacitation prior to impact.	Fatal
11/04/1992	Evans VP-2 Volksplane	The aircraft was conducting a flight for the purposes of stall testing to obtain a permit to fly. On the last stall with carburettor heat hot, the engine stopped at the point of the stall. An attempted airstart resulted in four compressions, but the engine did not start. The pilot conducted a forced landing at the selected emergency field, but during the landing both brake handles broke off. The aircraft came to rest between two fence posts.	Nil
17/04/1992	Luton LA.4 Minor	While en route, the pilot decided to conduct circling manoeuvres to lose time. During manoeuvring, the aircraft lost height and collided with terrain. The pilot suffered memory loss following the event, and there were limited witnesses to the accident. A further inspection of the aircraft found no mechanical issues that would have contributed to a loss of control.	Serious
02/05/1992	Jodel D.11	Shortly after take-off, the aircraft's engine failed at about 200 ft AGL, and the aircraft collided with terrain. Further inspection suggested that a weak magneto may have contributed to the loss of power.	Fatal
23/05/1992	Taylor JT-1 Monoplane	Shortly after take-off at about 400 ft AGL, the aircraft's engine began to run roughly and lost power. The pilot conducted a forced landing in a ploughed paddock, during which the aircraft nosed over. An engineering inspection could not determine why the engine had lost power.	Nil

Date	Aircraft model	Accident summary	Highest injury
01/06/1992	Air Charter Aviation Bristol F-2B (Replica)	During flight, the pilot noticed that the coolant and oil temperature were increasing coincident with a loss of engine power. The pilot turned the aircraft into wind and attempted conduct a forced landing onto a highway. During the landing, a wingtip collided with overhanging tree branches and the nose struck the ground.	Minor
14/08/1992	Lancair 320	On landing following a test flight, the pilot forgot to extend the landing gear.	Nil
14/09/1992	Lancair 320	During the landing roll, the pilot inadvertently selected gear up and retracted the landing gear while the aircraft was on the ground.	Nil
19/10/1992	Rand KR-2	On final approach, the pilot rounded out high. While adding power, the aircraft stalled and touched down heavily. During the landing roll, the aircraft began to porpoise on the runway. The pilot lost directional control, and the aircraft came to rest beside the runway boundary marker.	Nil
10/11/1992	Van’s RV-4	On short final into a private grass airstrip, the aircraft descended too low and sank into a standing crop. The aircraft suffered substantial damage to the main landing gear and to the firewall mounted assemblies.	Nil
24/12/1992	Viking Dragonfly	During a test flight, the aircraft’s engine failed. The pilot conducted a forced landing in a soft wet paddock, during which the nosewheel dug in and the aircraft nosed over. Further inspection of the engine found that a block fuel filter had led to fuel starvation.	Minor
25/12/1992	Corby CJ-1 Starlet	The pilot reported that he was conducting aerobatics over a lake when, at the top of a vertical climb during the entry to a stall turn, the propeller stopped rotating and the engine stalled. The pilot placed the aircraft into a dive in an attempt to turn the propeller over (engine airstart), but the engine did not restart. The pilot elected to ditch the aircraft in the lake as there were no forced landing areas available.	Nil
20/01/1993	Pereira Osprey II	Shortly after take-off at 100 ft AGL, the aircraft engine suffered a total power loss as the pilot raised the landing gear. The pilot conducted a forced landing on the remaining runway, and the aircraft landed heavily. The pilot reported that he probably inadvertently closed the throttle when raising the landing gear due to the ergonomics of the aircraft controls.	Serious
24/02/1993	Thorp T-18 Tiger	During the landing roll, the aircraft veered to the left despite the pilot's control inputs. The left hand wheel ran off the runway edge and into soft dirt. To avoid a collision with an embankment, the pilot turned the aircraft sharply to the left but the right wing tip was scraped and the right spat damaged.	Nil
03/03/1993	Falco F8L	Following completion of a test flight, the pilot inadvertently landed with the landing gear retracted. Further inspection of the aircraft found that the landing gear and associated position indication system was operating correctly. However, the landing gear warning horn had been set to the "override" position, apparently having been placed in that position during the test flight.	Nil

Date	Aircraft model	Accident summary	Highest injury
11/04/1993	Sopwith Pup Replica (Full scale)	The pilot began a take-off on a grass strip but was using only the last 700 of the available 2200 ft strip length. During the take-off, the engine surged. The pilot applied carburettor heat, full rich mixture and full throttle, but was unable to regain full power or maintain climb performance. To avoid trees, the pilot was forced to conduct a turn at low altitude and low airspeed. The aircraft stalled at an altitude of 50-100 ft AGL, and collided with terrain. The wings were damaged, the engine was pushed back into the firewall, and the undercarriage collapsed.	Minor
13/05/1993	Zenith CH200	After take-off, witnesses reported that the aircraft was not performing normally. The pilot apparently attempted to return to the strip but the aircraft struck trees.	Serious
12/06/1993	Cassutt IIIM Sport Racer	While taxiing in strong wind conditions, the tail wheel aircraft tipped on to its nose. The pilot required external assistance to right the aircraft before he was able to vacate the cockpit. A NOTAM was current for winds forecast to gust to 40 kts.	Nil
31/07/1993	Viking Dragonfly	Prior to touchdown, the aircraft floated then landed heavily. Both landing gear legs separated from the aircraft at their design failure point.	Nil
13/10/1993	Kitfox	Immediately after take-off at 150 ft AGL, the aircraft's engine failed. The pilot conducted a forced landing in a paddock just north of the airfield. During the forced landing, the aircraft collided with a fence. Conditions at the time were conducive to carburettor icing. The aircraft was powered by a two stroke dual ignition engine which was not equipped with carburettor heat.	Nil
25/10/1993	Bushby MM-II Mustang II	The pilot had calculated that he would arrive at his destination five minutes before last light. When still ten minutes before last light he realised that the light was fading to a dangerously low level. The pilot decided to conduct a precautionary landing at an ALA he could see below him. Due to the low light conditions, the pilot was unable to see the barbed wire fence with star picket posts marking the airstrip perimeter. The left wing struck the fence during the landing roll.	Nil
30/10/1993	Quickie Q-200	The wreckage of the aircraft was located in steep timbered terrain. The aircraft had broken up on impact. There were no witnesses to the accident. Investigation into the accident indicated that the pilot was flying in instrument conditions at low altitude in a mountainous area in an aircraft that was not equipped for instrument flight, and that the accident was most likely a controlled flight into terrain.	Fatal
20/11/1993	Sindlinger HH-1 Hawker Hurricane Replica (5/8 scale)	At the completion of a test flight, positive gear down and locked indications were obtained during the downwind leg of the circuit. As the aircraft touched down, the pilot detected a settling of the right main landing gear and elected to go around. A fly-by inspection confirmed that there was a fault with the right landing gear. The pilot adjusted his approach so that the right gear touched down at a low speed. The gear leg collapsed on landing, and the aircraft slewed off the runway.	Nil
04/12/1993	Lancair 235	Witnesses saw the aircraft make a low pass along the main runway before pulling up into a vertical climb. The aircraft then turned to the right and descended vertically into the ground. The wreckage was consumed by the ensuing fire, and the occupants were fatally injured.	Fatal

Date	Aircraft model	Accident summary	Highest injury
01/01/1994	Jodel D.9 Bebe	After take-off, the pilot reported that the aircraft suffered a gradual reduction in power. The pilot elected to conduct a forced landing on a railway line.	Nil
29/01/1994	Volmer VJ-22 Sportsman	Prior to the accident flight, the pilot had conducted a successful water landing and the aircraft was taxied on to the beach. On departure, the aircraft was positioned for a water take-off into a 10 kt southerly breeze on a slight sea. The pilot reported that the aircraft lifted off after a few bounces at the end of the water run, and was held level to build up climb speed. Shortly thereafter the aircraft appeared to yaw violently to the right. The right wing entered the water and the aircraft cart wheeled coming to rest nose down and inverted. While both occupants were wearing lifejackets and were rescued, the aircraft sank and was not recovered.	Serious
12/02/1994	Rutan Long-EZ	Witnesses reported that the pilot intended to conduct a low level pass adjacent to workers on his property. After the low level pass, the aircraft was observed to pull up and the main gear impacted powerlines. The main gear was torn off in the wirestrike, and the aircraft impacted the ground. The pilot was fatally injured.	Fatal
05/03/1994	Cassutt IIIM Sport Racer	During flight, the aircraft's engine failed. The pilot elected to conduct a forced landing in which the aircraft was damaged. Further inspection of the engine could not determine the reason for failure.	Nil
12/10/1994	Viking Dragonfly	During flight, the engine crankshaft broke and the propeller separated from the aircraft. The pilot conducted a forced landing on a road. During the landing, the aircraft collided with an embankment and was substantially damaged.	Nil
02/11/1994	Evans VP-2 Volksplane	Shortly after take-off and at low altitude, the aircraft encountered a strong downdraft. The aircraft collided with the tops of trees and overturned.	Minor
22/11/1994	Van's RV-4	Following a number of circuits and a local flight, his passenger disembarked and the pilot planned to conduct several more circuits. Shortly after take-off, witnesses observed the aircraft making what appeared to be a 'flat' left turn, and noted that the aircraft was about 100 m AGL and that the engine noise level was low. The aircraft then went out of their field of view. A short time later, wreckage was discovered. The impact was consistent with the pilot having lost control of the aircraft. The investigation could not conclusively determine the nature of the loss of control of the aircraft, however there was evidence of a fibreglass fairing from the base of the tailfin becoming detached in such a way that it could have restricted the movement of the elevator control surface.	Fatal
02/01/1995	Quickie Q-200	During the landing roll the aircraft encountered a wind gust causing the nose to pitch up and the aircraft to become airborne again. Before an effective recovery could be made the aircraft stalled, impacting the ground in a nose down attitude and rolling on to its back.	Nil
22/01/1995	Steen Skybolt	Witnesses observed the aircraft conducting aerobatic manoeuvres when it was seen to spin and crash. The pilot was fatally injured. Investigation of the accident found that unauthorised low flying, aerobatic manoeuvres at low altitude, low pilot experience on type, and a lack of formal aerobatic training may have contributed to the accident.	Fatal

Date	Aircraft model	Accident summary	Highest injury
14/04/1995	Kitfox IV	An engine malfunction was experienced in-flight, and the pilot decided to make a forced landing. Further investigation could not determine the cause of the engine failure.	Nil
24/04/1995	Rand KR-2	Shortly after take-off at 100-120 ft AGL, the aircraft's engine failed. The pilot turned the aircraft back towards the aerodrome, but the aircraft stalled and collided with the ground inverted.	Serious
13/06/1995	EAA Acro Sport II	During cruise, the aircraft's engine lost power. The pilot conducted a forced landing in a clearing, during which the aircraft clipped a tree causing substantial damage to the wing. After the aircraft stopped, the engine caught fire. Further examination of the engine revealed that the gascolator bowl retaining clip had partially separated, resulting in fuel starvation.	Nil
02/10/1995	Glasair III	At the end of the landing run on a wet grass strip, the pilot guided the aircraft to the edge of the strip to turn around. Directional control was lost during the turn as the aircraft began to slide sideways on the wet slippery surface into tussocky heavy grass, causing the main gear to collapse.	Nil
26/01/1996	Sindlinger HH-1 Hawker Hurricane Replica (5/8 scale)	During an approach for a touch-and-go landing, the aircraft encountered windshear at a height of about 15 ft AGL resulting in a heavy landing. The pilot applied power and continued for another circuit. It was the pilot's practice not to retract the gear during circuit training. He noted that the gear indications were still green during his pre-landing checks for the final circuit. At the completion of this circuit, the landing was normal but the right landing gear leg collapsed during the landing roll.	Nil
10/02/1996	Pitts S-1E Special	The pilot advised that he was ferrying the aircraft home after purchasing it earlier the same day. During descent, the aircraft's engine lost all power without warning. The pilot conducted a forced landing into what appeared to be a cleared paddock, however, the main wheels struck a tuft of thick grass during the landing roll and the aircraft nosed over on to its back. An investigation found that the pilot did not check the fuel level prior to the ferry flight, and the engine failed due to fuel exhaustion.	Nil
06/03/1996	Glasair II-S	The pilot was taxiing the aircraft for take-off when the left wing collided with refuelling equipment that had been positioned to refuel a regular public transport aircraft due shortly after. The pilot reported that he was distracted due to communication with the other aircraft.	Nil
16/04/1996	Rutan Long-EZ	The pilot landed short of the runway in a grassed area. The nose gear strut assembly broke and the aircraft slid to a stop on its nose.	Nil
16/04/1996	Bede BD-4	The pilot reported that the nose gear collapsed during the ground roll after a normal landing. The aircraft was known to develop severe nose wheel shimmy if the nose wheel was not held off for as long as possible after landing.	Nil
30/05/1996	Van's RV-6	During the take-off roll, the aircraft groundlooped to the left. The right landing gear collapsed and the propeller struck the ground. The pilot reported a crosswind from the left at the time of the accident.	Nil

Date	Aircraft model	Accident summary	Highest injury
22/07/1996	SeaRey	The aircraft was conducting circuits from a river when it nosed over during the fourth take-off. An inspection of the aircraft after the accident found that the builder had omitted two of the three required layers of woven glass from the hull foam core, causing the hull to leak.	Nil
09/09/1996	Kis TRI-R	During the landing roll, the right main landing gear leg collapsed. The aircraft slewed to the right and came to rest on the runway. An engineering inspection revealed that the bolts which retained the gear leg to the main structure had failed due to premature corrosion of the bolt heads.	Nil
19/10/1996	Corby CJ-1 Starlet	The pilot of an aircraft reported that a second aircraft (which was travelling in company) was making a forced landing. The pilot of that aircraft reported a rough running engine and severe vibration. Both aircraft were above broken cloud at the time and were having difficulties finding a clear hole to descend through. The aircraft impacted the ground in a 70 degree dive among trees. Investigation of the accident found that the propeller spinner had separated in-flight, causing damage to the propeller and severe engine vibrations which probably resulted in an in-flight breakup.	Fatal
19/01/1997	Corby CJ-1 Starlet	During climb, the engine started to misfire and the pilot elected to turn back. Shortly after, the engine failed and the pilot conducted a forced landing in a farm paddock. The terrain was rough causing damage to the landing gear attachments. The pilot reported that molten metal was found coming from one cylinder exhaust. An engineering inspection found that the location of the carburettor and fuel lines probably led to fuel vaporising when the engine overheated.	Nil
21/03/1997	Wheeler Express CT	After a normal touchdown, the nosegear collapsed. The aircraft was being test flown with the most forward centre of gravity as close to maximum take-off weight as possible, which was at the point where the nosewheel strut was welded to the airframe. An engineering inspection found that the weld may have failed due to a fault or corrosion.	Nil
30/03/1997	Jodel D.11	During the landing roll, the left main wheel collided with a shallow hole in the runway filled with soft sand. Directional control was lost and the aircraft veered to the left, contacting a runway marker on the edge of the airstrip. The aircraft then nosed over and came to rest inverted.	Nil
26/04/1997	Viking Dragonfly	During cruise, the engine gradually lost power. The pilot elected to conduct a forced landing, during which the aircraft flew through the tops of trees and then under a powerline. The aircraft then collided with two sheep, a ditch, became airborne again, and finally collided with the ground. A post-accident inspection revealed a coolant hose had detached from the water pump.	Nil
01/06/1997	Bushby MM-II Mustang II	During the flare, the pilot was not aware of the sink rate and the aircraft contacted the ground heavier than normal on a soft patch on the runway. The nose wheel separated and the aircraft overturned.	Minor

Date	Aircraft model	Accident summary	Highest injury
31/08/1997	Druine D.5 Turbi	On final approach as part of a spot landing competition with another aircraft, the aircraft encountered a downdraft. The aircraft collided with a cattle ramp and a fence, short of the runway, before it landed heavily and slid to a stop on a road prior to the threshold. Further investigation found that the pilot was seated in a lower than usual position, and did not have his normal visual cues available.	Minor
12/03/1998	Lancair 320	During flight, the aircraft's engine lost oil pressure, and the pilot declared an emergency (MAYDAY) to air traffic control. She reported that she would conduct a forced landing on a road. The wreckage of the aircraft was found in a recently cleared paddock surrounded by coastal scrub country. The investigation indicated that the aircraft was banked left at more than 90 degrees, and was approximately 45 degrees nose-down at impact. The aircraft had cart wheeled and broke up when it struck a windrow of felled trees. The landing gear was extended at impact. Engine oil was streaked along the lower fuselage aft of the engine compartment due to a burned-through oil supply hose.	Fatal
05/06/1998	Wheeler Express CT	During landing, the first touchdown was heavy and the aircraft bounced. On the second touchdown which was also heavy, the nose gear leg attaching bolts sheared and the aircraft came to rest on its nose. Subsequent examination found that the nose tyre had deflated on the second touchdown, generating additional loading on the landing gear assembly. The pilot indicated that he had been using a different seat position in the aircraft and this may have caused a distorted view of visual cues.	Nil
14/06/1998	Van's RV-6A	Following a test flight, the nose wheel bounced twice on landing before the nose landing gear failed below the attachment point on the engine mount. The pilot reported that before commencing the test flight, he had conducted a fast ground run. After the accident, witnesses reported that during the ground run the nose landing gear had been seen to be moving very rapidly fore and aft.	Nil
30/08/1998	Quickie Q-200	While conducting circuits, the pilot reported that the aircraft was not responding as usual to control inputs. During the roll out after a smooth landing, the right canard failed and the propeller was damaged when it contacted the runway. Engineering investigation determined that the upper surface of the canard had failed under a single application of a compression load parallel with the plane of the skin. Examination of the composite materials indicated that there was no apparent degradation of the matrix. Given these features it was considered that the wing had failed as a result of a large sudden upward force on the wing. The investigation determined that this was most probably the pilot's first flight in the aircraft. It is probable that the accident occurred because the pilot had no experience on the type, had very limited recent flying experience, and lost control of the aircraft on landing.	Nil

Date	Aircraft model	Accident summary	Highest injury
08/11/1998	Rand KR-2	During initial climb, the pilot noticed that the canopy was not fully closed. It was latched during the taxi to take-off about 1 inch proud of the closed position but had not been fully closed before take-off. When he attempted to close it, the canopy flew open, but remained attached to the aircraft. The pilot reported that he had to lower the nose and apply full left aileron and rudder to maintain control of the aircraft. He conducted a forced landing straight ahead in a paddock. The aircraft landed heavily and collapsed the landing gear. The canopy probably produced a blanking effect on the tail plane so the elevator control was less effective than usual during the flare.	Minor
06/01/1999	SeaRey	After touching down normally on a smooth water surface, the pilot reduced power when the cockpit suddenly began to fill with water and the aircraft nosed over. Later engineering examination found that the damage was consistent with water impact, and concluded that the aircraft had been subjected to a sudden wind gust associated with downwash from nearby high ground. This had resulted in the left wing-tip striking the water with an associated nose-down pitch.	Minor
15/02/1999	Mini Max TD	Immediately after take-off into a south-easterly breeze, the aircraft appeared to climb normally but then began to sink. The pilot was about to reject the take-off and land on the remaining runway when the climb rate was restored. However, a short time later the rate of climb deteriorated again and the pilot conducted a forced landing in a field beyond the end of the runway. During the landing, the aircraft flipped over. The pilot subsequently reported that, after vacating the aircraft, he noticed that the windsock was now indicating that the wind was from the northwest. The poor climb performance was probably a result of a loss of rudder effectiveness due to the change in wind direction.	Nil
23/02/1999	Van's RV-4	During the landing roll, the pilot lost directional control of the aircraft. The aircraft veered left and crossed a ditch causing substantial damage to the aircraft. The pilot indicated that it may have been the result of wind gust from the left.	Nil
07/03/1999	Bede BD-4	While flying in a club competition, the aircraft landed heavily and during the landing roll the right main landing gear collapsed.	Nil
28/03/1999	SeaRey	During the landing roll, the left main landing gear collapsed. The pilot subsequently reported that there was a strong crosswind from the south. After touching down, a strong wind gust lifted the right wing and the left landing gear collapsed through overload. Further inspection of the landing gear revealed that the solid-spoke left wheel hub had also collapsed.	Nil
31/03/1999	Van's RV-6	A witness reported that during take-off, the left wing of the aircraft struck the ground and it cart wheeled along the airstrip. The investigation could not determine why the aircraft hit the ground immediately after take-off.	Serious

Date	Aircraft model	Accident summary	Highest injury
02/04/1999	Lancair 235	Shortly after take-off, the aircraft's engine was heard to surge and lose power. The aircraft entered a spin, and collided with terrain. Even though the aircraft had been refuelled the previous day, only a small quantity of fuel was present at the accident site. The quantity was not consistent with the amount of fuel that had been in the aircraft's fuel tanks on the previous day. There were indications at the site where the aircraft had been parked overnight that fuel had been spilled on the ground from a fuel drum, which may have indicated that fuel had been siphoned from the aircraft's fuel tanks on the night prior to the accident flight. There was no indication that either the pilot or the passenger had been incapacitated at the time of the accident. It was not possible to determine why the aircraft entered a spin after the engine lost power.	Fatal
17/06/1999	Bushby MM-II Mustang II	Following a normal landing, the right main wheel appeared to immediately lock and began to skid. Heavy braking was applied on the left main wheel to maintain directional control. The aircraft had slowed to a walking pace when the left main landing gear leg collapsed and the aircraft nosed over, coming to rest on the right main landing gear, engine cowl and left wingtip.	Nil
26/06/1999	SeaRey	During an amphibious take-off in near perfect sea conditions, the aircraft suddenly settled and partially submerged as the aircraft reached rotation speed. As the pilot was exiting the aircraft he noticed that the flaps were up but the flap selector handle was still in the position for 20 degree/full flap, which is the normal setting for take-off. An engineering inspection revealed that a stainless steel screw in the flap control system had failed by an excessive tension/bending load.	Nil
19/08/1999	Glasair II-S-TD	During the landing roll, the aircraft began to drift to the right. The pilot applied full left rudder and normal braking, but the left brake faded and the aircraft slewed sideways and ran off the runway. The fuel tank ruptured and the fibreglass fuselage was fractured.	Nil
30/11/1999	Van's RV-6	The aircraft was being used to train a pilot obtaining a PPL. Witnesses reported that the take-off and initial climb appeared to be normal until about 500 ft AGL when the aircraft's engine noise appeared to cease. The aircraft maintained a wings level attitude for a short distance before commencing a steep descending turn to the left. The aircraft contacted the top of several trees, rolled inverted and impacted the ground. Both occupants sustained serious injuries and the aircraft was destroyed. The instructor reported that he had called for a simulated engine failure at about 300 ft AGL. The student pilot closed the throttle and altered heading about 40 degrees, seemingly towards a nearby open field. He then indicated to the instructor that he was at 500 ft and would return to the runway. As the instructor was looking back to check the relative position of the runway, the aircraft's nose and left wing suddenly dropped. The instructor took the controls and recovered the aircraft to a wings level attitude, however there was insufficient height remaining to prevent contact with the trees.	Serious
03/01/2000	Velocity XL	During the flare prior to touch down, the aircraft was buffeted by strong cross-wind gusts. The pilot lost directional control as the aircraft bounced, then yawed and landed sideways. The main landing gear collapsed and the aircraft slid along the runway.	Nil

Date	**Aircraft model**	**Accident summary**	**Highest injury**
12/03/2000	Van's RV-3	Shortly after take-off at 200 ft AGL, the engine lost power rapidly. The pilot lowered the aircraft nose attitude and the engine restarted itself. Following a further short climb the engine again failed and did not restart. The pilot turned the aircraft to the left, apparently with the intention of returning for a landing on the grass runway. During the turn, the aircraft lost altitude rapidly and collided with the ground in a sports oval. Further investigation found a loose fuel line connection on the suction side of the fuel pump, leading to fuel starvation.	Fatal
18/07/2000	Kitfox III	During flight at approximately 1,500 ft AGL, the aircraft's engine failed. The pilot conducted a forced landing onto a road, during which the right wing struck a road sign and spun the aircraft around and into a ditch. An engineering inspection of the engine attributed the engine failure to a failure of the rear lower connecting rod bearing.	Nil
11/12/2000	Corby CJ-1 Starlet	On final approach about 200 m from the runway threshold, the aircraft experienced severe downdraughts. The pilot lost control of the aircraft, and it impacted the ground short of the runway and collapsed the undercarriage.	Nil
26/12/2000	Van's RV-6	While performing aerobatics at approximately 6,000 ft AGL above an airfield, the engine stopped. An attempted engine restart was unsuccessful and the pilot positioned the aircraft for a forced landing on to the airfield. However, on final approach the aircraft encountered windshear and touched down 150 m before the threshold. The landing gear became entangled in the low vegetation and the aircraft overturned.	Minor
01/01/2001	Pioneer Flightstar FS-IIL	During the climb after a touch and go at 300 ft AGL, the engine abruptly stopped. The pilot conducted a forced landing in a vacant playing field, during which the aircraft overran and sustained damage on impact with trees bordering the playing field.	Nil
06/01/2001	Europa	During the take-off roll, the aircraft struck a kangaroo. The impact fractured one of the propeller blades and caused the aircraft to yaw sharply to the left. The aircraft became prematurely airborne, and the pilot succeeded in turning the aircraft parallel to the runway before the aircraft impacted the ground.	Serious
28/01/2001	Pitts S-1E Special	The pilot was conducting an aerobatics practice session, during which he performed numerous vertical manoeuvres and steep high-G turns. A witness observed the aircraft conducting such manoeuvres and descending before the aircraft was lost to sight behind a ridge. Investigation of the wreckage indicated that the aircraft had struck the ground at about 100 kts while a wings-level 30 degree nose-down attitude. It was travelling in a direction opposite to that in which it was last seen. No witnesses observed the aircraft impact the ground. The investigation found that the pilot was wearing a parachute (he usually did not), and that the resulting change in his seating position may have affected his visual cues and perception of control positions when performing precision manoeuvres.	Fatal

Date	Aircraft model	Accident summary	Highest injury
04/02/2001	Bowers Fly Baby	On approach to land in strong, gusty wind conditions associated with a sea breeze, the aircraft encountered windshear. The pilot did not detect the high sink rate and the tail wheel collided with the top strand of the airfield boundary fence. The pilot attempted to applied power to go around but lost control of the aircraft, which inverted and collided with the ground. In addition to poor visual cues on approach, and vegetation obscuring the fence, it was the pilot's first flight in the aircraft type.	Nil
10/02/2001	Lancair 320	During take-off in gusty crosswind conditions, the right wingtip contacted the ground just after rotation. The pilot lost control of the aircraft, and the propeller struck the ground and the landing gear collapsed.	Nil
10/02/2001	Van’s RV-6A	The aircraft landed hard and bounced, and on the subsequent touch down the nose gear leg collapsed causing the propeller and engine cowling to strike the ground. The exhaust pipe then contacted the fibreglass canopy, which caught on fire. Further examination of the gear leg indicated the failure most likely resulted from an overload.	Nil
17/02/2001	Thorp T-18 Tiger	This was the first flight in the aircraft following the fitting of an overhauled carburettor. The aircraft was ground run satisfactorily before the flight. The pilot reported that the aircraft initially appeared to accelerate normally, but lifted-off rather sluggishly about halfway along the runway. At 15 ft AGL, the pilot determined that the engine was not developing the required take-off RPM and rejected the take-off. However, insufficient runway remained to brake the aircraft normally and it overran into the airfield boundary fence and scrub. The aircraft nosed over and came to rest inverted.	Minor
13/03/2001	Lancair 320	During approach, the aircraft was observed by witnesses to spiral to the ground. Investigation of the accident established design issues with the aircraft that resulted in the aircraft having marginal longitudinal static stability at low speeds. The pilot probably lost control and the aircraft entered a stall and spin during approach. The aircraft had also had a modified propeller fitted, but it was not determined whether this contributed to the accident.	Fatal
25/04/2001	Rutan Long-EZ	During a cruise climb, the pilot heard a single loud bang and the engine stopped. The pilot broadcast an emergency call (MAYDAY) and conducted a forced landing onto a nearby section of beach. The pilot landed the aircraft safely along the water line with the nose landing gear retracted in order to shorten the landing roll and avoid any possibility of the nose wheel digging in to soft sand and overturning the aircraft. Further inspection found several bent pushrods and damaged valve gear on engine, and that the propeller had separated from the aircraft.	Nil
22/06/2001	Quickie Q200	During the climb at 3,000 ft AGL, the aircraft’s engine stopped. The pilot elected to conduct a turnback to the departure aerodrome. On final approach, the aircraft encountered sink, and the right canard collided with an airport boundary fence post. The aircraft swung through 180 degrees and the left canard impacted the ground.	Nil

Date	Aircraft model	Accident summary	Highest injury
03/07/2001	Airdrome Aeroplanes Nieuport 17 Replica (Full scale)	Immediately after take-off at 10 feet AGL, the aircraft's engine lost power and the pilot elected to conduct a forced landing. In attempting to avoid a ditch, the pilot dipped the right wing, which struck the ground. The aircraft overturned and came to rest inverted. Subsequent inspection of the engine showed that two spark plugs had evidence of a very rich mixture. The problem had occurred previously during ground running.	Nil
25/07/2001	Van's RV-4	Witnesses heard the aircraft arrive from the west across the airstrip, and pass between the homestead and the shed. The property owner heard the engine stop, and then a thump. The aircraft was destroyed by impact forces and post impact fire. Police on site reported that the aircraft collided with a single power line prior to impacting the ground. It was noted that the power line would probably have been hard to see against the background.	Fatal
29/03/2002	Van's RV-6A	Upon landing, the aircraft experienced gusty conditions that caused the aircraft to bounce, which resulted in the aircraft's nose landing gear collapsing and the propeller striking the runway. The pilot later reported that the aircraft manufacturer was recalling the nose landing gear strut for defect appraisal.	Nil
10/04/2002	Glasair GlaStar	During initial climb, the engine lost power at approximately 300 ft AGL, temporarily regained power, then reduced to fast idle. The pilot conducted a forced landing to the north of the field in inaccessible terrain. Further examination of the engine revealed that the fuel pump had failed.	Nil
20/07/2002	Van's RV-6	A de Havilland DH.82 Tiger Moth was backtracking to exit the runway after landing when the RV-6 collided with its right wing. The Tiger Moth was substantially damaged, and the left wing and fuselage of the RV-6 were damaged. The pilot of the RV-6 reported that his attention had been distracted by a passenger.	Nil
15/09/2002	Rand KR-2	During the take-off run, the pilot rejected the take-off due to a lack of airspeed indication. While lowering the tail, the aircraft became airborne then bounced heavily twice, resulting in a broken propeller, left wing tip damage and possible damage to the wing spar and undercarriage attachment bolts.	Nil
09/10/2002	Thorp T-18 Tiger	During the landing roll, the aircraft veered to the left off the sealed surface onto rough ground. It then overturned before coming to rest.	Minor
11/11/2002	Lancair 320	The pilot reported nose landing gear problems and then engine failure, and conducted a forced landing in a paddock. Further investigation found that the landing gear issues were due to a maintenance error in which an undercarriage bolt was replaced in reverse. It is possible that the bolt abraded a fuel line, leading to fuel starvation.	Nil

Date	Aircraft model	Accident summary	Highest injury
20/12/2002	Lancair IV-P	The aircraft was undergoing a flight test program following construction by the owner. During an earlier test flight, the aircraft had entered a stall, and rolled 45 degrees right and left during the recovery. On the accident flight, the aircraft intentionally entered a stall (for stall testing) at a height of approximately 6,000 ft AGL. The aircraft rolled at the initiation of the stall, and continued to roll as it descended rapidly at an angle of approximately 40 degrees to the horizontal. The aircraft accelerated to 150 knots with low engine power. Power was increased shortly before impacting the ground with wings level and a pitch angle of 40 degrees nose down. The aircraft was built under the experimental designation, and was based on a Lancair IV-T kit. The design had been heavily modified during construction, including changes to the propeller, engine, and wing position. There was no evidence of any significant risk assessment process associated with design changes to assess the safety implication of the changes. There was no significant risk assessment process for the planning and conduct of the flight test program. Such an assessment could have enabled the safety implications of any hazards to be considered prior to subsequent tests.	Fatal
16/03/2003	Luton LA.4 Minor	During the landing roll, the right main landing gear collapsed resulting in the aircraft ground looping and coming to rest on its nose.	Nil
19/04/2003	Glasair II-S-RG	On landing, the nose wheel collapsed. The pilot reported that the nose wheel retaining nut could have loosened off despite being a nyloc-type thread.	Nil
15/07/2003	Lancair 360	During the approach when the landing gear was selected down, the pilot received no indications that the nose landing gear was extended. A fly-by inspection was conducted and this confirmed that only the main landing gear legs were down. The pilot then set up for a two-wheel landing, however, the aircraft touched down on grass short of the runway, collapsing the remaining landing gear.	Nil
05/08/2003	Glasair II-S-RG	When the landing gear was selected down, the left main landing gear did not extend. The pilot was unable to manually extend the landing gear and a landing was conducted with only the right main landing gear and nose wheel extended. The remaining landing gear retracted on landing, causing substantial damage to the exhaust, propeller, landing gear and gear doors.	Nil
05/10/2003	Van's RV-8	During the cruise, aircraft engine noise began to rise and the pilot thought it was losing power. As the aircraft was approaching inhospitable terrain, the pilot elected to carry out a precautionary landing on a road in which the aircraft sustained substantial damage. Further examination found that an exhaust pipe was later found to be broken off at the flange, leading to a noise increase.	Nil
24/10/2003	Glasair II-S-TD	While taxiing for take-off, the right brake failed. The pilot disembarked the aircraft to investigate, and found smoke coming from the right wheel spat. An attempt to extinguish the fire failed and flames quickly spread to the fuel tank. The aircraft was subsequently consumed by fire and destroyed.	Nil
06/11/2003	Dyn Aero MCR-01 Banbi	During cruise, the aircraft's canopy shattered. The aircraft then entered a spin to the right. The pilot recovered control after three to four turns and conducted a forced landing in a paddock. During the landing roll, the nose wheel dug in to soft ground and the aircraft overturned.	Minor

Date	Aircraft model	Accident summary	Highest injury
06/12/2003	Van's RV-6A	During the landing roll, an aircraft wheel struck a depression and the aircraft tipped over.	Minor
11/02/2004	Bede BD-4	During the landing, the pilot encountered heavy turbulence. The aircraft landed heavily and sustained substantial damage.	Nil
23/02/2004	Van's RV-8	During the landing roll, the aircraft was affected by a wind gust. Despite pilot inputs to control the aircraft, it ground looped and departed the runway to the left. The pilot described the approach as normal with a small correction for crosswind. The aircraft incurred substantial damage to the gear, right wing and propeller.	Nil
18/03/2004	Van's RV-8	During the landing roll in a crosswind, the pilot lost control of the aircraft resulting in a ground loop. The aircraft was substantially damaged.	Nil
27/03/2004	Van's RV-6A	Shortly after take-off, the pilot noticed water coming out of the engine bay followed by an engine temperature increase. The pilot conducted a turnback to the departure aerodrome. On touchdown, the aircraft bounced and then impacted the ground heavily. The nose wheel dug in and the aircraft flipped on its back. Further inspection revealed a detached water pump hose.	Minor
14/05/2004	Van's RV-7A	At the beginning of the take-off run during a test flight, the nose landing gear collapsed and folded back causing substantial damage to the aircraft.	Nil
22/07/2004	Lancair 360	On landing, the aircraft bounced and overran the runway strip. The aircraft was substantially damaged.	Nil
06/09/2004	Piel CP30 Emeraude	While en route, the aircraft's engine stopped and the pilot conducted a forced landing in a nearby paddock. The aircraft sustained substantial wing damage during the landing. Further examination of the engine by the builder suggested that a design change to the cowling may have led to a vapour lock in the fuel line, causing fuel starvation.	Nil
25/10/2004	Van's RV-4	Shortly after take-off at 600 ft AGL, the pilot turned off the electric fuel pump and the engine stopped. The pilot conducted a forced landing in a nearby paddock during which the aircraft was substantially damaged.	Nil
14/11/2004	Europa XS	During the take-off, the engine suddenly went up to full power even though the throttle was only about half open. The aircraft became airborne and climbed quickly to 20 ft AGL, then the engine partially lost power. The pilot conducted a forced landing on the remaining runway strip, but despite attempting a ground loop to the right was unable to stop the aircraft before it impacted a drain. Although not confirmed, the pilot concluded that the engine had experienced a 'turbo surge' which the engine manufacturer warned can occur on engine start. The pilot suspected that the apparent power loss was only the engine returning to the power selected by the throttle setting.	Serious
19/11/2004	Jabiru J400	The pilot was conducting circuits in the aircraft, which was equipped with an automotive engine. As the aircraft climbed through 300 ft AGL on the second circuit, the engine began to run rough. The pilot attempted a turnback to the departure runway, but when the aircraft was halfway through the turn the engine failed. The pilot conducted a forced landing in a paddock. Further examination determined that the engine management computer had failed.	Nil

Date	Aircraft model	Accident summary	Highest injury
03/12/2004	Van’s RV-6A	On touchdown, the aircraft landed heavily and ballooned before landing heavily again. The nose landing gear separated from the aircraft, and the propeller struck the runway.	Nil
04/12/2004	Kitfox IV	While flaring to land the airspeed decayed and the aircraft touched down heavily and then bounced. A go-around was initiated but the aircraft drifted to the right of runway, stalled, and then ground looped.	Nil
29/12/2004	Van’s RV-6	On landing, the aircraft bounced along the runway three times. On the third bounce, the nose gear collapsed and separated from the aircraft, resulting in the propeller striking the runway.	Nil
17/04/2005	Glasair III	During the landing roll, the aircraft's nose wheel oscillated from side to side then turned sideways causing the nose to contact the ground. The aircraft pitched inverted and came to rest on its back. The pilot reported that incorrect tensioning of the shimmy damper during maintenance could have contributed to the accident.	Minor
13/09/2005	Thorp T-18 Tiger	The ATSB was advised that an amateur-built aircraft had impacted the ground and was destroyed. The aircraft may have broken up in flight.	Fatal
08/10/2005	Steen Skybolt S	During a go-around in strong crosswinds, the pilot lost directional control and the aircraft struck two trees.	Minor
29/10/2005	Van’s RV-7	The ATSB was advised that an aircraft had crashed.	Minor
18/11/2005	Van’s RV-6A	During the landing roll, the aircraft's nose landing gear struck a rut on the airstrip. The aircraft bounced before touching down again, when it came to rest inverted.	Nil
14/01/2006	Van’s RV-6	During a touch-and-go, the aircraft failed to achieve take-off performance, overran the runway strip and collided with an embankment and fence.	Minor
21/01/2006	Jabiru SP	On turning base, the pilot noticed that the throttle linkage had failed and that the power could not be reduced. Once established on final, the pilot shut down the engine with the intention of making a glide approach. During short final, the aircraft passed through an area of rapid sink which put it close to power lines. The pilot turned the aircraft towards a clear area and conducted a forced landing, during which the aircraft skidded into a fence.	Nil
16/02/2006	Viking Dragonfly	On touchdown, the aircraft landed heavily and bounced. It porpoised several times at low altitude during the recovery but then stalled, pitched nose down, and collided with the ground.	Serious
10/03/2006	Lancair 320	During the landing roll, a severe nose wheel shimmy developed and the nose landing gear collapsed. The propeller contacted the runway and the aircraft came to rest on the main landing gear and the cowling below the engine.	Nil
12/03/2006	Glasair II-RG	The ATSB was advised that the aircraft had crashed. The two occupants were fatally injured.	Fatal
18/03/2006	Rutan Long-EZ	After a slightly heavy touchdown on the main wheels, the nose wheel collapsed and separated from the aircraft. The aircraft veered off the runway and came to rest on grass within the runway strip.	Nil

Date	Aircraft model	Accident summary	Highest injury
31/03/2006	Lancair 320	During the cruise, the aircraft departed controlled flight and impacted the ground. The loss of control was consistent with an accelerated aerodynamic stall, at a height from which it was not possible to recover, followed by the aircraft entering a spin to the left prior to impact. The loss of control occurred when the pilot was operating in adverse weather conditions of low cloud and was tracking towards an area of reduced visibility in rain and towards terrain that was higher than the aircraft. The pilot's decision to continue the flight into instrument meteorological conditions, even though neither he nor the aircraft were certified to operate is those conditions, increased safety risk. The pilot's ability to fly the aircraft and manage the flight was limited by his relative lack of experience on high performance aircraft, and deficiencies in the training that he had received on operating this particular type.	Fatal
31/03/2006	SeaRey	During the initial climb at about 50 ft AGL, the left wing stalled and the aircraft impacted the ground. The pilot described that the aircraft was caught in a cross wind from the right, and while still on the ground was drifting to the left of the runway. To counter this the pilot elected to lift off early. It is likely that the pilot lifted the aircraft off the ground and corrected the drift by increasing right bank, thereby increasing the load on the left wing beyond the critical angle of attack with the subsequent aerodynamic stall.	Minor
05/04/2006	Lancair 360	Following a touch-and-go while conducting circuits, the engine was heard to malfunction at about 100 to 400 ft AGL by witnesses. Almost immediately, the aircraft rolled into a steep right turn. Engine power was heard to return, but sounded intermittent. After turning approximately 90 degrees, the aircraft rolled out of the turn momentarily to about wings level, before the turn steepened again to the right. The aircraft rolled further to the right and descended at a steep angle into the ground. The investigation found that the engine power loss was probably due to interruptions of fuel flow to the engine, but could not conclusively determine the reason. The aircraft stalled at a height insufficient to allow the pilot to recover. It was the aircraft's first flight since being repaired after a landing accident in 2003.	Fatal
24/07/2006	Van's RV-6	During the landing, the aircraft veered to the left of the runway and collided with a fence.	Nil
07/08/2006	Zenith CH801	During a crosswind landing, the aircraft veered to the right due to a deflated right tyre and struck a tree.	Nil
25/11/2006	Corby CJ-1 Starlet	Shortly after take-off, the aircraft's engine failed. Shortly afterwards it resumed operating then failed again. The pilot attempted to conduct a turnback, but the aircraft stalled, collided with terrain and cart wheeled.	Nil
23/02/2007	Van's RV-4	The owner-pilot was observed conducting aerobatic manoeuvres in a designated aerobatic area, when witnesses observed the aircraft descending in a downward spin after completing a stall turn. The aircraft engine was heard to gain power during the spin and the aircraft speed rapidly increased. The aircraft was then seen to enter an unstable spiral dive. At 1,500 ft AGL the engine noise was heard to be very high pitched and loud and pieces were seen to separate from the aircraft. The rapid spiral descent continued and the aircraft impacted the ground almost vertically. The aircraft was destroyed by impact forces and a post impact fire.	Fatal

Date	Aircraft model	Accident summary	Highest injury
03/03/2007	Rand KR-2	Due to a wind gust, the pilot lost directional control of the aircraft on landing.	Nil
04/03/2007	Marcel Jurca MJ-5 Sirocco	Shortly after take-off, the aircraft's engine lost power. The aircraft then struck a wire before the aircraft impacted the ground.	Nil
20/05/2007	Bede BD-5	The ATSB was advised that the aircraft overran the runway and caught fire.	Serious
31/05/2007	Van's RV-4	During the take-off run, the pilot lost directional control of the aircraft. The aircraft collided with the airfield boundary fence.	Nil
23/07/2007	Gardan GY-201 Minicab	The ATSB was advised that the aircraft had suffered an engine failure after take-off. The aircraft was subsequently located in trees near the airport. The pilot advised that carburettor operation was disrupted during initial climb by ram air pressure, leading to fuel starvation.	Nil
07/09/2007	Van's RV-6A	Shortly after take-off, the aircraft's automotive engine lost power and the pilot conducted a turnback for a precautionary landing. While the take-off had been in nil wind conditions, the aircraft encountered a tailwind during the landing roll. The aircraft overran the runway causing substantial damage to the left fuel tank and fuselage skin. Further examination of the engine revealed that the main bearing in the supercharger had seized.	Nil
28/09/2007	Thorp T-18 Tiger	During final approach, the aircraft encountered a downdraft, collided with terrain and came to rest inverted.	Minor
08/10/2007	Van's RV-7	During flight, the aircraft's engine failed. The pilot declared an emergency (MAYDAY) and conducted a forced landing on a road. During the landing roll, the slipstream of a truck ahead caused the aircraft to land heavily, damaging the main landing gear and the tail wheel spring. The propeller and the trailing edges of the flaps contacted the road. The aircraft slid off the side of the road and nosed into soft sand.	Nil
01/12/2007	Supermarine Mk.26 Spitfire Replica (80% scale)	During a go-around, the aircraft stalled at low level and landed heavily off the runway. The main landing gear collapsed and the aircraft sustained damage to the fuselage and the right wing.	Nil
05/01/2008	Supermarine Mk.26 Spitfire Replica (80% scale)	Just prior to touchdown and while attempting to avoid a flock of birds, the pilot lost control of the aircraft, side-swiping the left landing gear leg. The landing gear collapsed, causing the left wing tip to contact the runway surface. The aircraft slid off the runway onto the grass.	Nil
07/03/2008	Zenith CH601 XL	It was reported to the ATSB that the aircraft impacted the sea. Recreational Aviation Australia (RA-Aus) commenced an investigation into the occurrence, and the ATSB provided technical assistance in examining several pieces of canopy from the aircraft. The examination revealed that the canopy had sustained an in-flight structural failure, probably leading to a loss of control.	Fatal
30/06/2008	Jake Special	Immediately after take-off, the aircraft's engine began to run roughly. The pilot reduced power to idle and attempted to land on the remaining runway. The aircraft touched down heavily and bounced three times before coming to rest before the tree line at the end of the runway. The engine subsequently caught on fire and the aircraft was destroyed.	Minor

Date	Aircraft model	Accident summary	Highest injury
09/09/2008	Van's RV-6A	During the landing, the pilot was unable to stop the aircraft and it overran the runway end. The aircraft struck a fence pole causing substantial damage. The pilot reported that the wind had swung 180 degrees but this was not indicated on the windsock.	Nil
27/09/2008	Van's RV-7A	The aircraft landed hard and bounced twice, causing the nose landing gear to bend backwards. The pilot lost directional control and the aircraft skidded off the runway, flipping onto its back.	Serious
09/10/2008	Kolb Twinstar Mk.3	On final approach, the aircraft's engine failed. The aircraft began to sink and impacted terrain short of the airstrip. The pilot reported that he had not closed the choke properly, and as he turned the aircraft onto final, he throttled back and the open choke flooded the engine.	Serious
21/11/2008	Van's RV-7A	It was reported to the ATSB that the aircraft struck trees and impacted the ground.	Fatal
27/11/2008	Thorp T-18 Tiger	It was reported to the ATSB that the aircraft collided with terrain.	Fatal
05/12/2008	Australian Aircraft Kits Hornet AG	During the take-off run, the pilot lost directional control of the aircraft and it ran off the runway. The aircraft collided with a ditch. Further investigation found that the rudder cable was broken. The pilot reported that operations from the short, narrow strip, combined with limited experience on tail dragger aircraft may have contributed to the accident.	Nil
11/01/2009	Bushby MM-II Mustang II	It was reported to the ATSB that the aircraft had collided with terrain. Witness reports suggested that the engine may have been running rough prior to the accident.	Fatal
25/02/2009	Pitts Samson	It was reported to the ATSB that the aircraft had collided with terrain. It was reported to the Civil Aviation Safety Authority that the pilot lost control of the aircraft after the engine failed during aerobatic manoeuvres.	Fatal
06/03/2009	RJ Francis RJF2	During taxi trials, the aircraft unintentionally became airborne. The pilot returned the aircraft to the ground but it landed heavily, causing the main landing gear to collapse and the non-structural fuselage enclosure to sustain serious damage. The pilot reported that low experience on type contributed to the accident.	Nil
09/03/2009	Van's RV-7A	After touchdown, the aircraft pitched up and down on the undulating runway surface causing the front wheel to bury into a slight mound. The propeller struck the ground causing the aircraft to flip onto its back.	Nil
29/03/2009	Giles G-200	During the landing roll, the left main landing gear leg struck a dog. The landing gear separated, and the aircraft slid along the runway.	Nil
19/04/2009	Monnett Moni	During a circuit and after the aircraft had turned onto the crosswind leg, the aircraft entered a spin. The pilot lost control of the aircraft and it collided with the ground. The pilot reported that he was attempting to conduct a turnback following an engine failure shortly after take-off.	Serious
02/05/2009	Australian Aircraft Kits Hornet AG	During the initial climb at 250 ft AGL, the aircraft encountered windshear and lost airspeed. The pilot attempted to conduct a turnback, but the aircraft stalled and collided with the ground.	Minor

Date	Aircraft model	Accident summary	Highest injury
30/06/2009	Wheeler Express CT	The pilot was performing an aircraft familiarisation flight. Shortly after take-off, the aircraft's engine lost power and the pilot conducted a forced landing on the remaining runway. The aircraft overran the runway end and collided with shrubs.	Nil
06/07/2009	Van’s RV-6	During the initial climb, the aircraft’s engine lost power. The pilot conducted a forced landing in a nearby paddock, and flipped over sustaining serious damage.	Nil
20/07/2009	Rihn Sabre	During the initial climb, the aircraft’s engine failed. The pilot conducted a forced landing during which the aircraft was seriously damaged.	Nil
10/08/2009	SeaRey	During the landing roll, the left main landing gear collapsed. Directional control was lost and the aircraft veered off the runway and ground looped. Further inspection found that the tail wheel was not in position for landing upon touchdown. As a result, the tail wheel was forced back pulling the starboard leg from the over centre position. The owner/builder reported that an electric undercarriage was later fitted to prevent this problem from reoccurring.	Nil
23/08/2009	Glasair II-S-FT	During a landing in gusty conditions, the aircraft landed heavily and sustained serious damage.	Nil
01/09/2009	Supermarine Mk.25 Spitfire Replica (3/4 scale)	During landing, the aircraft's left main landing gear wheel detached from the aircraft. This caused the right wing to rise and the left wing to contact the ground, seriously damaging the aircraft.	Minor
12/09/2009	Jabiru J430	Just prior to touchdown, the aircraft encountered turbulence. The pilot commenced a missed approach, but the aircraft stalled and struck the ground causing serious damage.	Nil
25/11/2009	Lancair 320	During the initial climb, the aircraft’s engine lost power and the aircraft subsequently collided with terrain. The pilot reported that a poor engine cowl design led to the engine developing a high cylinder head and oil temperature, which may have caused the power loss.	Nil
30/11/2009	Thorp T-18 Tiger	During the take-off run, the pilot lost directional control of the aircraft. The pilot reported that a brake lock may have occurred.	Nil
07/02/2010	Lancair IV	During the initial climb, the pilot received an unsafe landing gear indication. The aircraft continued to its destination where the pilot conducted an intentional wheels-up landing. An engineering inspection revealed that a hydraulic flare fitting had failed on the landing gear pressure line.	Nil
27/02/2010	Jabiru UL-T	During descent, the aircraft’s engine failed. The pilot conducted a forced landing, during which the aircraft struck trees and collided with terrain.	Serious
02/04/2010	Jabiru J400	During initial climb at 500 ft AGL, the aircraft’s engine lost power. The pilot turned back, conducted a glide approach, and landed about two-thirds of the distance down the runway. On applying the brakes there was no brake pressure. The pilot pumped the brakes causing the left brake to catch on fire. The pilot lost directional control of the aircraft which veered off and overran the runway end and collided with a small ditch and a fence.	Nil

Date	Aircraft model	Accident summary	Highest injury
28/04/2010	Murphy Rebel	During the cruise, the aircraft struck a bird, causing damage to the windscreen. The pilot conducted a forced landing on a nearby beach.	Nil
11/05/2010	Pulsar	During cruise, the aircraft's engine lost power and subsequently failed. The pilot attempted a forced landing in a nearby paddock, but the left wing and nose dropped and the aircraft collided with terrain. Further examination indicated that the engine probably failed due to carburettor icing.	Minor
19/07/2010	Lancair IV	During cruise, the aircraft's engine began running roughly and the pilot observed the cylinder head temperature reducing. The pilot diverted to a nearby airport. During the approach, the engine failed. The aircraft landed hard on the nose landing gear which subsequently collapsed. The pilot lost directional control of the aircraft, which veered off the runway and was seriously damaged. An engineering inspection revealed that an exhaust valve rocker arm had broken.	Nil
14/08/2010	SeaRey	During cruise, the aircraft's engine lost power and began running roughly. The pilot conducted a precautionary landing on a nearby road. During final approach, the aircraft encountered turbulence and landed hard, causing the landing gear to collapse. An engineering inspection found evidence of fuel contamination.	Nil
07/09/2010	Zenith CH200	During the takeoff run, the pilot lost directional control of the aircraft, which veered off the grass airstrip and struck a fence.	Nil
19/09/2010	Pitts S-1E Special	During the landing roll, the aircraft veered to the right and the pilot initiated a go-around. The left landing gear subsequently collapsed and the propeller struck the runway.	Nil
01/10/2010	Van's RV-7A	During the cruise, the aircraft's engine failed. The pilot conducted a forced landing into trees, during which the aircraft sustained serious damage. An engineering inspection revealed that the upper left camshaft sprocket and timing belt had failed.	Minor
03/10/2010	Van's RV-7A	During the landing roll, the nose landing gear entered a depression on the runway causing the aircraft to flip onto its back.	Nil
31/10/2010	Van's RV-6	During landing, the nose landing gear dug into the grass airstrip. The aircraft stopped abruptly, and bounced onto the wings before falling back onto the main landing gear. The aircraft was seriously damaged.	Nil
17/12/2010	Van's RV-6A	During crosswind circuit training, the aircraft landed heavily. The pilot lost directional control of the aircraft, which veered off the runway.	Nil

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Research

ATSB Transport Safety Report
Aviation Research Investigation
Amateur-built aircraft
Part 2: Analysis of accidents involving VH-registered non-factory-built aeroplanes 1988-2010

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